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Herbert L. Meiselman
Editor

Handbook of Eating and Drinking

Interdisciplinary Perspectives

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With 183 Figures and 77 Tables

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Preface

Before I introduce *The Handbook of Eating and Drinking: Interdisciplinary Perspectives*, let me explain why we need another book on food and eating. There are already so many books on food, especially cookbooks and travel books. There are also many scientific and technical books on subjects surrounding food, including food science, food technology, biology, physiology, nutrition, dietetics, social sciences, and many others. There are also books on the history of food and philosophical approaches to food and eating including ethics. And there are many books on the issues involved in serving food and on culinary applications.

However, there are fewer books examining the acts of eating and drinking, bringing food and beverage in contact with people, and in context with people. Thus, this Handbook differs from many other books because it is not aimed at eating and drinking in isolation nor at food and drink separate from the people who are consuming them.

In addition to this different perspective on eating and drinking, this Handbook is aimed at combining in *one place* all of the various fields that deal with eating and drinking. This includes technical and scientific subjects such as biology, nutrition, social science, etc. It also includes applied subjects such as food service, culinary arts, and business/marketing. It also includes non-technical subjects like the history and philosophy of eating/drinking.

Why is it important to combine all of these fields into one book? Why has this never been done before? First, it is important because the solutions to most problems of eating and drinking involve many disciplines. We slowly have learned this over the past decades. Dieting for better health involves knowledge of food chemistry, social sciences, nutrition, cultural food choices, food pathologies, and probably others. If we want to address dieting in specific population groups, we might need to get into ethics, culinary approaches, and food service approaches. Providing for undernourished populations in the developing world and undernourished parts of the developed world involves some of these same approaches, as well as others. We cannot solve the varied problems of eating and drinking without understanding the complexity of eating and drinking.

That is another reason why it is important to combine all of the relevant fields of inquiry into one book. People who want an overview of the component fields of eating and drinking need a place to find comprehensive knowledge across these fields. So too, professionals who work in one field need up-to-date reviews of the state of the other fields in eating and drinking. One cannot expect either laypeople or professionals to read individual textbooks in each subject area of interest.

The Handbook of Eating and Drinking: Interdisciplinary Perspectives presents over 70 chapters in 15 areas of eating and drinking. The book begins with an historical perspective and ends with perspectives on what may lie ahead in eating and drinking. The Handbook is not a static view of each field; rather chapters will be updated, replaced online, and then published when new editions are released. Also new topics will be added over time. The goal is to keep the Handbook updated with progress in the fields as they grow. The Handbook will be a living book.

I hope you will benefit from this first-time presentation of this very broad view of eating and drinking, both in your personal approach to eating and drinking and in your professional pursuits as they relate to this important topic.

I am pleased to acknowledge the support of the following individuals:

1. For support in launching the Handbook: Morgan Ryan, Senior Editor, Behavioral Science, New York
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About the Editor

Dr. Herbert L. Meiselman is an internationally known expert in sensory and consumer research on food, food product development, and food service. He received his training in Psychology and Biology at the University of Chicago, University of Massachusetts, and Cornell University. Dr. Meiselman retired as Senior Research Scientist at Natick Laboratories where he was the highest-ranking Research Psychologist in the United States government. His accomplishments were recognized with a 2005 Award from the President of the United States. Dr. Meiselman has served in Editorial roles for *Food Quality and Preference*, *Journal of Foodservice*, and *Appetite*. His current interests include the effects of context/environment, emotion, wellness, psychographics, and meals and menus. He edited a large volume on *Emotion Measurement* in 2016 (2nd edition expected 2021) and published an edited volume on *Context: The Effects of Environment on Product Design and Evaluation* in 2019. Dr. Meiselman is the author of over 190 research papers and 6 books. Dr. Meiselman has worked in a broad range of fields related to eating and drinking: basic academic research, food product development, institutional food service design and evaluation including hospitals and military, fine dining food service, health and wellness, culinary evaluation, and an historical approach to meals. He has served as President of the Research Committee of the Institut Paul Bocuse, Lyon, France, and also served on the Research Committee for the Culinary Institute of America, Hyde Park, New York, and the food service program at Orebro

University, Sweden. Dr. Meiselman has served as Visiting Professor at Bournemouth University, UK; Reading University, UK; and Orebro University, Sweden; he is currently an Adjunct Visiting Professor at Charles Sturt University, Australia.

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Part I

Introduction and Background

1 The Origin and Evolution of Human-Centered Food Product Research

Howard R. Moskowitz and Herbert L. Meiselman

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Abstract

This chapter presents a history of human-centered product research including product design and product evaluation. The chapter begins with the world of food business in the early 1900s and moves through a variety of themes and disciplines, including the period of testing for quality, the reign of the "golden palate," the emergence of descriptive analysis, and the growth of psychophysical thinking. The chapter traces the history of this field up until the growth of modern methods beginning in the 1970s. The chapter shows the approaches, some of the early research pioneers, some of the types of results obtained, an analysis of "whys" behind the themes, and the controversies based on intellectual histories.

Historical Background: The Early Twentieth Century

If one were to look at the way products are developed today, one might think that statistics, modeling, professional expertise, and a strong intellectual heritage have been in play for decades. Most food companies, worldwide, subscribe to the now widely held belief that to design foods requires a knowledge of the consumer, a talent in the creation of tasty mixtures, and a profound understanding of trends, all together collaborating to make today's test products become tomorrow's massive successes. One cannot help but be impressed by the talents involved, whether one refer to expert panels (e.g., Caul 1957), to statistical texts (Box et al. 2005), to consultants specializing in new product design, or to trends monitoring which drive the development of new foods (Costa and Jongen 2006).

This review covers the various *Zeitgeists* (*German term literally meaning "spirit of the time"*), in the history of human-centered research, including both product design and product evaluation, beginning with the "golden palate," and moving to today, with the plethora of product offerings, the paradox of choice, the change in the nature of expertise, and recently the focus on low cost testing.

A Century Ago or Even Earlier: Before Consumers

If one wants to understand how today is so different, then one can go back a century or more, to a time when the packaged goods industry for foods was just developing (► Chap. 57, "Measuring Meaning of Food in Life" by Ruffieux in this volume also discusses this early period). The time was decades just before the turn of the century to some 10 or 15 years after World War I. Those with a penchant for photographic history are treated to the myriad photographs of the stores those days, the corner grocers, often weighing out the product, in a way that can be still seen when one goes to some stores or to farmer's markets. The shopper could buy some packaged goods, but there were few supermarkets, and even fewer, if any, elaborate food halls in the way we now know. Of course, big cities had big food markets even years ago, to entice shoppers and make the effort easy and social. The storekeeper might offer the customer a taste of the product before purchase, a delightful custom which remains today, but today's in-store tastings are now efficient affairs, with companies specializing in in-store demonstrations and tastings.

Nonetheless, in such a world product development proceeded with commercial products like Kellogg's Corn Flakes (started 1906) and Campbell Soup Company (started 1869, condensed soups 1896–1897), along with other iconic companies and brands. The world of iconic brands stretched all over Europe, from Twinings and Cadbury in the UK to Liebig in Germany and so forth. The focus was on the one product to sell, not on the paradox of choice driven by a plethora of products which occupy the shelf in a marketing war, so-called facings, each item being a different size of the basic product, a different flavor, and so forth, all designed to proclaim "Buy Me," and grab the customer's last money.

The Early Days, Product Quality, Statisticians, and Statistical Tests

Quality Control and the Rise of Subjective Testing

In the 1930s and 1940s, product design was just a gleam in the mind of some forward thinkers. The notion that one could formalize product design using subjective perceptions was new and only infrequently recognized, much less implemented. Typically, practitioners used sensory perception to determine whether two products were the same or different (e.g., two batches from the product, two samples from different suppliers). This seemingly simple task laid the groundwork for product design, not so much because difference tests guide design, but because they paved the way to use subjective measures to guide decisions about products, such as accept/reject. What began as new efforts by some bench researchers and developers to understand differences would lay the groundwork for today's product design efforts. The full flower, however, would take years, as well as the entry of many different talents, such as marketers as well as experimental psychologists, especially psychophysicists.

The individuals who were doing tests of acceptance in the late 1930s and early 1940s, worked in companies and, later, in the late 1940s, were at the Food and Container Institute of the Armed Forces operated by the US Army Quartermaster Corps in Chicago. From these professionals and others who attended the yearly conferences of the IFT (Institute of Food Technologists), one got a "picture" of sensory evaluation in the guidance of product design.

Among the biggest contributors to the development of the field of human-centered research on food products were the US Army and its laboratories, first in Chicago, Illinois, and then in Natick, Massachusetts. The Army laboratories in

Chicago and Natick are extensively reviewed by Meiselman and Schutz (2003). The Army's Quartermaster Subsistence Research and Development Laboratory in Chicago established a Food Acceptance Branch in 1944, headed by Franklin Dove. This was followed by a food acceptance conference in December 1945, probably the first food acceptance conference worldwide. Dove published a paper on food acceptability in 1947 which describes the new taste panel booths at the laboratory. In 1949, David Peryam became head of the Food Acceptance Branch. Peryam was a psychologist, marking the introduction of psychologists into the field of food acceptability. Peryam was joined by psychologists Norman Girardot, Howard Schutz, Joseph Kamen, and others. A long line of research psychologists followed Peryam leading up to the current authors of this chapter who joined the Army's laboratory in Natick in 1969.

The work of the Food Acceptance Branch in Chicago focused broadly on food-related behavior, including both acceptance testing of products and studies of food habits. For acceptance testing, the laboratory used both expert and trained panels and consumer panels, usually using a paired preference method (Dove 1947). Studies of food habits were conducted under contract by universities who studied food preferences for a list of foods, along with consumer information on preparing and serving these foods. The studies of food preference continued from the Chicago period to the Natick period.

The most well-known output of the Food Acceptance Branch in Chicago was the development of the nine-point hedonic scale. This project was started by Peryam and Girardot in 1949 (Peryam and Girardot 1952) who were joined by researchers at the University of Chicago in 1951, including L. L. Thurstone, Lyle Jones, and Darrell Bock (Jones et al. 1955). The team conducted many individual studies including testing the semantic meaning of various phrases ("like extremely," etc.), varying the number of categories, scale balance, numbers of positive and negative scale categories, and presence of a neutral category. They found an advantage for longer scales, but no advantage for a neutral point or the same number of positive and negative categories. The nine-point hedonic scale has probably been the most widely used scale of food acceptance in the world, because it is easy for consumers to use. Many people using it do not know the extensive testing that went into its development. Nevertheless, the scale has had problems because of problems with translation into other languages (ref) and because of the lack of equal intervals as should be found on in interval scale (see ► Chap. 12, "Measuring Liking for Food and Drink" by Ares and Vidal in this volume) (Fig. 1).

Both Chicago and Natick Laboratories worked on the relationship of food acceptance to food consumption. Schutz and Kamen found that 50% of the variance in choice or consumption could be accounted for by hedonic mean scores but that up to 75% could be accounted for if one looked at individual food groups rather than food items. Cees de Graaf and colleagues (de Graaf et al. 2005) found significant but moderate correlations using data from Natick field testing of rations,

Like Extremely
Like Very Much
Like Moderately
Like slightly
Neither Like nor Dislike
Dislike Slightly
Dislike Moderately
Dislike Very Much
Dislike Extremely

Nine point hedonic scale: in its pure form the 9 point hedonic scale does not have lines connecting the scale points and does not have numbers associated with each scale point.

Fig. 1 Nine-point hedonic scale

indicating that acceptance is an important factor, but not the only factor contributing to intake.

Statisticians, Difference Tests, and the Emergence of Interest in Design of Experiments (DOE)

The emergence of interest in testing differences naturally involved statisticians, who were the experts regarding inferential statistics. By the period between the late 1930s and the 1950s, the world of food design and development was becoming more professionalized. There was interest in doing the "right test." For the first few years, the focus was on inferential statistics, namely, do two or more products differ from each other? The question of the time was "is there a difference, and is the difference making the product better, or is it making the product worse?" Product designers and developers were not thinking about systematic variation of products, nor about uncovering rules. The times called for the human being simply as a tester, an "assessor," in many of the scientific papers.

Statisticians, however, were moving to modeling, in order to understand the relation between variables. A new culture was beginning to emerge, a culture of systematic variation. Statisticians realized that they could use their armory of tools to understand the relations between variables, specifically those variables under the developer's control, and other variables measured by people, namely, perception. For example, one could learn how the amounts of two ingredients, e.g., sweetener and flavoring, together drive the perception of "perceived strength of flavor" by systematically mixing different levels of sweetener with different levels of flavoring (the ingoing experimental combinations or experimental design) and instructing panelists to rate the flavor intensity as they perceived it. This systematic approach produced a body of useful knowledge for the developer, far deeper than the knowledge that would be obtained by asking why two beverages of the same type differ in their respective "strengths of perceived flavor."

The foregoing, focusing on systematic variation, and the linkage between two variables, an independent variable under control and a dependent variable that is measured, falls into the category of designed experiments, or more typically and formally DOE, Design of Experiments. The application of DOE to the design of food would come later, in the late 1940s, more in the 1950s and 1960s, and flower in the 1970s–1990s. During 1950–1965, there was a growing interest in DOE in the chemical industry, perhaps because it had financial ramifications such as increasing the yield from chemical reactions.

DOE opened the minds of professionals, allowing for more complicated experiments, and thus laid the groundwork for product design. The traditional scientific method postulated how important it was to isolate a variable and study it. The notion that one should look at mixtures, to understand the system, was occasionally thought of, but the lack of fast and easy computation made these multivariate studies more of theory to be studied than a work tool to be used. DOE would become far more important later, when computers enter the science, because DOE PLUS COMPUTERS enabled the statistician, and thus the engineer, and scientist, to study the workings of several variables at once, and even nonlinearities and interactions between variables. All these would become important in the world of food design. Names such as Cochran (1950) and Box et al. (2005) are important, as are Plackett and Burman screening designs (Vanaja and Shobha Rani 2007). These statisticians contributed to this newly emerging field of DOE, which would lead to food design some decades later. The reader is directed toward the later papers cited here, because they put the earlier work into clear focus in terms of the major contributions made in those early methods.

Describing Versus Designing: Structuralist Versus Functionalist Agendas

By Way of Introduction to this Section

Structuralism and functionalism are two early schools of experimental psychology, holding sway from the end of the nineteenth century to the early and middle part of the twentieth century (Benjamin 1988). Their use here is metaphoric. Structuralism asserted that one could “understand” the psychology of perception by understanding the attributes or aspects that people perceived. To researchers in structuralist psychology, the prescribed approach was introspection, to list the different attributes of perception, whether those be the attributes or dimensions of vision, hearing, smelling, tasting, and feeling. One could get a sense of how people organized their perceptions. In contrast, researchers in functionalist psychology asserted that a better approach was to understand how the person behaved and how different aspects or dimensions of perceptions “functioned” to guide behavior.

Structuralism seems always to precede functionalism, going back to Aristotle. Aristotle's science classified to understand how aspects of the natural world distributed themselves. Yet even for a genius such as Aristotle, knowing the aspects of the world, the different features shared or not shared by living organisms, did not tell Aristotle how these organisms functioned. One could only guess about function by knowing structure.

The same distinction between structuralism and functionalism applies to the design of foods, with the structuralist agenda of description virtually always preceding the functionalist agenda of determining relations between variables. As we see below, the world of food design was dominated in the early days by description, holding the belief that if one "knew" the different notes or perceptual characteristics of the product, one might be able to develop better products of its type, or perhaps correct some of the quality errors. In contrast, later scientists and practitioners developed the relations between ingredients/process levels and consumer acceptance, in order to drive better product design.

Contrasting Beliefs and a Detour: What Can Be Judged and by Whom

A sense of what "was" sensory analysis, and what was its focus, comes from the now historic book by Amerine et al. (1965), *Principles of Sensory Evaluation of Food*. The 602-page book was the first book in the set of monographs published by Academic Press. This book, published more than a half century ago in the mid – 1960s, emerged from years of painstaking library research as well as personal experience. The topics in the Amerine et al. book deal less with the design of foods and more to with the study of the assessors. Examples of chapter titles are Factors Influencing Sensory Measurements (Chap. 5), Laboratory Studies: Quantity-Quality Evaluation (Chap. 8), Consumer Studies (Chap. 9), Statistical Procedures (Chap. 10), and Physical and Chemical Tests Related to Sensory Properties of Foods. The Amerine et al. (1965) book helps us understand the background out of which product design emerges. If one were to trace the history of product design back to first-order questions, perhaps the first question would not be about the product itself but rather about the person who is doing the judging. The first question was "who is able to judge the product?" The question about what the product should be hardly emerges in the early days.

The detour in consumer-driven product design comes out of a continuing issue in the evaluation of food, namely, who is competent to judge the aspects of food and thus give direction to design. Some of this focus on the "expert" can be traced to the world of certain kinds of products, such as wine, beer, and perfume. These products came with a mystique, the wine expert, the *beer meister*, and the expert perfumer. There was a sense that only these experts "knew" the product. The patronizing undercurrent was that for the most part, consumers simply did not know good from bad, although of course they knew what they liked and disliked. As of this writing, 2019, the role of "experts" continues to be important, especially in the aforementioned areas of wine, beer, and perfume, where sensory properties can be romanticized in advertising, in turn increasing the value of the brand.

A Land of Plenty: The Rise of Descriptive Analysis (Structuralism) to Guide Product Design

Product design would "somewhat" change in the 1930s, as the world enjoyed the bounty of better food, through advances in food preservation and food transportation. An important step was taken by the Arthur D. Little Company, a technical consulting company in Cambridge, Massachusetts, where Stanley Cairncross and his colleagues developed a system for describing the sensory characteristics of a product (Cairncross and Sjöström 1950). The method was being worked on in the late 1930s and would become a flagship approach in the 1940s. The notion was to help product design by identifying the sensory characteristics, so-called "notes" of a product. It was assumed that the product developer would "know what to do" once the notes were identified in the Flavor Profile. Importantly, the exact linkage between this description and product development could not be specified as a series of specific operations, which converted these "notes" to formulations.

The logic of identifying "notes" or attributes, and assuming that such identification, either by experts or consumers would guide product knowledge and thus product development did not begin with the Arthur D. Little Corporation. As noted above, describing one's sensation appears to be the first step in systematic science, going back to Aristotle's classification of animals, plants, and even constitutions of city states. Then there was Francis Bacon and, in psychology, the emergence of the Structuralist School, which assumed that we would know how perception works if we could only describe the perceptions that we have. The efforts did not end there. It was assumed in wine making, beer brewing, and fragrance development that a description of one's perception would somehow lead the developers to design and develop a better product. Again, as noted above, these descriptions resided in the purview of the expert, whether the business-oriented expert (e.g., perfumer) or the trained expert.

Modern-day efforts for product design using descriptive analysis have focused on training panels, including the Texture Profile (Civille and Szczesniak 1973), the Spectrum™ method (Meilgaard et al. 1999), and Quantitative Descriptive Analysis (QDA®; Stone et al. 1974). There remains little published evidence showing the *precise* steps in the linkage between descriptive analysis and product design. Professionals in the world of sensory analysis have, for the most part, directed their use of expert panels to quality control. The experts, trained in descriptive analysis, can describe two samples, and identify the sensory aspects, the notes which make these samples different from each other. This ability to describe the nature of differences can, of course, be a hint to copy a product by incorporating the "notes," but it's more often used to identify the nature of differences between a "gold standard" product (the "ideal") and a production or storage sample.

Psychophysics (Functionalism) Moves into the Food Industry

In the early 1860s, the German polymath scientist, Gustav Theodor Fechner, hypothesized that one could measure the perceived intensity of a stimulus, doing so by measuring successive difference thresholds (Stevens 1961). That is, one could begin with a sample of salt water and find the concentration of salt water that would be just noticeably different. This magnitude of change was defined as one JND, one just noticeable difference. One could erect a "sensory scale" by cumulating these JNDs and plotting them against the physical level of a test stimulus (e.g., the salt concentration in the water).

The foregoing is an academic treatment of the foundation of psychophysics. It has little or nothing to do with product design, but successors in psychophysics would have a great deal to do with design, and with the success of products. What Fechner suggested is that one could relate the physical intensity of a stimulus (think "ingredient") to the perceived intensity.

It would be about 80 years until a more direct approach would take hold, one which would link practical product design to psychophysics. This more direct approach is called *direct scaling*. The respondent is exposed to an array of test stimuli, one stimulus at a time in irregular order, and assigns a number on an attribute scale to match the perceived magnitude of the stimulus. The attribute could be sensory, such as the saltiness of salt solutions, or hedonic, such as the liking of the salt solution, or even a more cognitively complex phrase such as "perceived healthfulness of the salt solution."

Psychophysics/scaling entered the food industry in a slow but relentless progression. The Army psychologists in Chicago, Peryam, Pilgrim, etc. worked with the scaling expert Thurstone at the University of Chicago to develop the hedonic scale and to test many variations of that scale. At the US Army Chicago laboratory, Pilgrim, Schutz, and Kamen conducted a number of studies in taste and odor psychophysics in the 1950s. They conducted research on difference thresholds for the basic tastes (Schutz and Pilgrim 1957a), as well as on the relative sweetness of a number of natural and synthetic sweeteners using suprathreshold rather than absolute threshold measurements, demonstrating the importance of suprathreshold rather than threshold measures (Schutz and Pilgrim 1957b). The first systematic study of interactions of suprathreshold taste stimuli was conducted, and it was found that in most cases the effects were those of simple enhancement or masking. A one-person olfactorium was constructed, and studies included olfactory adaptation and development of an odor classification system.

When the Chicago laboratory moved to Natick, none of the researchers moved with it, and most of them went into industry and did not publish many research papers (see Meiselman and Schutz 2003). The exception was Howard Schutz. Schutz had received his education in experimental psychology in the 1950s. Schutz was interested in statistical modeling and analysis, rather than in rigorous testing. Schutz's contribution may be to have opened the eyes of the field to the importance of consumers, perhaps because of his tenure at Hunt Wesson Corporation, where he was responsible for running a commercial sensory evaluation laboratory in the 1960s. Schutz moved to UC Davis after Hunt Wesson and spent many summers working at the Natick Laboratory – he was the only Chicago alumnus in sensory and consumer testing who worked at Natick.

Roland Harper was probably the first psychologist in Europe to work on the sensory properties of foods beginning in the 1940s, around the same time as the US Army Chicago group. Harper joined the agricultural laboratory in Shinfield from 1946 to 1950 (where author Meiselman worked in 1990–1991 along with Howard Schutz). There is evidence of Harper's communication with Thurstone in 1948, around the same time that Thurstone was working with the group of Army psychologists in Chicago (Land 1988). In 1961–1962 he spent a sabbatical year in S. S. Stevens' psychophysical laboratory at Harvard University, from which author Moskowitz graduated 8 years later in 1969.

By the late 1950s, another sensory scientist interested in food emerged in Europe, Egon (Ep) Koster in the Netherlands. He also received his degree in sensory psychology, specializing in the sense of olfaction. Later he would apply his sensory and psychology skills to working on food products. Koster contributed important papers in sensory and consumer psychology of food well into the 2000s. Both Harper and Koster were trained in psychology, while another influential early figure was trained in food science.

These later years were the same years that Rose Marie Pangborn was starting her career in the United States. She attended New Mexico University (degree 1953) and then Iowa State University (degree 1955). She began working at the University of California at Davis in 1955, where she worked for 35 years until her death in 2000. UC Davis became a powerhouse in sensory and consumer science during and after her tenure. Her early papers (maiden name Valdes, married name Pangborn) were published in 1956 and 1957.

Drewnowski (1993) reviewed the contributions of Rose Marie Pangborn at the first Pangborn Sensory Science Symposium in 1992. He noted that her work covered sensory evaluation of food and the evaluation of food preferences. Pangborn was one of the first sensory researchers who moved from model systems (sugar in water, salt in water) to real foods, using canned apricots (Valdes and Roessler 1956) and vanilla ice cream (Pangborn et al. 1957). She also studied more complex sensory stimuli, combining several sensory modalities (sweetness, viscosity, texture). Pangborn also was among the first to study individual differences in perception, applying this to product perception and to the relationship to food preference and management of body weight. This interest in individual differences also extended to determinants of food acceptance, and Pangborn included individual attitudes in her research on nutrition. Perhaps the biggest contribution of Rose Marie Pangborn was her pioneering efforts in training 30 years of undergraduate and graduate students to do testing in a logical, scientific, rigorous way and to report the data in the proper format. Pangborn produced a generation of good researchers and teachers.

A Cadre of Chemosensory Psychophysicists Enters the World of Food

The 1960s grew into a fertile period for the growth of interest of psychophysicists in the chemical senses, taste and smell, and in the lower senses, touch. The focus would first be limited to so-called model systems, a focus that would later evolve to real foods and even full meals. The impetus for this was what has been called the "new psychophysics." This new psychophysics attempted to uncover quantitative relations between the physical stimuli and subjective responses, with many of the results suggesting that the relation could be described by a power function of the form: sensory rating = k (physical intensity)^n. It was the exponent which was of interest (Stevens 1975).

Natick Laboratories was opened in 1954 as the Quartermaster Research and Development Center, and the US Army food research program moved from Chicago to Natick in 1963. The nutrition research from Chicago moved to Colorado and eventually to Natick, and the dietetic services moved to Virginia. Between 1963 and 1966, a taste test laboratory with 11 testing booths was constructed in Natick. A joint annotated bibliography on acceptance and preference research was published jointly by Chicago and Natick (Bell et al. 1965). Beginning in 1966, Harry Jacobs began a program in behavioral sciences (psychology and other human sciences) with a strong emphasis on food. Harry Jacobs hired Linda Bartoshuk from Carl Pfaffmann's sensory laboratory at Brown University. Jacobs was interested in basic animal studies of appetite regulation. Bartoshuk was interested in basic human studies of taste processes and taste perception. Shortly after that, Howard Moskowitz and Herbert Meiselman were hired. Both Moskowitz and Meiselman would eventually apply their research to actual foods, with Moskowitz interested in the relation between ingredients and perception and Meiselman interested in meals in real-world settings out of the laboratory. Over time a number of other professionals/psychologists worked at Natick including Richard Bell, Armand Cardello, Barbara Edelman-Lewis, Dianne Engell, Edward Hirsch, F. Matthew Kramer, Owen Maller, and Richard Popper. These professionals were joined by a cadre of technical support people and by a rotating group of Army psychologists assigned to Natick for a two-year period, often bringing with them valuable skills in related disciplines. The military psychologists were especially helpful in conducting large-scale studies of food products and food service with military personnel on military bases and in the field. Finally, the civilian staff and the military staff were joined by a large number of visiting scientists from laboratories all over the world.

The Natick researchers conducted basic psychophysical studies of taste, smell, and texture and their relationship to liking. They applied related methods to study food preferences, food compatibilities, and boredom as applied to menu planning. They extended the study of short-term food preferences to studying long-term preferences. They studied the relationship between data collected in the laboratory and data collected in the field from soldiers and from university students. They extended this work with research on the role of context or environment on ratings of food and beverages. This topic would become a major topic in the field decades later (see Meiselman 2019). Another new approach in sensory and consumer research was the introduction of expectation theory and methods – this topic is covered below.

In both Europe and America, the psychophysicists were just beginning to look at the relation between the physical stimulus and liking, first with model systems as science (e.g., sugar in water), but insensibly moving toward the evaluation of real foods. Their work was primarily academic, but both authors moved inexorably toward the study of actual foods. For example, fairly early in his tenure at the US Army Natick Laboratories, author Meiselman began to measure liking both in the laboratory and in the field (see Meiselman and Schutz 2003). In contrast, during the same period, author Moskowitz began to use psychophysics to study the nature of liking as well as sensory perception as they are driven by the interactions of sweeteners in cola (Moskowitz et al. 1979). In a parallel path, psychophysics was at the ground in one of the first syntheses in behavioral economics, the economics of sweetness scales (Moskowitz and Wehrly 1972). These latter psychophysics studies would remain academic for the early part of the 1980s but then evolve into larger studies, using psychophysical thinking and experimental design. Those will be covered below.

The Zeitgeists of "Disciplines": Psychophysics, Sensory Professionals, and Market Researchers

The German philosopher Hegel postulated the ever-repeating dialectic of thesis, antithesis, and synthesis. Advances in every era bring with them conflicts and then synthesis and advance in the wake of those conflicts. We turn now to the 1970s, when forces would interact with each other in ways that might now have been expected from the decades before but which would prove extraordinarily fruitful as one looks back at these conflicts. The focus of the period was "drivers of liking," or in effect, what makes a product good? We move past the era of difference testing, a worldview which remains with us in full force but generally relegated to quality assurance.

In the 1960s, a new discipline emerged, market (or marketing) research. The focus of this new discipline was the consumer and the market. Most of the efforts focused on the role of consumer responses to product advertising and to product packaging at the point of sale. Market researchers combined scientists and practitioners, with an array of learned journals, such as the *Journal of Market Research*, to memorialize some of the more important efforts of an academic nature. There was also Robert Ferber's book, *The Handbook of Marketing Research* (Ferber 1974) and the comprehensive *Handbook of Marketing Scales* (Bearden et al. 1993).

Market researchers were interested in people, specifically in the response of people to products. It was market researchers who popularized the notion that product acceptance might vary, some of the variance traceable to error inherent in measuring subjective responses, but perhaps also traceable to the fact that people simply had different preferences. Market researchers were able to recognize these differences in their "product tests," evaluations of product samples before the product would be launched, to guard against market failure (so-called disaster checks).

With the introduction of market researchers into the world of product testing, there were three different groups of professionals offering direction and "insight" on the design of products, inputs which were sorely lacking just a decade before:

1. *Sensory psychophysics*: Psychophysicists were entering the business world, choosing to work for manufacturing companies or consulting groups. Often, the psychophysicists would work in the sensory department of a company. Abandoning the traditional academic route, these business-oriented scientists often brought with them the desire to use their psychophysics to drive product creation, rather than to continue the clerical work of difference testing, to which the sensory department had evolved.
2. *Sensory professionals*: The sensory professionals remained bound to their descriptive analysis and graphical representation of the data. They seem not to have been able to show the way that descriptive analysis would drive improved product acceptance. Perhaps their main contribution was to pronounce in their presentations that the product developer would (somehow) recognize certain departures from the standard for current quality control or recognize new notes in products that were to be copied, used as springboards for the company's new and competitive entry.
3. *Market and consumer research*: The discipline of marketing research was growing. The focus, limited as it was on whether a product passed a specific level for acceptance or was better than a comparison product, necessarily had to look at differences among respondents, the individuals who participated in the market research studies. Whereas psychophysicists and sensory professionals focus at the product itself, marketing researchers focused on the consumer and the resulting pattern of acceptance, recognizing that people differed. They did not, however, have the necessary tools to understand what drives liking beyond the so-called cross-tabulation methods, comprising tables of product scores by subgroups of respondents (e.g., frequent vs infrequent users, older vs younger, brand-loyalists vs non-loyalists, and so forth). As part of the contribution of market and consumer research, there would spring up a new form of understanding consumers, so-called psychographic segmentation (Wells 1975). The focus would be on the psychology of the consumer, specifically what type attitudes were possessed by different segments of consumers and what types of behaviors were exhibited. Food was no longer simply the ingredients and taste, but rather the "right message to the right person" and "the right product to the right person."

Zeitgeists of Method in the 1960s, 1970s, and 1980s

The three groups of players in the design of product used different tools. We will look at the research tools and then discuss the underlying rationale of each tool, the role of the relevant group, and finally how each tool helped move forward the capabilities of food design.

Single Test Stimulus and Analysis: Cross Tabulations

The term “cross tabulation” refers to the evaluation of one product (or perhaps two), deconstructed into the ratings by different groups or different test conditions. As strange as that might sound today, as of this writing (2019), when cross tabulations were done for product tests, mainly by market researchers, there was a sense that the “answers were in there, in the cross-tabs.” A good analogy today is “Big Data.” There is no reason to assume that the analysis will produce an answer telling the product design what to do to create a better product, but it is satisfying to the researcher to show an “effect,” e.g., that more frequent users prefer the less sweet product.

Single Test Stimulus: Just About Right (JAR) Scales

The JAR or just about right scale is widely used today to identify what to change. The JAR scale asks the respondent to judge whether a product has too little of an attribute (e.g., sweetness), just the right amount, or too much.

Although there have been many developments using the JAR scale, such as penalty analysis (Narayanan et al. 2014), the origin of the JAR scale as used today may have its origins in a discussion about applying psychophysics to business issues in product design. During the September 1968 meeting with Loren B. Sjostrom and Anne Nielsen of Arthur D. Little, Inc., author Moskowitz suggested that the Flavor Profile could be improved by using psychophysical scales to identify how to change a product. The researcher would instruct the respondent to rate the amount of a sensory attribute and the degree of change to make a better product. The psychophysical scale would then show the sensory level and in turn the physical level to optimize acceptance, in the opinion of the respondent. Four years after that first 1968 meeting, the approach was codified in a peer reviewed paper in the *Journal of Applied Psychology* (Moskowitz 1972), demonstrating the practicality of the approach with Kool-Aid, tuna fish spread, and hamburgers of different grinds, respectively.

The JAR scale was and remains attractive. It was easy to apply, to analyze, and to report to product developers who could understand what the scale meant. What was not so clear was what exactly to do with the results when the data fail to be accompanied by a functional relation between “sensory amount” and “physical level,” i.e., when the psychophysical curve was absent. For example, when the respondents said much too sweet, just what did that mean? And what should one do when people disagree? And what about certain attributes for which one never has enough, such as “natural flavor?” In commercial applications for manufacturers conducted as far back as the 1980s, author Moskowitz discovered that for some attributes such as “real chocolate flavor,” the more chocolate one added to the product, the more bitter the product tasted, and the less natural the product tasted. The same type of finding emerged for flavor. Real flavor did not come from the flavoring but from the “sugar.” It required product development expertise to understand just exactly what the JAR data required in terms of subsequent product design.

Single or Multiple Test Stimuli: The Self-Designed Ideal

Once we admit of the ability of consumers to point to changes in a product, e.g., by the JAR scale, it is not far afield to instruct consumers to describe their ideal product, using the same attributes and the same scale as they used to describe products. One can then compare the magnitude of the ideal product (emerging from the mind of the consumer) to the scores of actual products, tested by these same consumer respondents, at the same time. The products which score closest to the self-designed ideal are presumed to represent target products.

The JAR Scale, the Self-Designed Ideal, and Efforts to Validate Them

The JAR scale and the self-designed ideal instruct consumers to rate products and conceptualize how they would change the product. When it comes to validating the results, how does one then validate the JAR scale and the self-designed ideals, respectively, either analytically or in subsequent direct tests.

Some published literature, primarily in the academic world rather than in the corporate world, has focused on the ability of the JAR scale and the self-designed ideal to guide successful product design. We thus rely on the literature, which presents studies that can be described primarily as methodological. The published studies suggest that the JAR scale and the self-designed ideal do point, albeit in a general way, to a better product (Li et al. 2014).

Finding actual corporate case studies in the literature is difficult to do, but one industry-facing organization, ASTM, the American Society for Testing and Materials (Committee E-18 on Sensory Analysis), has created recommended practices for the JAR scale. That such attention is paid to the topic of standardizing the JAR scale attests to its practical use and importance for product design. The JAR scale is used to guide product redesign, with the directional referring to changes in the sensory attributes of the product being tested. In contrast, there seems to be no clear literature about the practical, industrial use of the self-designed ideal to guide product design, even though the approach has been around for more than 46 years (Drewnowski and Moskowitz 1985; Moskowitz 1972).

Let us assume that we can, in some way, predict the liking of the product which is perfect on the JAR scale, or which "delivers" the sensory profile of the self-designed ideal. Are there data showing that this product expected to perform in an optimal way, if we were able to estimate the liking of this product? Keep in mind that the JAR scale and the self-designed ideal work only with sensory attributes, and do not involve the key evaluative criteria of overall liking, or likelihood to purchase. In a study of pizza, with all ingredients disguised to maintain corporate confidentiality, Moskowitz demonstrated through modeling that one could create a set of equations relating formula variables to liking, to sensory attribute levels, and to JAR scales. Using the model, it was possible to set the JAR scale values all to 0 (no change required) or to set the sensory attributes to the level defined by the self-designed ideal. The results suggested that the products emerging from this exercise were not optimally acceptable, i.e., the formulations expected to generate JAR scale values of 0 (just about right), or to generate the self-designed ideal (Moskowitz 2001).

It may be that the JAR scale and self-designed ideal work for attributes which are not inherently hedonic, such as appearance, texture, and flavor attributes. For those nonjudgmental attributes, respondents have a sense of what they want. For many other attributes, such as salty, fatty, and so forth, the JAR scale and the ideal levels must be interpreted with a note of caution because the respondent often either never gets enough (natural flavor) or always has too much (e.g., fatty for a health-oriented food). Table 1 (section A) shows the results of a commercially funded study with

Table 1 Data from a 1993 commercially funded study on consumer responses to 11 prototypes of frankfurters, prior to the selection of one product to "go to market." No prototype ever scores sufficiently "meaty," whether in terms of the JAR scale or in terms of the self-designed ideal

A – Average JAR (just about right) scale results for 11 frankfurter prototypes					
	JAR	JAR	JAR	JAR	JAR
Code	Dark	Smoky	Meaty	Salty	Greasy
101	6	−1	−8	2	−1
102	7	−4	−10	1	−3
103	−17	−8	−16	2	−1
104	−10	−11	−16	2	1
105	−21	−16	−14	5	−2
106	1	−8	−11	4	5
107	31	−16	−13	−5	2
108	−4	−7	−10	−2	−4
109	−20	−13	−20	−7	−5
110	−29	−14	−17	−4	−1
111	−4	−8	−21	9	1

B – Minimum, Self-Designed Ideal, and Maximum for 11 frankfurter prototypes on nine 'sensory' attributes			
	Min	Ideal	Max
Dark	19	45	67
Long	26	67	74
Processed App	57	30	69
Aroma	41	46	54
Smoke Flavor	31	36	51
Meaty	34	76	55
Salty	30	25	51
Aftertaste	40	32	61
Firm	29	46	60
Juicy	42	57	60
Greasy	21	13	34

"frankfurters," wherein the respondent rated the sensory intensity of attributes, the sensory ideal of the attribute, and the JAR scale for the attribute. We show the results for the 11 products. The important thing to note is that none of the 11 test samples ever scored high enough on the attribute of "meaty." Of course, it might well be that these frankfurter prototypes were simply not sufficiently "meaty," but we find similar types of failure to deliver on other attributes which are "hedonics in disguise," such as "real chocolate flavor, etc."

When we move to the self-designed ideal (Table 1, section B), we see the same type of problem emerging. One attribute, meaty, shows a self-designed idea outside the range of the levels achieved by the 11 prototypes. Again, the problem emerges, namely, "what should the developer do with these results?"

Multiple Test Stimuli: Mapping

Placing points on a geometrical space appeals to researchers. Whether the points define some type of function or the points define the location of an item in space, there is the perennial desire of a research to display data visually. Quite often, such displays reveal patterns that would be otherwise undetected. Mapping began with statisticians, who suggested that factor analysis, which reduces the dimensionality of a set of variables to a simpler set of orthogonal primaries, could be even more valuable when one plotted the stimuli as points in this orthogonal space, as Fig. 2 shows. The size of the letter is proportional to overall liking (LTOT).

When used for product design, maps reveal open areas, opportunities for new products. In today's business parlance (2019), the term is "white space." Author Moskowitz developed methods by which to identify the sensory profile of the products to be fit into this whole, using a method called "sensory-based engineering." The approach used the coordinates of the map as independent variables and each of the sensory attributes and the rating of liking as separate dependent variables. The optimization routine identifies the coordinates in the factor space corresponding to the "best product" and then estimates the likely sensory profile of that best product (Moskowitz 1994).

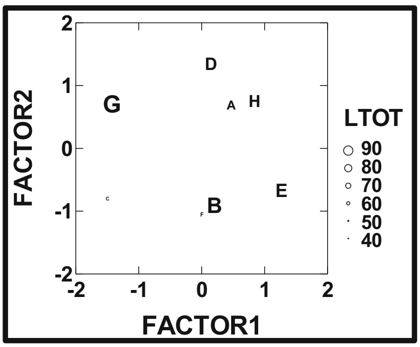

Fig. 2 Example of a map, showing the location of products as letters, with the size of the letter proportion to product acceptance (LTOT = overall liking)

Multiple Test Stimuli: Response-Response Analysis

Regression analysis occupies the honorable position of being perhaps *the* statistical method to uncover so-called drivers of liking. The original use of regression analysis by statisticians involved the analysis of large data sets in order to identify which of the measured factors covary with a key evaluative criterion.

Focusing on food, the application translates into the simple problem of which of a variety of ingredients drives liking or which of a set of sensory attributes drive liking, respectively. The researcher assembles a set of products, either variants of each other in terms of ingredients/processes or of the same general type. The researcher instructs the panelists (consumers, experts) to rate the products on a set of scales (e.g., sensory perception of color, aroma, taste, mouthfeel) and instructs the consumers to rate the products on an evaluative criterion, e.g., "liking" or "purchase intent." The latter evaluative ratings are obtained either from the same panelists providing the sensory ratings or from other panelists representing the ultimate consumer.

When the researcher works with a single set of products, whether or not these products are systematically related to each other by an underlying design, it is straightforward to plot the relation between acceptance (e.g., overall liking) on the ordinate and sensory attribute level on the abscissa. Figure 3 shows the results for the study of the frankfurters, from personal data collected by author Moskowitz in 1993.

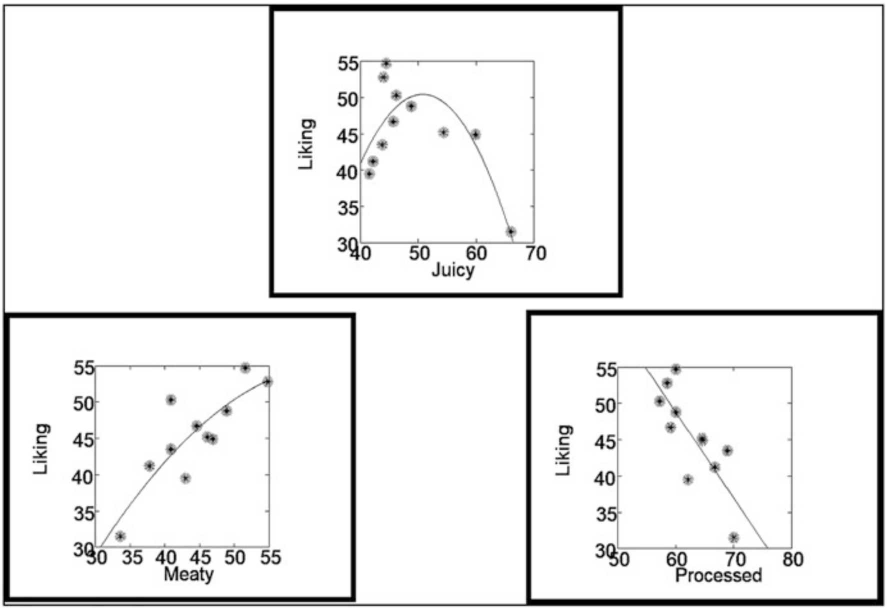

Fig. 3 The scatterplot relation between sensory attribute level and overall liking for the 11 frankfurters introduced in the previous sections. The filled star/circles correspond to the 11 samples. The statistical program (Systat) fits a quadratic function to the scatterplot

The abovementioned approach is called R-R analysis, or response-response analysis. We look for relations between two variables, neither of which is systematically varied. Rather, both variables emerge from the evaluation of the same 11 meat samples. We cannot discover "causality" but simply get a sense of which attribute covaries with liking.

Systematics: Creating and Using Psychophysical Curves

The new psychophysics has had a direct impact on the world of product design, perhaps one that was anticipated. Over the earlier decades of the twentieth century, researchers began to explore the use of people as "measuring instruments." For food, this systematized effort began in earnest with ratings of liking of different products, with such ratings being analyzed for differences (Peryam and Pilgrim 1957). Some researchers realized, however, that they had a tool by which to understand how ingredients drove responses, whether the response is the perceived sensory intensity of the food or beverage (e.g., the sweetness of cola) or the degree of liking. Psychophysicists, specializing in the study of the relations between sensory magnitude and physical intensity, soon began to contribute to this effort, especially with simple systems, such as colas and some foods (Moskowitz et al. 1979). What is important to keep in mind is that these curves provided foundational knowledge. It was quickly discovered that the same percent change in ingredients could very well produce radically different perceived changes. Doubling the concentration of a flavor ingredient, for example, was seen to be less effective than doubling the concentration of sugar for the same food. We will elaborate this type of thinking below, when we deal with stimulus-response analysis and response surface designs.

Stimulus-Response Analysis

Product design becomes far more powerful when we move from testing one product or several unrelated products to a set of prototypes that are systematically varied. The original thinking comes from both statisticians who promoted the idea of DOE (design of experiments) and from psychophysicists who promoted the idea of uncovering lawful relations between physical stimuli and subjective responses.

Beyond the design of experiments, the creation of the systematically varied prototypes lies on an entire body of statistics known as regression analysis or curve fitting. With regression analysis, one discovers how a physical ingredient or set of ingredients drives a response, the most important response being overall liking. Furthermore, with nonlinear regression analysis, it becomes easier to uncover optimal or most highly liked product formulations within the range of prototypes tested, but a formulation not necessarily one of the prototypes created.

Figure 4 shows a schematic example of the approach. The regression modeling typically creates either a linear plot, described by the equation and shown as

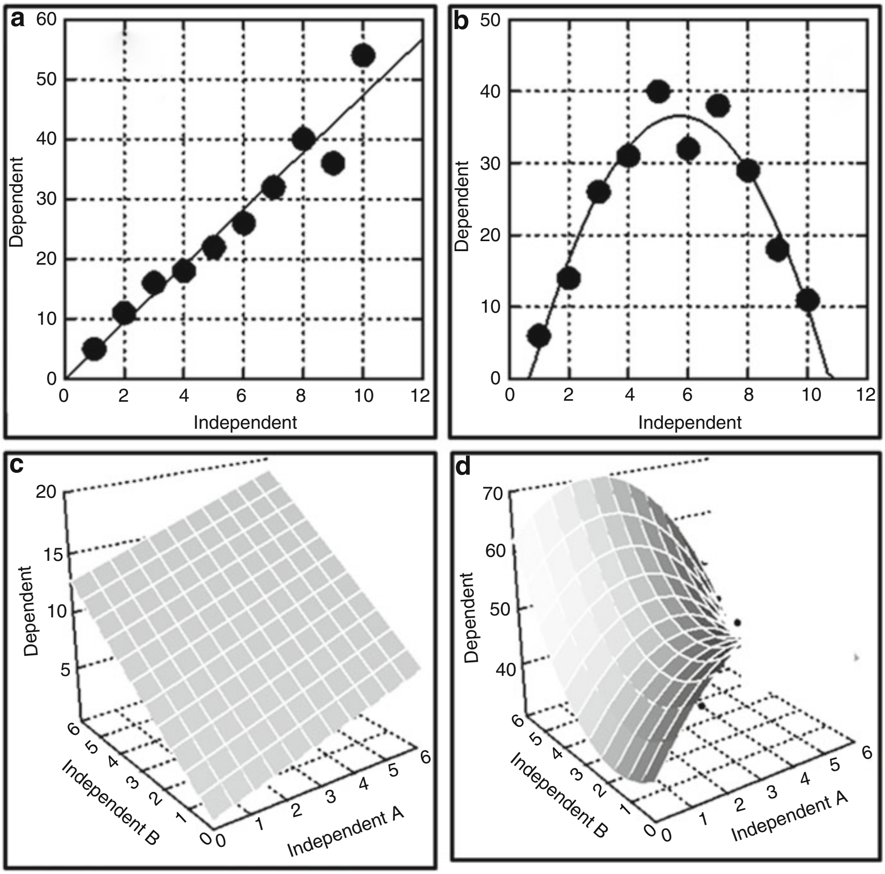

Fig. 4 Schematic example of scatterplots showing the relation between a dependent variable (ordinate) and either one independent variable (panels A and B) or two independent variables (panels C and D). The plots represent the type of relations one might observe when the dependent variable (ordinate) continues to increase linearly with increases in the independent variable (panel A, panel C) or when the dependent maximizes at some intermediate point of one or both independent variables (panel B, panel D)

examples (left panels) or described by a quadratic equation, in Fig. 4 (right panels). The plot can either reflect a one-ingredient system (Panel A, Panel B) or a two-or-more ingredient system (Panel C, Panel D). We present a visual only of the two-ingredient system, but the mathematical modeling can accommodate many more independent variables, even when we cannot easily visualize the model.

Regression modeling plays an important role in product design for at least two reasons.

1. Regression provides insights into what might be important, giving specific, testable direction for product design. The developer creates a quantitative

structure to discover what operationally varied factor might be important, rapidly providing insights that could not be obtained were the effort to be focused on one product.

2. The second, perhaps more important, is that regression analysis forces the necessary shift from focusing on one product to focusing on many products. One soon realizes the futility of efforts to understand the drivers of liking by relating the rating of liking for one product to the rating of sensory attributes for the same product, using as inputs, both the sensory and the liking ratings assigned to a single product by many respondents. The reliance on one product alone produces a fallacious approach, confusing the "noise or variability-based" information in the variation of responses to one product with the "signal-based" information from the variation of responses to many products. As the intellectual development of the field proceeded, this change in focus, from the study of variability to the study of patterns, would inevitably lead to more powerful tools.

Expectations

Another methodological breakthrough in the development of consumer methodology for food and drinks was the application of expectation theory and expectation methods. Perhaps the lead researcher in this area has been Armand Cardello from the US Army Natick Laboratories. Cardello (2007) lays out the history of expectation theory and research. Like some other methods in this chapter, expectation theory and methods developed within psychology in the earlier part of the twentieth century. Broadly speaking, expectations refer to the anticipation that something will occur; when applied to foods and drinks, expectations refer to the anticipation that a product will contain an attribute or result in a consequence. Early discussion of expectations focused in its role in human behavior, especially motivation and cognition. Expectation was applied to consumer research in the 1970s in the context of models of consumer satisfaction and service quality. This satisfaction work led Cardello and colleagues to apply the expectation model to product satisfaction (Cardello et al. 1985; Cardello and Sawyer 1992).

Expectation research uses the model of confirmation/disconfirmation in which a person's expectations are either met (confirmation) or not met (disconfirmation), resulting in a product producing satisfaction or rejection. Research has shown that the acceptance rating of a product often moves in the direction of its expectation, referred to as assimilation. If you expect a product to be good, you will rate it higher than if you expected a lesser rating. This is important for product design, product advertising, and product success, because final acceptance by the consumer is due to the actual product attributes but also to the expectation of those attributes. Product liking is due to more than the physical make-up of the product, as noted above. In addition to the assimilation model of expectations, there are also other models including (1) generalized negativity, (2) contrast, and (3) assimilation-contrast. The contrast model is one that is observed when a product falls much below its expectation, leading to rejection. Setting product expectations too high can lead to product rejection.

Conclusions

As we reach the end of this history, and this writing (2019), we are approaching the greater part of a century since the first efforts at applying knowledge about the human senses have been applied in a significant way to the development of foods. What then have we learned in the past century? What has really transpired, and how have we developed? There are some key trends that we should note.

1. *Descriptive analysis*: Research revealed that for easily understood attributes, the ability of consumers to detect and report the magnitude of changes was equivalent to that of experts, at least for sensory attributes that were obvious, and did not need explanation to be recognized before being evaluated in an experiment (Moskowitz 1997; Ares and Varela 2017). Research has shown that it's not all about experts, with consumers relegated to relatively blunt instruments whose only ability was to respond with "like, neutral, or like." Rather, one should look at experts as trained to recognize notes and to describe whether this description is relevant to product design or simply limited to quality control. It is important, to note, however, that consumers, even untrained consumers, can do a reasonably "good job" evaluating sensory attributes that are easy to understand and with which they have had everyday experience. However, some commercial research heavily depends on trained panels for quality control and other functions.
   In a broader sense, trained panel work has not delivered what people thought it would deliver. There was a sense, perhaps not well stated, that if we understand the sensory properties of the food, we could formulate newer and better products. Unfortunately, the promise of descriptive was never fulfilled in an operationally defined way. That is, there seems to be no simple relation between how a product is described and what the product developer must do to change the product.
2. *Product testing*: Testing products has survived and flourished. Today, more than ever, corporations depend upon the scores in so-called product tests to move forward with a prototype toward market, to modify the prototype, or sometimes to just "kill" the project. Testing, in fact, of all the contributions from human research, has been the most absolutely robust, perhaps because it is structured and well-choreographed, admits to "best practices," and can be supported by numbers, by statistics. All three of these reasons make it easy to adopt testing as a standard procedure in corporate work.
   But a number of things have changed in product testing. The product evaluations are typically done with "target consumers," i.e., with consumers who are representative consumers of the products. They are less frequently done with

convenience panels, i.e., panelists who are company employees and available for testing. For larger companies, product testing is often done in multiple countries, without the assumption that one test in one country guaranties global success. What remains to be done is to better design these cross-cultural tests, which remain a challenge, as discussed at a Pangborn Sensory Science Symposium (Goldman 2006). Another change in product testing is the growth of the field of sensometrics, with much more advanced statistical designs for data collection and analysis. A final change is the growing appreciation of the context in which product tests are conducted, with a growing use of home testing and non-laboratory testing. Of great interest here is the growth of virtual reality as an alternative to changing actual testing locations (Meiselman 2019).

3. *Experimental design*: Experimental design of products has had its ups and downs, due in great measure both to the benefits it provides and to the effort and cost it demands. Experimental design forces the developer to create products, an effort often resisted because it requires time, investment, and effort, all three in a world which seeks success using faster and less expensive methods. Those are the downsides, which stop experimental design in its tracks and limit its true value. We can expect more experimental design work, however, when the methods become less expensive, faster, and obvious, rather than seeming esoteric and unapproachable.
4. *Expanding the field – sensory becomes sensory and consumer*: In the early 1970s, the Institute of Food Technologists formed the Sensory Evaluation Division (SED). At that time, the world of human food research as we think of it comprised the so-called sensory researchers in laboratories. There were some researchers such as author Meiselman who campaigned for the broader study of food habits (Meiselman 1992), but the majority of research facilities and research focus remained steadfastly on what we today would call sensory issues, with foods as the primary focus and the person as a secondary, convenient instrument on par with instruments but of course an instrument which "evaluated" as well (good versus bad, etc.). Over the decades, however, the world of human food research expanded its borders, incorporating market researchers and anthropologists. The IFT later changed its name to the Sensory and Consumer Sciences Division to recognize the importance of consumers.
5. *Data analysis*: The advent of the computer has brought with it many methods. It is hard to know which methods have lasting impact. There are those which appear at one or another conference, and have "staying power" such as temporal dominance as a research tool or conjoint measurement for messages as research and as a development tool. There are also methods that are accepted, but their utility is less clear, such as mean drop analysis, a method of cross tabulation of one product to find out what are the important attributes. We can be reasonably assured that the continually increasing group of young, sophisticated, and motivated researchers will continue to introduce new data analytic methods at today's pace and no doubt increase the pace in the future.

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Part II

The History of Eating and Drinking

A Swift Overview of Eating and Drinking Since Antiquity

2

Paul Erdkamp, Wouter Ryckbosch, and Peter Scholliers

Contents

Abstract

This chapter offers a very broad survey of the transformation of diet in past 2500 years. Such an ambitious venture tends to highlight spectacular changes, such as the so-called Columbian exchange of the late sixteenth century. These changes undoubtedly altered the diet radically, but many other, small and less striking developments also played their parts in the long run. This survey focuses on the history of eating and drinking, primarily but not exclusively in the West, and *not* on the history of agriculture, commerce, retailing, or cooking. It emphasizes the quantity and diversity of food, its consumption, food policies, and health implications. Inevitably, all big and small changes in the food chain are reflected in the history of eating and drinking.

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Dietary transformations · World history · Long-term food history · Nutritional transition

Introduction

Writing a survey of about 2500 years of eating and drinking throughout the world cannot but be unsatisfactory and incomplete. Authors or editors who have ventured to do this used hundreds of pages or several volumes, unless they considered one specific foodstuff. All of these studies emphasize the crucial role of food in great transformations such as urbanization or migration, as well as in everyday processes such as identity construction or social differentiation. By asserting a central role of eating and drinking in social relations, economics, policy, language, medicine, gender, fears and dreams, or any other domain, this survey aims to do no less.

Rather than proposing a chronological ordering, a thematic structure is chosen with topics that have recently attracted great interest in historical studies. This yielded eight chapters. The daily diet is connected to malnutrition and health, which links up with dietary insights and advice; the latter connects to food beliefs, policies, and rituals; all is situated within the exchanges of ideas, people, and products. Geographically, this survey at first concentrates on Ancient Greece and Rome, as the world of classical antiquity shows that developments did not take a linear course, and at the same time often offered the origin and inspiration of later ideas. Our survey takes a more global view from the late Middle Ages onwards. Because the emphasis is on eating and drinking, this essay only marginally addresses the history of agriculture, retailing, or cooking. Some aspects are, inevitably, also largely ignored, such as time spent on eating or its material culture.

Daily Diets

For long, the basic foodstuffs consisted of vegetables that provided the necessary carbohydrates. Grain continued to be the staple source of life across Europe, rice performed a similar role in East Asia, and maize allowed for the Inca, Maya, and Aztec civilizations to prosper. The importance of complimentary foodstuffs – dairy products, fish, meat, and legumes – varied according to place and time, but the tyranny of the starchy crops was most prominent when necessity forced people to choose for the cheapest sources of energy (Braudel 1992). Caloric intake was near the subsistence limit for most people living before the industrial era, averaging approximately 2,400 kcal per adult per day (Pomeranz 2005). Nevertheless, huge chronological, geographic, and social variations existed.

The diet in Classical Antiquity it is often observed was dominated by the so-called Mediterranean triad consisting of cereals, olive oil, and wine. Although not entirely untrue, this view needs nuance and clarification (Garnsey 1999; Wilkins and Hill 2006; Wilkins and Nadeau 2015). First, there was no common diet in Antiquity, as it varied according to geographical, rural/urban, and socioeconomic background. Moreover, the general term "cereals" encompasses a wide variety of crops, including various species of wheat and barley, each with different properties and eaten in different forms. On the Greek mainland and islands, species of barley remained important, as they were better suited to the dry climate, while the Romans preferred wheat. There is a general trend over time from hulled wheats (such as emmer wheat) to naked wheats, in particular hard wheat, which were easier to process and transport, and therefore better suited to provisioning the cities (Heinrich and Hansen 2018a, b).

Literary sources show a clear cultural preference for consumption in the form of leavened bread, made out of hard wheat, although other forms of (un)leavened bread were eaten too. Cereals were also eaten in the form of porridge. Various kinds of cereals offered the largest part of calories, mostly so in cities, as the people in the countryside had access to a wider variety of foodstuffs. Yet, consumption of pulses, such as lentils, chickpeas, and faba beans, should not be underestimated. Cereals and pulses were often eaten in combination. Olive oil was a staple in Mediterranean lands, while lard or butter took its role in Central and Western Europe. Wine mixed with water was common, but the poor generally drank sour wine (*posca*) mixed with water, or the last dregs of pressed grapes. In the countryside, the milk of cows or goats was drunk, but cheese was a more common way of consuming milk (Broekaert 2018).

Rich Greeks and Romans basically ate the same foodstuffs, but in more luxurious forms – white bread rather than porridge – and in different proportions, with more meat, sea-fish, richer wine, and fruits. Poor people, in particular in the countryside, often had to rely on food that well-to-do Romans saw as fodder, such as barley and other "inferior" cereals, while some country-dwellers had to make do with acorns and chestnuts during part of the year.

Not only the number of calories matters, but also the variety of caloric sources. Pulses and legumes were a vital source of proteins, which was all the more important as the consumption of animal proteins was probably limited for most people, not only in Antiquity, but also in later centuries. In the Greek world, many people probably consumed meat of cattle, pigs, or sheep mainly in a sacrificial context (Ekroth 2007). In Roman times, access to meat seems to have increased (MacKinnon 2004, 2018; Chandezon 2015). Fish was consumed fresh, salted, or otherwise processed for long-term storage (such as the famous fish-sauce *garum*), but consumption of seafood was limited away from the sea-coast (Mylona 2015; Marzano 2018).

The extent to which Europeans in medieval and early modern times were more carnivorous than Asians, Africans, or Americans has been an important topic of debate among historians (Braudel 1992). When European travelers, diplomats, or merchants in the seventeenth and eighteenth centuries wrote about the diet of the Chinese, Turks, or Japanese, they often remarked how rarely meat was eaten, although later estimates have placed the aggregate protein consumption in the seventeenth century in China on par with that in England (Pomeranz 2005). Perhaps differences were clearer in earlier times, since it is commonly held that in the two centuries following the Black Death (ca. 1348), meat consumption in Europe was more common than it had been before or would be again until modern times (Abel 1937; Teuteberg 1986). The idea was that the decline in population numbers and the redistribution of resources and economic bargaining power following the demographic crisis of the Black Death allowed for a richer diet for the remaining population. More recent research has called into question this straightforward relation between meat consumption and demography, and in particular the rise of meat consumption in the post-Plague period (Thoen and Soens 2010). However, it is clear that after 1550, when the population began to exceed pre-Plague levels again, regularly eating meat became a prerogative of the rich, or at least confined to a more limited number of days per week or per year. Declining numbers of butchers, decreasing revenues from excises on slaughtered animals, and the dwindling share of meat in hospital budgets all suggest that the carnivorous consumption of Europeans had finally reached the lowest point of its long decline since the Middle Ages.

Everywhere across the world before the eighteenth century, most of the food and drink was locally produced. Cities procured their food provisions as much as possible from their immediate surroundings (a distance of some 25 kms), and the local prevalence of meat, fish, and specific vegetables largely determined the daily diet of consumers. Transport costs and the hazards of long-distance trade loomed too large to allow for most – but not all – bulk consumables to be transported. However, exceptions existed, and these became more prevalent over time. Some densely populated places did import their basic necessities from much further away. Imperial Rome depended on grain from Egypt and modern Tunisia, while Constantinople, capital of the Byzantine Empire, received grain from the lands surrounding the Black Sea and the Aegean. Florence relied on Sicilian grain since at least the thirteenth century, regions such as Picardy exported large quantities of grain to Paris and Flanders since the late middle ages, and in early modern times the urban population of Holland relied on the regular shipping of grain from the Baltic Sea (Braudel 1992).

However significant such reliance on trade trade, these quantities and regions were exceptional, as the vast majority of food and drink was consumed in the immediate vicinity of where it was produced. This reliance on local produce does not imply that monotony was the rule. Even for those who could not rely on the import of foodstuffs from farther away, there was often a great variety of food types available in medieval and early modern times. Forests, rivers, and wild places abounded with wild birds, fish, mushrooms, herbs, berries, roots, nuts, fruits, and edible plants that either disappeared over time or were in later times no longer deemed sufficiently edible (Albala 2003).

By the late eighteenth century and worldwide, the so-called industrial revolution had affected the daily life of ten-thousands of people in a negative way: many men and women lost their job, called upon charity, moved to overcrowded towns and became fully market-dependent. Only few people gained from the process of industrialization thanks to high returns or well-paid jobs in new trades. As a consequence, social and spatial inequality grew, with direct effects on the daily diet. It took several decades before the majority of the people, aided by rising purchasing power, benefited from improvements in agriculture, transport, manufacturing and distribution, which coincided with big geographical disparities.

Data of the *Food and Agricultural Organization*, starting in 1961, allow to assess the nutritional transition in the world since 1800 by adding estimates on caloric intake per head in the nineteenth and first half of the twentieth centuries (FAOSTAT 2018; Allen et al. 2005). Around 1800, parts of Asia, Europe, and North America had a similar supply of about 2,300 kcal per head per day, but different protein intake due to higher consumption of meat and dairy products in Europe and North America. Other parts of the world had much less food available. The average caloric supply in Western Europe rose slowly until the late 1850s, albeit with huge fluctuations and geographical variations, to grow almost linearly up to the 1910s (3,200 kcal), which, for the first time in history, assured food security for most of the West-Europeans. Then, calorie supply declined until the 1960s (3,050 kcal), to increase again since then (3,350 kcal).

In general, most parts of the globe lagged behind this West-European pattern to various degrees. Changes of the human height (in which food plays a crucial role, next to diseases, hygiene and preadult labor) allow us to assess nutritional standards in the past. The average stature of men in northern Europe gradually declined from the late middle ages until the early nineteenth century, when it started to grow irregularly (Baten and Blum 2014; Steckel 2005). In Latin and North America, height stagnated in the nineteenth century and grew afterwards, especially in Canada and the United States; in Asia it dropped until 1880 and, again, in 1910 to only increase after 1950; height fluctuated heavily in Sub-Saharan Africa in the nineteenth century, to stagnate in the twentieth century; finally, height oscillated in North Africa and the Middle East until the 1910s, to increase from then onwards. After 1960, the world's average caloric supply grew to 2,880 kcal per head per day (in 1961: 2,200). This caloric intake fulfills energetic needs and brings about a fast-growing group of people with overweight in many countries. Yet, health concerns gradually influence the wealthier people's food consumption in well-off countries, who lower their consumption of, for example, sugar and alcohol.

As mentioned above, up to the 1900s most people ate and drank what was locally produced. Only small, elite groups regularly consumed food and drinks that came from remote shores, for example, cocoa, wine, or spices. Yet, radical changes occurred with the coming of new foodstuffs that, gradually, were locally grown (see below, the Columbian exchange). For instance, the diffusion of potatoes in Europe or of cassava in Africa and South-East Asia transformed the staple food in the first half of the nineteenth century. However, as the international trade intensified after 1850 (among other things, caused by expanding colonialism), the daily diet transformed once and for all. Worldwide, a pattern has developed in which the rising purchasing power of the masses determined the pace of changes. At first, more of the staple food is consumed, then, little by little, more expensive food (meat, fats, sugar, dairy products) drives back the importance of staple foods, and finally, a diverse diet emerges with a high share of animal foodstuffs (Grigg 1999). This global process involves the expanding consumption of manufactured food, the lengthening of the food chain, the fading away of seasonal foods, the appearance of "food niches" (aimed at particular groups such as youngsters, sportsmen or young mothers), and the idea of food security and of individual choice regarding eating and drinking (Scholliers 2007). This transformation can be summarized by the concept of nutritional transition, or the move from almost constant undernourishment to enough and even too much food (Popkin 2011).

From Malnutrition to Obesity

The cereal-dominated diet of the premodern world has often been regarded as poor in nutrients, but this is a misconception that takes insufficiently into account that other elements of the diet (though often contributing little in calories) offered various nutrients (Heinrich and Hansen 2018a). While two decades ago it was generally assumed that dietary deficiencies were widespread among the population of ancient Greece and Rome (Garnsey 1999), recent studies are less pessimistic about health and living standards (Waldron 2006; Killgrove 2018). Medical literature indicates the presence of diseases, like scurvy, that are the result of an unbalanced diet, but does not indicate how many individuals were affected. Osteological analysis of skeletons offers insight into the health of individuals. Porotic hyperostosis, for example, a condition that leads to porous bone tissue in the cranial vault, has been interpreted as an indicator of widespread iron deficiency, but was in most cases probably caused by red blood cell shortage, parasites or lead poisoning. Recent studies find relatively few indications that individuals had suffered from chronic dietary deficiencies. On average, yet, people in Roman times were shorter compared to earlier and later periods. However, this is largely the result of the lesser intake of animal proteins, as the skeletons were predominantly taken from urban graveyards. Most osteological studies do not point to a clear difference between men and women, although, in view of male dominance within the households, it is reasonable to assume that under stressed circumstances, women and children were more vulnerable than adult men.

Chronic under- and malnutrition were common experiences in the medieval and early modern world as well – but again this should not be generalized. The spread of diseases related to overly monotonous diets also points to the role of malnutrition – especially in the centuries leading up to the industrial revolution. *Scurvy*, caused by lack of vitamin C, is well known for its prevalence among sea-farers. More common was *pellagra*, also caused by vitamin deficiency, which was widespread in eighteenth-century Italy as a result of an overreliance on maize (the daily diet of the poor). In Asia it was *beriberi* that was caused by poor diets with a lack of variety and vitamin content. Health implications, caused by deficient nutrition, endured in the nineteenth and twentieth century, but diminished unevenly and gradually according to dietary improvements in specific parts of the world. The nutritional transition initiated different health issues.

Overweight people have always existed, but they constituted a small minority in most parts of the world during most of the time. In Europe and the United States, corpulent men and women often were a sign of well-being, but very obese men and women were a curiosity at fairs (Oddy et al. 2009). Only after the transition from insufficient to rich diets, fat people were perceived as an issue. In the United States, a "creeping" obesity crisis occurred. It appeared in the 1910s, when health concerns about overweight people mixed with notions of the ideal body, which led to innumerable dieting schemes, but burst after the Second World War.

With regard to both under- and overconsumption of food, debate exists about responsibility: the individual or "society"? For a long time, the former received the most attention, but more recently the latter gained more support – referring to the global escalation of convenience foods, fast expanding eating out, and the role of advertisements.

Famine

The harvest of staple foods was vulnerable to adverse weather, but also to man-made disruption, such as plundering soldiers. Growing barley or other so-called inferior cereals, which had short growing cycles and were less vulnerable to drought, alleviated but did not solve the threat of harvest failure. During Antiquity, general mentions of the fear of shortage and famine are numerous, but it is difficult to establish how frequent and serious food crises were. Literary sources on the ancient world pay most attention to political centers like Athens, Rome, or Constantinople, but precisely their political status ensured them a stronger entitlement to food. High food prices probably caused increased mortality among the urban poor and certainly caused increased inequality. If literary or epigraphic sources mention food shortages, it generally is to emphasize the measures taken by rulers, benefactors or – in the Later Roman Empire – the Christian church, but the gravity of the crisis is hidden from our view. Widespread drought or back-to-back harvest failures depleted reserves, leading to famines characterized by increased mortality. The few famines that are narrated in detail show that, just as in later times, they caused high mortality due to epidemics rather than starvation. Reliable figures are rare in sources on the ancient world, but occasional claims of hundreds of thousands of victims (e.g., 800,000 in Numidia in 125/124 BCE according to Orosius 5.11.1) are not to be rejected out of hand (Erdkamp 2018).

In the medieval and early modern world too, famines were a recurrent phenomenon, given the persistently low surplus produced in premodern agriculture. Almost everywhere famines were frequent: at least once every generation in premodern times a wide-spread famine struck most places in Europe, leading to anxiety and insecurity (Ó Gráda 2010). Unlike modern famines, medieval and early modern food shortages were usually caused by back-to-back harvest failures, often the result of too little or too much rain. They could be influenced by natural disasters such as long-term climatic shifts or volcanic eruptions (for instance, the Famine of One Rabbit of 1454).

However, the risk of famine was not equally spread across premodern societies, and man-made factors could severely exacerbate the destructive forces of nature. Warfare increased the chance that bad harvests would result in famine, as when the notoriously wet springs of 1315 and 1316 combined with warfare, caused a three-year-long famine across much of Northern and Central Europe. The unevenness across time and space with which famines struck the preindustrial world also suggests that risks could be mitigated even before modern times. Harvest shocks could be better absorbed where yields were higher, where transport networks were developed more fully, and where agricultural surplus in good years allowed for coping mechanisms to be better developed. A wide range of precautionary measures were practiced throughout premodern Europe. In times of scarcity, marriages were postponed, with a reduction in births as a result. Public granaries could allow the storage capacity to overcome temporary adversities, and trade or exchange arrangements could similarly help to overcome setbacks. If dearth struck nevertheless, poorer consumers tried to safeguard their caloric needs by "trading down" to inferior substitutes for wheat, such as oats or barley.

As a telling sign of the early improvement in the English economy, the size and duration of food crises declined gradually over time, to such extent that it was spared major peace-time famines since the 1620s. In Japan famines occurred less regularly in the seventeenth and eighteenth centuries than before. In Germany famines also became rarer in the eighteenth century, but in most parts of Eastern Europe the threat of famine lingered on until at least the end of the eighteenth century (Ó Gráda 2010).

In the nineteenth century, the general improvement of food supply and the growing buying power ended periods of starvation, except for specific episodes linked to war. Yet, also plant illness, weather conditions, ruinous policy, and speculation caused starvation. Some of these factors were increasingly under control in more and more parts of the world since the 1950s, although there remain "problem areas" while new risk areas emerged (Messer 2013). Estimations of the number of deaths due to famine reveal huge fluctuations between 1870 and 1920 (3.1–16 million deaths per decade), a disastrous increase between 1920 and 1970 (9.8–16.6 million), and an impressive fall since 1980 (0.9–1.3 million) (De Waal 2018). Mass starvation occurred in India under colonial rule in the 1870s, in Ukraine in 1932–1934, in large parts of the world as a consequence of the Second World War, and in China during the Great leap forward of 1958–1962. Since the 1960s, the Horn of Africa is permanently imperiled by hunger, which international aid campaigns only partly remedied.

Globalization and Intercultural Exchange

Throughout Antiquity crops and animals were spread from East to West, including such seemingly ordinary foodstuffs as peaches, wine, and chicken (Garnsey 1999). The consumption of wine, which was imported into Gaul by Greek traders, was adopted by Celtic leaders as a means to emphasize status. The increasing communication and trade across long distances under Roman rule stimulated the process of the diffusion of new crops and animals even more. Roman soldiers and civilians in central and northern Europe held on to their culturally accustomed foodstuffs, and in the early empire olive oil, wine, and fish sauce were transported from the Mediterranean to the northern provinces. Wine cultivation spread northwards too, first in southern Gaul, later also further north. Olives only grow in a limited range along the Mediterranean coasts and hence olive oil disappeared in central and northern Europe when the ethnic composition and dietary preferences of the Roman army changed.

Among the plants spread northwards were several Mediterranean herbs like coriander, poppy seed, dill, and mustard. Commerce along trade routes towards the East, reaching India and even beyond, ensured a steady supply of black pepper and other spices (Sidebotham 2011). The price of pepper was not excessive, and it was within reach of large segments of society. With the decline of the Roman Empire in the West, many imported foodstuffs disappeared, though some plants became permanent features of central and northern European garden plots (Cool 2006).

From the late middle ages onwards, the search for profitable spices spurred European overseas expansion and the desire for more reliable and abundant supplies of exotic cash-crops lay at the heart of the slave-based plantation system that was set up across the world (Curtin 2002). A desire for exotic foods and drinks was not the only factor in these developments: so, too, were intra-European warfare and imperial competition, the search for precious metals, and nonfood consumer goods. Nevertheless, food did play an important role. Exotic condiments had been known in Europe since Antiquity, and with the growth of international commerce in the later middle ages, they regained their place in the European imagination, if not perhaps in most kitchens. Spices such as pepper, cinnamon, cloves, or nutmeg travelled from East Asia to Venice, and then further across Europe (Freedman 2008). Since quantities were low and prices high, the incentive to find new routes was huge. By the end of the fifteenth century, Portuguese and Spanish seafaring had resulted in the establishment of a direct sea route around the African continent to the Indian Ocean, and in the opening of the American continent to European exploration, conquest, and commerce.

The spectacular strengthening of global commercial ties as a result of the new sea routes pioneered by Vasco da Gama and Christopher Columbus brought about major shifts in eating and drinking practices across the world. The variety of edible crops expanded everywhere. Europeans, for instance, discovered sweet potatoes, maize, chili peppers, and tobacco in the Americas. Over the following centuries they would also become familiar with tomatoes, green beans, turkeys, cacao, and squash. Meanwhile, wheat, horses, and livestock travelled in the other direction. This so-called Columbian exchange did not leave untouched the world outside of the Atlantic. Maize, cassava, and groundnuts were introduced from America to Africa, while tomatoes, sweet potatoes, and chili peppers influenced Asian eating practices (Albala 2003). Other things being equal, these exchanges themselves reduced global vulnerability to famine (Ó Gráda 2010).

From the sixteenth century onwards, the grip of European trading companies on the global production sites of exotic comestibles was gradually strengthened. In the most extreme cases, this resulted in colonial exploitation, with slave-based plantations for the production of sugar, nutmeg, coffee, or tobacco as sad examples. In other cases, such as those of tea or pepper, no unfree labor was involved until the nineteenth century, yet the quantities produced, shipped, and consumed globally still expanded to unprecedented levels. Already before modern times this implied that global consumer goods could become within reach of average – and even poor – households in Europe (O'Rourke and Williamson 2009). However, it is a telling irony of the early modern age that even though globalization in theory brought more potential variety in eating and drinking habits, in practice it was for many a period of increasing monotony. Sugar and pepper became more widely consumed than ever before, but at the same time a range of other spices almost entirely disappeared from European kitchens after the sixteenth century. Potatoes and maize could offer more – and cheaper – calories per hectare, as a result of which some European regions gradually became overly reliant on a monoculture of those crops, leading, for example, to the Irish Great Famine of the 1840s.

The Colombian exchange not only affected the types of food and drink consumed worldwide but also sorted cultural effects. From at least the sixteenth century onwards, eating and drinking rituals, their meanings, and their connotations travelled the world. They influenced the performances of eating and drinking themselves, as in the case of smoking or the drinking of hot beverages, which were unknown in Europe before the introduction of tobacco, coffee, and tea in the seventeenth century, but also the meanings of food and drinks: their perceived medical effects, or the degree to which they could function as social markers. This globalization of foods and drinks thus brought with it a complex history of cultural and scientific exchange, in which the perceptions, uses, and qualities of foodstuffs became appropriated differently in new contexts. Chocolate, for instance, was first introduced in Spain from Meso-America as a spicy rather than as a sweet drink, yet between the seventeenth and early nineteenth centuries it was gradually transformed into a sweet beverage with aristocratic connotations (Norton 2008).

International food trade grew swiftly from 1815 to 1914, then weakened up to 1940, but skyrocketed after 1950 (Federico and Tena-Junguito 2016). The colonial system until the 1960s and, then, free trade enabled this growth. Foods such as cocoa, life cattle, alcoholic beverages, and, increasingly, grain represented the bulk of the overall trade until the First World War. The share of fresh food diminished as manufactured foodstuffs, such as canned food, biscuits, dried pasta or soft drinks, grew in the 1920s. New modes of transport and preservation, particularly cooling – also in private homes, first in the West, then globally – revitalized international trade in fresh food such as herbs and dairy products since the 1960s, which contributed to the idea of ever-expanding choice, although it furthered global homogenization.

Availability of food from far remote shores changed the diet radically. The mass import of American wheat into Europe from the late 1870s onwards, for example, caused the fall of bread prices, which was *the* condition to revolutionize the overall spending pattern. The share of bread in the total budget of an average West-European household plunged from about 40% in the first half of the nineteenth century to 15% in the 1920s and to 3% today, gradually initiating the so-called consumer society.

Exchange of goods came along with the exchange of money, people, and ideas. Migrants took with them not only their language and religion, but more tenacious, also their foodways (Gabaccia 2017). The flow of migrants rose impressively throughout the nineteenth and twentieth centuries, with millions of people moving from Europe to the Americas, from Africa and Asia to the Americas and Europe, and within each continent. They all opened their own shops and eating places, often confronted with prejudices and xenophobia, although, inevitably, mixed diets emerged to various degrees, such as fusion (i.e., combination of existing foodways) or creolization (i.e., creation of new forms). This led to paradoxes to which testifies the fact that chicken tikka masala was labeled the English national dish in 2011. Culinary writers and performers (chefs, travelers, bloggers, . . .) contributed to the wide diffusion of both indigenous ("authentic" or "traditional") and creolized dishes in an ever-growing flow of culinary books, exhibitions, articles, and radio- and TV-shows.

Governing Eating and Drinking

All over the world and throughout time, governments interfered with eating and drinking, and in some periods most people actually depended entirely on help to survive. Starvation, however, was not the only reason to develop specific policies. Political and economic structures and strategies were aimed at securing the food supply of the urban populace in Ancient Greece and the Roman Empire. Most towns and cities relied largely on their hinterland, and taxes and rents ensured a large percentage of the harvest. When local harvests failed, imports were required. However, high transportation costs over land and limitations of communication, commercial networks, and buying power restricted access to outside resources for much of the people. Apart from the most powerful ones, towns and cities did not control outside resources and were therefore limited to measures intended to attract traders to supply the urban market. Guided by the notion of a "just price," close supervision and regulation of the city's food market aimed at keeping prices low and avoiding speculative behavior. However, authorities did not have the means to prevent high prices when the supply failed. Members of the urban elites frequently stepped in by selling food at prices that were below current market level (Erdkamp 2005). Only with the rise of Christianity in the Later Roman Empire did measures emerge specifically aimed at the poor and destitute (Garnsey 1999).

Food riots did not occur in classical Athens, as the democratic institutions gave the citizens sufficient means to put pressure on authorities. Urban food riots did occur in Roman times, though, and not only in Rome. Riots were seen as the expected consequence of price rises, which indicates that they were relatively common (Erdkamp 2002). The political status of Rome and, later, Constantinople ensured a stable supply. The well-known distribution in Rome of free grain (later, bread) to adult male citizens was instigated in 123 BCE as a measure to stabilize the food market. From Augustus onwards, roughly about one third of the population of Rome ate grain or bread provided through this scheme, but also the remainder largely went through state-controlled supply channels known as the *Annona* (Erdkamp 2005).

In classical Athens, public largesse was a civic duty of the rich; in imperial Rome it was a monopoly of the emperor. Outside Rome the local elites demonstrated and legitimized their social and political position by benefactions that included public banquets, which reflected the social hierarchy of the communities: the higher the status of the recipient in the community, the better treatment in terms of food and wine that he could expect during the banquet. Sumptuary laws issued by Roman statesmen and emperors ostentatiously aimed at limiting excessive spending on luxuries, but the frequency with which these were issued shows that they had little impact on reality, beyond emphasizing the virtues of the lawgiver.

Medieval and early modern governments were most clearly concerned with regulating access to foods and drinks, rather than with eating and drinking itself. Market regulation attempted to guarantee the fairness of the prices for basic foodstuffs (the aforementioned notion of a "just price" lingered on until today), as well as the quality and safety of foods that spoiled quickly, or of which the quality could not be visibly or tacitly gauged. Eating and drinking itself was much more rarely the subject of governance intervention, unlike the abundant sumptuary legislation that attempted to regulate the wearing of clothes by limiting specific clothing types to specific social groups or occasions. In some cases, such legislation was also imposed on eating and drinking habits, for instance by imposing limits on the lavish spending on wedding and funeral banquets. It is unclear if such regulation sorted much effect (Hunt 1996).

Today, food supply still worries authorities because lack of food often causes social outbursts (e.g., Egypt's bread riots in 2017). In the nineteenth century, securing sufficient food came along with quality concerns about food. The former intensified throughout the world because of the growing dependency of the market and the need to feeding the wage workers at low cost, but the latter – food safety – was mostly new (Bruegel 2012; Joseph and Nestle 2012).

To secure sufficient and cheap food when domestic output coped with difficulties, national authorities lowered taxes, subsidized producers and retailers, established control systems with maximum prices, put up storehouses, and organized food distributions. In many countries after 1950 food crises vanished, and only tariff policy remained. Yet, many people hold authorities responsible for taking care of the food supply. In other countries, however, diverse food policies continued to be applied according to food availability. Local initiatives influenced eating in a very direct way: public and private charity distributed staple foods on a daily basis, as was the case in Europe in the 1840s, 1850s, and during both world wars. This still is the case in many countries around the world until today, including rich Western countries.

Other interference with food related to alcohol consumption (Phillips 2014). For long, too much alcohol drinking was seen as lack of self-control. Although it was tolerated, public drunkenness was rebuked and penalized, lest it was totally prohibited for religious reasons. In Western countries in the nineteenth century, however, drinking was medicalized and conceived as a social problem, labeled alcoholism. It was central to the authorities' so-called social question that included immorality, delinquency, disease, prostitution, socialism, and other calamities. Consumption of strong drinks would lead to unemployment, poverty, misery and, inevitably, ruin the body and the family. Antialcohol campaigns emerged in the 1810s and intensified in the 1840s and, again, 1880s, which brought about successful temperance movements all over the world. In turn, since 1900 this led to temporarily or partly prohibition of producing, selling, or consuming alcohol in many countries across the world, such as Australia (1910–1928), some states in India (after independence), Norway (1916–1927), Russia (1914–1923), the USA (1920–1933), and Yemen (1962–1990).

Wine and spirits were often adulterated. Food fraud was not new, it came under many forms and related to many foodstuffs. However, the nineteenth century, again, led to new challenges (Atkins 2013). These were due to big transformations (industrialization, urbanization, individualization, . . .), as well as to the lengthening of the food chain, which included a growing number of actors who saw profit opportunities. Water was added to milk, chalk and field beans to flour, which was illegal but did not threaten health; copper sulfate, coloring agents, alum, and all sorts of stuffs were added to flour, which also was illegal but, moreover, could harm health. Until the 1860s, authorities focused on honest food trade, but since then also health concerns were part of regulations. Detecting food adulteration was done by chemists, physicians, and charlatans, but increasingly so by recognized chemical laboratories, serving the authorities, merchants, and consumers. These could easily discover falsifications by 1900 but had difficulties with the emerging sophisticated production processes (chemical flavor improvers, emulsifiers, color agents, sweeteners, . . .), of which the general public became aware in the 1970s.

National and, later, international institutions fixed norms for quality so as to guarantee generally accepted quality norms and, hence, trust in food. Influential was the 1905 French legislation on appellations of origin pertaining to wine, mustard, cheese, cider, and other foods, primarily intended for economic reasons, but with an effect on quality and health. In 1963, the World Health Organization started establishing international food standards (the Codex Alimentarius). Recurring food scandals, however, led to genuine food panics, as for instance in Scotland in 1964 (corned-beef typhoid outbreak) or Japan in 2008 (poisoned dumplings), which backs Ulrich Beck's notion of "risk society" (Ferrières 2006).

Optimal Diet

Philosophy and medicine in classical antiquity are intricately linked, and both can be seen as characterized by a system of contrasts. First, the contrast in Greek and Roman perception between the cooked and uncooked, cultivated and wild, civilized and barbaric, which reflected the dichotomy between "us" and "the other." Barbarians ate uncooked food and products of the wild, unlike civilized people who ate the produce of cultivated fields and domesticated animals. Whether Scythians, Huns or Homer's cyclops, they were characterized in Greek writing as not belonging to the realm of civilization by their food and drink. Another contrast was that between excess and moderation, the first also a mark of the uncivilized. In Plato's view of the soul and body, intellect is located in the head, emotions in the heart, while the lower belly is linked to the lesser needs of humankind. Giving in to the needs of the body is a sign of moral weakness, to which not only barbarians, but also slaves and women were thought easily to succumb. Restraint in the face of luxury and pleasure is a common ideal in Graeco-Roman philosophy, most explicitly in that of the stoics (Wilkins and Hill 2006).

Medical thinking was based on the principle of the four humors (or temperaments), propagated by the writings of the second-century physician Aelius Galenus (or Galen). According to this theory, the balance of bodily fluids in the body determined one's health. The four humors were either hot or cold, dry or moist. Food and drink were not only characterized by both contrasts, but they also contributed to the balance of the body. Hence, food played a large role in medicine, as ailments were thought to be caused by an imbalance that could be cured by a particular diet. Women differed from men, being moist and cold, and therefore required a different diet from men (Wilkins and Hill 2006).

These lines of thinking largely prevailed in the early modern period. As is fitting for a world in which medicine enjoyed only few successes, and the little effect it sorted was more obviously noticeable in preventing rather than in remedying illness, knowledge about the dos and don'ts in eating and drinking was considered crucial for good health. More so than in modern medical or dietetic sciences, mental and physical well-being were thought to be very directly linked to what one ate and drank. Medical thinking on the subject in the medieval and early modern era still relied mostly on the synthesis made by Galen, whose ideas were re-introduced in the European middle ages by Arab translators. This theory provided the framework from which arose a range of theories that would dominate discussion about the optimal diet up to the 1910s.

Since each individual had his/her own humoral composition, and all organic matters were composed of elements with specific humoral properties, there existed no universal optimal diet. Rather, the specific humoral properties of each individual at a given moment determined what the optimal diet was. Age, gender, weather, illness, occupation, and activities all played a role in determining the suitable diet. The main object of discussion was then how to reliably determine which humoral properties a given condiment possessed. For this one could rely on the knowledge inherited from antiquity, on appearance and taste, or on similarity in provenance and type to other foods whose properties were known.

This is not to say that medical thinking on diets did not change between the high middle ages and the end of the eighteenth century: sixteenth-century humanists such as Andreas Vesalius turned their attention to the original Greek texts of Galen, instead of relying on older translations from Arab, and as a result of the studies of humanist scholars, the texts of Hippocrates were re-discovered as one of the original sources that had influenced Galen. However, by and large such changes in medical knowledge required only minor adjustments and corrections to dietetic knowledge but did not fundamentally alter the way of thinking about the relation between food and health. Deeper shifts in medical thinking about the optimal diet emerged only in the seventeenth and eighteenth centuries, when different schools of medical thinking emerged, such as the iatrochemical school of Paracelcus, and the Leiden school of Hermann Boerhaave. However, the effect of these new modes of thinking on dietetics was in most cases superficial and slow to spread. Until the early nineteenth century most prevailing ideas about diets derived from older, humoral, ways of thinking about the human body, even if they were no longer explicitly motivated in those terms (Albala 2003).

For the majority of the world population before the nineteenth century the choice of food and drink was overwhelmingly dictated by local availability. Nevertheless, for better-off households there was room for fashion and taste. In sixteenth-century Europe, Italy was the culinary fashion-maker, the place from which shifting tastes gradually spread around. The most influential exponent of Italy's role was Bartolomeo Scappi, whose *Opera* of 1570 provided an exceptionally thorough illustrated guide to Italian gastronomy in his time. In the early seventeenth century, Spain would become the new gastronomic center, before moving to France. Although the limited availability of imported foods and drinks compared to today might make the impact of fashion less obvious, there are clear examples of changing tastes over time in the early modern period. The separation of savory from sweet courses (deserts) in the different courses of a meal is an invention of seventeenth-century French gastronomy that became so self-evident that for many modern observers it is hard to perceive that it is not a universal preference of humans, but a taste that was only developed very recently in the history of humankind.

The importance and success of culinary fashions in early modern Europe was greatly helped by the invention of the printing press in the fifteenth century. Although recipe books in scriptural form were frequently copied and enjoyed some popularity already in the late medieval period, the sheer number of recipe books printed from the sixteenth century onwards indicates a change in scale that is unlikely to have occurred without the printing press.

Throughout the nineteenth and twentieth centuries, nutritional insights renewed drastically, which directly affected the way people conceived of *good* eating (Carpenter 2003). Around 1800, centuries-old concepts about the diet still prevailed, although gradually new insights had emerged in the eighteenth century linked to the so-called chemical revolution in Western Europe. Despite this, very old concepts related to the four bodily humors left traces up to the 1960s. Three big innovations may be detected in nutritional sciences in the nineteenth and twentieth centuries: the application of the concept of calorie (1880s), the discovery of vitamins (1920s), and the full awareness of dangers of overeating (1950s). Of course, dietitians dealt with food-related illnesses (beriberi, scurvy, pellagra, etc.), but particularly the three innovations inspired food recommendations to which the general public mostly reacted ambiguously: some recommendations were totally ignored, while others were eagerly applied.

Prior to the "calorie-era," food advice and eating rules aimed at well-balanced diets. This consisted of the staple food that should be complemented by protein-rich foodstuffs, some variation in the menu, and suggestions regarding a peaceful eating atmosphere. These, and other eating rules, appeared in household education for young girls in several parts of the world after 1870, aimed at cooking well at low cost and creating a joyful home for husband and children. After 1900, the general public started to learn about the notion that all food and drinks consist of carbohydrate, protein, and fat that provide energy, which is quantifiable by calories. Bodily requirements were established too (3,000 kcal per day for an adult man). Hence, it became easy to compute exactly the necessary daily intake of food. Moreover, the kilocalorie "equalized" all foodstuffs, and therefore energy-rich food, such as peas and sugar, was highly promoted, while even alcohol was seen as energy provider. It took several decades to realize that sugar was not harmless, while the antialcohol lobby immediately reacted against the preeminence of the calorie (Scrinis 2013).

The coining of the vitamin in the 1910s, previously the "unknown substances essential to life," had immediate impact on food advice and manufacturers, to which testify the many advertisements in popular newspapers throughout the world in the 1920s and 1930s. Moreover, the insight that heating fresh food may partly eliminate the effect of vitamins led to the reappreciation of raw foodstuffs. Whole meal bread contains more vitamins than white bread. This led dieticians to promote the former type, which the (European) consumer rejected until the 1990s. After 1950, food supplements with all sorts of vitamins became increasingly popular.

Finally, the insight of the dangers of overeating concurred with the expanding availability of food in most parts of the world after 1980 since it may lead to heart diseases, diabetes or some cancers. So far, the avalanche of food advice and a never-ending stream of dieting gurus cannot end the recent "obesity crisis."

Restrictions

Unlike Jewish religion, which imposed strict dietary laws about what and with whom one could eat, Greek and Roman beliefs were not linked to strong ideas concerning impure foods. This is not to say that there were no cultural boundaries, for example, concerning the animals to eat. Eating wild animals, apart from wild boars, deer, or hares, was frowned upon, but also domesticated animals, like dogs or horses, were not normally eaten. Cannibalism, which is sometimes mentioned in the context of severe famines, was obviously a strong taboo. Vegetarianism was rare in Antiquity, although it existed among certain groups. Pythagoras believed in the reincarnation of human souls, be it in humans or animals. Hence, he and his followers regarded the eating of animals as a form of cannibalism. Also, the Neoplatonist Porphyry rejected eating meat. In general, he advocated an ascetic table, but realized that only philosophers could pursue this.

Paradoxically, food and eating were *and* were not important to most mainstream communities of Christianity, as it spread into Graeco-Roman society. Commensality, the act of eating together, was at the heart of Christian rituals. At the same time, these same communities chose not to adhere to Jewish dietary laws, thereby allowing Christians to remain part of wider, predominantly pagan communities. In its late first-century formulation, the Gospel says that purity was a matter of belief, not of food (Mark 7, 14–19; cf. Luke 11, 37–42). However, against the background of philosophical approaches to the relationship between body and soul, Christian writers developed a Christian discourse on food, which was mainly aimed at reaching higher forms of Christian religiosity by negating the demands of the temporary, worldly domain. Christian asceticism, which became strongly developed in the fourth century, aimed at fighting the body by depriving it from its sustenance and by condemning pleasure that could be arrived from the act of eating. Asceticism became a predominant feature of monastic life in Late Antiquity. However, outside monasteries there remained a tension between the emphasis on asceticism in Christian thinking and reality, as banquets and self-indulgence remained important elements of Christian ways of life among the elites (MacGowan 1999; Smith 2003).

Medieval and early-modern medical thinking about the optimal diet provided a few guidelines in making dietary choices, but before the nineteenth century it imposed little in terms of general rules or restrictions. If medicine offered few universal recommendations for restraint, religion did. In late medieval Christian Europe, there were an estimated 150 fasting days spread over the year, during which all healthy individuals were expected to abstain from consuming animal products – not only the flesh, but also derivatives such as butter or milk. Some of those fasting days were strict, others – such as the weekly fasting on Friday – were "minor" and allowed for some flexibility. After the Reformation, thinking about restraint in eating and drinking diverged across Europe. Lutherans did not adhere as strictly and as often to fasting as Catholics did, while Calvinists tended to favor a more austere living style in general, but not necessarily according to the rhythm of feasting and fasting imposed by the Catholic calendar (Albala 2003).

Regardless of the specific religious confession one belonged to, it was widely held throughout medieval and early modern Europe that the ability to refrain from eating and drinking could be a powerful marker of spiritual achievement. Mystic women, ascetic movements among the clerical orders, and heretics demonstrated their exceptionality by imposing specific restrictions in eating and drinking (Bynum 1988). This phenomenon lingered on, or re-emerged, in the eighteenth and nineteenth centuries, when the temperance movement allied religious ideas with restraint in eating and (especially) drinking habits.

Religion was not alone in imposing restrictions on eating and drinking. Starting from the Renaissance, a growing concern for more restrained and civil table manners gradually spread across Europe. Communal dishes made way for individual plates, table cloths, and napkins presumably improved table hygiene, and as the fork was gradually introduced from Italy to the rest of Europe, eating with bare hands became less accepted. Historians and sociologists have debated whether this concern for civility spread across early modern Europe as a result of the influence of courts, urbanization, rising living standards, changing social inequalities, or shifts in moral thought (Sarti 2004). Yet, between medieval and modern times there was much less change in *what* was eaten, than in *how* it was eaten.

In the nineteenth and twentieth centuries too, food restrictions come under many forms. Religious prescriptions continue to form the basis of food and drink regulations and avoidances, thus constituting clear and strong identifying boundaries. Yet, regulations were followed to different degrees throughout space and time. For example, alcohol consumption in countries with a Muslim majority fluctuated under the influence of the intensity of faith, legal prohibition, social pressure, international exchanges, or identification with peers (such as youngsters). Still, century-old food restrictions remain important as part of traditions that recently obtained new interest in some parts of the world. In Europe, however, the impact of the Church diminished after the Second World War, which clearly shows in the declining fasting observance and the vanishing of fish-days on Wednesdays and Fridays.

New food restrictions surfaced. Deliberate refusal of meat eating existed since classical Antiquity, while meatless days were part of religious rules, and some doctors advised to moderate meat consumption for health reasons. However, in Western countries, by the end of the nineteenth century, vegetarianism was institutionalized when various associations with a slowly growing number of (middle-class) members appeared. Sign of its success was, for example, the opening of a vegetarian restaurant at the 1910 World Exhibition in Brussels (Belgium). Motives for refusing to eat meat included animal welfare, economic concerns, health, philosophical objections, or expression of solidarity and empathy with other people, which all persuaded a growing number of people throughout the world in the late twentieth century. Nonetheless, vegetarianism (and its variants such as veganism or *flexiterianism*) remains a marginal phenomenon worldwide (Ankeny 2017).

Deliberately restricting eating and drinking occurred also within the frame of slimming. Dieting was not new, but with the increased attention to the (Western) beauty ideal of the body, more and more men and women paid attention to food intake. Long-established food avoidance may vanish. The recent case of eating insects (entomophagy) in Western countries exemplifies this. After being qualified for centuries as inedible food that arouse disgust, insects for human food are now praised for its high protein supply, sustainable production, and low cost.

Transgressions of food avoidances and taboos occur for various reasons and are accepted momentarily. For example, unrestrained eating may be stimulated at particular occasions such as Christmas eve, when even children may be allowed to drink some alcohol.

Commensality and Celebrations

The Greeks and Romans preferred to eat three meals a day, with the evening meal as the main one. This structure persisted in many parts of the world until today. In Antiquity, breakfast and lunch were usually light, with some bread, possibly dipped in olive oil, cheese or eggs, and meat for the prosperous. The famous poem *Moretum* depicts a farmer getting up in the morning and eating freshly baked bread with a mix of cheese, vegetables, herbs, and salt before he sets out to work. The evening meal could either be eaten in the domestic sphere or in a more public setting. In Greece, women may not have joined their husbands during the evening meal. Homer depicts aristocratic women as being present at banquets and busy with textile work, while the men enjoyed their meal. In classical Athens, aristocratic men reclined during dinner at home, while their wives sat beside them. Roman custom, however, was for men and women to have their meals together. During more formal meals, children sat at a separate table (Dunbabin 2003; Wecowski 2014).

In cities many kinds of cold and warm food and drink were available in the inns and taverns and from street vendors, which may be related to the generally limited living space of the common people and requirements of work. For the same reason, for more festive meals many common people relied on celebratory meetings of the *collegia* (associations of different kind combining religious and professional functions), which were often sponsored by rich patrons. In Roman times, women were present at such meetings, as were slaves.

Festive meals of all classes were meant to express one's social standing. While the aristocracy in Homer sits during banquets, from the archaic onwards until the end of Antiquity, the well-to-do recline during their dinner, while being served by servants. Even Jesus is depicted in the Gospel as reclining during the Last Supper. The symposium in classical Greece was solely a meeting of men of the upper classes. Social equality was limited to the guests present. The etiquette and conversation during the symposium ruled out the participation of the uneducated. The only women present were servants and fluteplayers. The ideals of the Roman banquet centered on simplicity, friendship, and social equality, in other words, the pleasant gathering of likeminded people who enjoyed a good meal. Reality was different, though, as social hierarchy was expressed in the arrangement of guests and even quality of food and wine served. Writers like Martial and Juvenal complained about the haughtiness of their patrons at dinners, while conspicuous spending could lead to excess, as famously parodied in the Banquet of Trimalchio scene in Petronius' *Satyricon* (Wilkins and Hill 2006).

Social hierarchy was not limited to the upper classes, as is revealed by the regulations of the *collegia* dinners. Patrons celebrated their own birthdays and those of family members by paying for these festive meals, but distinction was also made among the *collegia* members between the well-to-do "middle class," who contributed wine and food, and the common members. Seating arrangements expressed this hierarchy, while rules applied against rowdy behavior.

In many respects, the role of eating and drinking in celebration during the medieval and early modern period formed a logical counterpoint to the importance of fasting in the Christian calendar. The indulgence in food (meat) and drink during Carnival stood in contrast to the period of fasting that followed it. Some religious celebrations were linked to specific foods or drinks, such as the symbolic importance of eating lambs and eggs at Easter. However, more so than religious meaning, feasting was infused with social significance. Communal eating and drinking cemented social ties, both horizontal and vertical ones. The community and cohesion of a family was tellingly symbolized by the sharing of "bed and table," while confraternities, guilds, civic militias, and voluntary associations rarely spared expenses for the organization of their guild meals. Drinking also played an important role in social life, in particular alcoholic consumption. The consumption of intoxicant drinks probably increased during the early modern period and forms an intriguing contrast to the growing importance contemporaries placed on civil table manners during this same period.

In the modern period and until today, food and drinks continue to be used to show rough and subtle differences between countries, regions, towns and countryside, men and women, and especially, rich and poor. Celebrating was one of the most evident occasions to clearly mark these differences, but in the course of the nineteenth century new occasions appeared on the individual and collective level.

The process of individualization comprised the celebration of one's career moves, birthdays, or anniversaries, which all led to special dining. This was mainly limited to well-off people: poor people celebrated collective events (e.g., the end of the harvest) by having loads of their habitual fare. However, in the twentieth century, a birthday or school success was increasingly celebrated among the middle and working classes too. Moreover, people tended to visit friends and relatives much more than ever before, to share a meal. In general, dinners of the rich were to some extent imitated by poorer people, and according to the increase of the purchasing power of the masses, more or less luxurious food and drinks were consumed, which became particularly apparent in the 1980s. The case of (sparkling) wine illustrates this well. This imitation led to the search of new forms of distinction by the rich who eagerly use haute cuisine and its continuous innovations.

Collective eating and drinking have existed since long, but the nineteenth century, again, brought about new features: throughout the world, big banquets were organized to celebrate the nation, the monarch, an institution (e.g., parliament, a trading board, or a workers' union), an international exhibition, the visit of a diplomat, or an aristocratic marriage. On a more modest level, collective meals were organized by a literary society, savings association, sports club, or any cultural group. The aim was to create and strengthen solidarity and identity.

A new possibility to draw clear lines of distinction was offered by the modern Parisian-style restaurant. Fancy eating out in public places existed in earlier centuries, for example, in China in the seventh century, but the nineteenth-century restaurant had more influence in that it appeared throughout Europe and its colonies, North and South America, Australia, and parts of Asia. Worldwide, eating out was common for travelers who could visit locales of very different kind, but where, in general, choice of food was limited. The Parisian restaurant appeared somewhere in the 1780s as a public place catering for richer patrons with specific characteristics: individual tables, menu cards, prices, stylish décor, and waiters and, above all, the possibility to choose among a wide selection of food and wine. The bourgeois clientele, men and women, visited these places to see and be seen, meet with people, and enjoy food. Culinary journalists and writers of traveler guides commented upon this new cultural locus of the rich, thus establishing, destroying and diffusing cooks' reputations (Shore 2007).

The middle and lower classes ate out for reasons linked to work: they purchased soup, bread, cold meats, and the like, often sold by street vendors. In big cities in the last quarter of the nineteenth century, new forms of popular eating out appeared, such as the snack-bar or the automat, which were the precursors of today's (transnational) fast food eating places. By 1900 more and more people dined for pleasure in restaurants of various status (brasseries, bistrots, cafés, inns, . . .), offering local specialties, and increasingly, foreign cuisines. The latter's success is connected to movements of migrants and tourists, particularly after 1950.

Conclusion

Most people for most of the time and in most places ate very monotonously, had barely enough and risked starvation frequently. Only a small group enjoyed food security and diversity, using it as a sign of status. Despite the many innovations of the Columbian exchange, the diet of the masses started to change definitely with the growth of agricultural output, international trade, and transportation facilities around 1800. The disparate evolution of purchasing power, however, led to very uneven nutritional changes throughout the world.

Perhaps the most telling transformation in the world's food history is the changing significance of food. For centuries, food was a bare necessity for most people, and although it obviously still has this function, more and more people see and use food in a different way: a means of individual and group expression, element of pleasure, and idea of choice. This is the move from the "taste of necessity" to the "taste of freedom" or even "of luxury." A clear chronology is lacking, although worldwide the 1980s seem to have played a decisive role because of striking changes in world trade, demography, purchasing power, politics, consumption, and perhaps decisively, meaning of food.

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History of Eating and Drinking in the Ottoman Empire and Modern Turkey

3

Özge Samancı

Contents

Abstract

This chapter offers a broad survey of the history of food and drinking culture in the Ottoman Empire and Modern Turkey covering a time period of more than 700 years. This study aims to present changes and continuities that occurred in the Ottoman culinary culture in more than 600 years. Considering the vast territories of the Ottoman Empire encompassing modern Turkey, most of Southeastern Europe including present day Balkan region, Greece, parts of Ukraine, Middle east, North Africa as far as Algeria, and large part of Arabian Peninsula, it is not easy to make a comprehensive portrait of the food culture in all of the Ottoman territories. Istanbul, the capital city of the Empire as well as the Ottoman palace that represents a model for the rest of the empire, constitutes the subject matter of

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the chapter. Ottoman palace culinary culture, courtly banquets versus daily food and drinking habits of the common people, food culture in religious communities, and traditional and new table manners are the thematic topics in the chapter. Eating and drinking habits in modern Turkey reflecting a direct continuation from the Ottoman past constitutes another subject.

Introduction

Ottoman Empire was founded in Anatolia (Asia Minor) at the end of the thirteenth century by the Turkish tribes who originated from Central Asia. This Empire grew to be one of the most powerful states in the world during the sixteenth century. The Ottoman period covered more than 600 years and came to an end in 1923 when it was replaced by the Turkish Republic and by the various successor states in southeastern Europe and the Middle East. Considering the long-shared history across the vast territories of the Ottoman Empire, the formation of food cultures in the Middle East, Anatolia, and the Balkans reflects a synthesis of multiple culinary heritages in which migrations, wars, political domination, trade, and religions played an important role. The culinary heritages on these geographies have been formed over the centuries as a result of culinary amalgamation of ancient Anatolian and Mediterranean civilizations, nomadic Turkish, medieval Arab-Persian, Byzantine, and Ottoman cultures. Among these ancient culinary heritages, the last is Ottoman. For centuries, Ottoman territory had been a house for different cultural groups, where Sunni and Alevi Muslims, Orthodox Christians, Catholics and Jews mingled and co-habited. The interaction between these cultural groups had an impact on the formation of a hybrid and rich cuisine over time. Istanbul, the capital city of the Empire since 1453, became the house of the Ottoman elites where a refined culinary culture flourished over hundreds of years. Although the culinary habits and traditions were noticeably changed, enriched, or renovated in the Ottoman territories since the end of the thirteenth century to the last days of the Ottoman Empire in the 1920s, a coherent gastronomic language with some distinctions was formed in the vast territories of the empire (Samancı 2019).

Ottoman Palace Cuisine

The Ottoman palace cuisine had the characteristics of an “haute cuisine” that differed from the cuisine of the common people by the quality, abundance, and diversity of the foodstuffs used in the preparation of the dishes as well as by the number of its kitchen staff, the quality of the food, the tableware used at table, and the codes of good manners at the table (Samancı 2015a). The food and drinking habits of the Ottoman ruling elites in different part of the Empire reflected also the qualities of the imperial cuisine.

The Topkapı Palace built by Sultan Mehmet II after the conquest of Istanbul in the fifteenth century remained the center of refinement and elaboration of Ottoman haute cuisine until the nineteenth century. The kitchens of the Topkapı palace, which are extended along the right side of the second court, were designed as a huge complex for different functions. They were divided into nine units catering to different groups of the palace hierarchy (Necipoğlu 1991). They had a separate confectionery and an outer commissariat each with its own staff and equipment. The confectionery was used to prepare fruit conserves, syrups, desserts, pickles, and medicinal preparations as sweet pastes. Apart from the nine imperial kitchens and the confectionary, which were located in the second courtyard of the Palace, a special kitchen located in the Harem was only reserved for the Sultan. The organization of the kitchen staff in the palace was similar to that of the army. Under the supervision of the chief imperial cellar, the head chef directed the kitchen staff. Under the chief cook and the secretaries of the storeroom, the cooks worked with apprentices and helpers recruited from young boys conscripted for the janissaries. Tasters supervised the preparation of the dishes. The waiters were responsible for importing food to the different rooms in the palace (Bilgin 2008). The kitchens of Beşiktaş Palace (or the former Çırağan Palace), Dolmabahçe Palace, which later replaced the Beşiktaş Palace, and finally Yıldız Palace, the imperial residences during the nineteenth century, resemble Topkapı Palace in terms of kitchen structure and organization (Samancı 2008).

The royal kitchens were the heart of the palace serving food to its thousands of inhabitants. At the beginning of the sixteenth century, the Topkapı palace kitchens were serving food per day to more than 4000 people. Apart from its practical significance, the huge complex of the kitchens played a central role in the palace ceremonies. The kitchens symbolized the generosity of the sultan who distributed food to his inner household, the resident staff, his slave soldiers, and the imperial council officials and also to official guests visiting the palace (Necipoğlu 1991; İnalcık 1991). Apart from these, during the imperial festivals, the kitchens worked with a high capacity serving food to more than 5000 people.

The palace was the residence for both the Sultan and for members of the dynasty as well as the center for the administrative mechanism; therefore, due to its function, a special attention was given to the provisioning of the palace. The imperial kitchens had the privilege of providing the best qualities of food products from different parts of the empire in Istanbul. A department reserved for purchases and expenses for the palace kitchen was established at the end of the fifteenth century. The network of provisioning of foodstuff to the palace was founded, supervised, and maintained regularly by the palace officials (Bilgin 2008). Provisions for the palace were supplied by Istanbul markets and from the countryside. All perishable food items and most of the other food products were purchased from Istanbul markets. The areas from where provisions were supplied to the palace were dispersed over large and geographically diverse lands of the Empire such as southern and northern parts of Marmara, Eastern Anatolia, the Aegean Islands, Balkans, Wallachia and Moldavia, Egypt, Cyprus and Crimea (Bilgin 2008).

Food and Beverages in the Ottoman Palace

The basic consumption food items in the Ottoman palace were meat, rice, flour, butter, and sugar. Sheep meat was the most favored one, along with lamb, kid, and poultry. Beef was used to make pastrami in the imperial kitchens. Offal, that is the head, the tripe, the feet, and the intestines of the sheep, were also used in cooking in the imperial kitchens. Fowl such as pigeon, partridge, pheasant, duck, and goose were the delicacies served to the table of Sultan and high dignitaries in the palace. Compared to meat and poultry, the supply of fish to the imperial kitchens was very limited until the nineteenth century. Seafood such as oysters, shrimps, fish roe, and caviar were generally absent in the palace cuisine; except in the fifteenth century where these food items were supplied to the kitchen of the Ottoman Sultan Mehmet II. During the nineteenth century, the consumption of fish increased in the Ottoman palace. Salted bonito, caviar, bottarga along with fresh fish from the Bosporus were served to the table of Ottoman Sultans (Samancı 2015b).

Dairy products such as milk, butter, cheese, milk cream, and yogurt were the staple foods in the Ottoman cuisine, both for the elites and the common people. Clarified butter was the favorite one among the other types of fats and oils such as tail fat, olive oil, and sesame oil. The use of olive oil was restricted in the Ottoman palace cuisine. During the nineteenth century, the consumption of olive oil was relatively increased in the Ottoman palace (Samancı 2015b). Wheat flour was the major ingredient used in the preparation of different types of bread (with yeast or without yeast), sweet, and savory pastries. Different types of bread were prepared in the imperial bakeries according to the hierarchy of palace residents. Rice was a luxury cereal devoted to the table of Ottoman elites, while cracked wheat (called *bulgur*) was the staple in the daily diet in rural areas. Lentil, chickpea, and broad bean were the types of legumes consumed in the Ottoman Empire until the late eighteenth century. Common beans and green beans, originated from the Americas, were introduced into the Ottoman cuisine during the nineteenth century.

The consumption of desserts as well as sweet drinks was a privilege devoted to the elites. Thus honey and sugar were used extensively in the preparation of different types of desserts, sorbets, compotes, and jams in the Ottoman palace. Treacle of grape (called *pekmez*) was another sweetener used in the kitchen. Spices were expensive but indispensable ingredients in the palace cuisine. Saffron, mastic (the resin obtained from *Pistacia lentiscus* tree), cinnamon, ginger, cumin, lemon pepper, cardamom, cloves, musk, and black pepper were the major types of spices used in cuisine. Allspice, paprika, red pepper, and vanilla (both originated from South America) enriched the spice repertoire of the Ottoman elite cuisine in the nineteenth century (Samancı 2015b). Seeds such as sesame, nigella seeds, and poppy seeds were used mainly in the preparation of savory pastry products. Apart from a wide range of spices condiments such as verjuice (juice of unripe grapes), rose water and orange blossom water were used regularly in the preparation of dishes in Ottoman elite cuisine. The use of spices was important also from the dietetic point of view. They were also used in the preparation of therapeutic products such as pastes and elixirs.

Apart from the high consumption of meat in the Ottoman kitchen, the various kinds of vegetables were the main ingredients used in making dishes. Eggplant, spinach, gourd, leek, cabbage, turnip, chard, fresh broad-bean, carrot, okra, artichoke, and cucumber were the vegetables used in the preparation of dishes in the palace kitchen until the nineteenth century. Onion was the basic ingredient of many kinds of dishes. Parsley, dill, mint, and garlic were used to give a flavor to the dishes. In addition to the list given above, celery, lettuce, vine leaves were other vegetables mentioned in the imperial kitchen records. New vegetables, native of Americas, such as tomato, corn, potato, green bean, zucchini, Jerusalem artichoke, green, and red peppers were introduced into the Ottoman territories since the eighteenth century, but they began to be used in the kitchens of the Ottoman palace during the nineteenth century (Samancı 2006).

Both fresh and dried fruits were commonly consumed and used in cooking in the palace cuisine. Plum, quince, apricot, sultanas, and sour cherries are examples of fruits used in the preparation of meat stews. Apple, pear, sour, and sweet pomegranate, various kinds of grape, watermelon, melon, date, fig, plum, peach, apricot, cherry, lemon, bitter orange, wild apricot were the fruits mentioned in the kitchen account registers of the palace. Chestnut, almond, hazelnut, walnut, and dried fruits such as prunes, dried apricots were present also in daily diet of the palace inhabitants.

Apart from water, beverages consumed in the palace consisted of fruit compote (*hoşaf*), sherbet (şerbet), a cereal-based fermented beverage (*boza*), and coffee. *Hoşaf* was a kind of sweet soup made of pieces of fresh or dried fruits, water, and sugar. It was served in big bowls and consumed with spoons during the meals. Sherbets made of fruit juice, flower's essence, or dried fruits were served during the day (Samancı and Croxford 2007). Sherbets prepared with rose, violet, tamarind, narcissus, quince, sour cherry, and flavored with expensive spices like musk, ambergris in the palace cuisine symbolized the refinement of the Ottoman elite culinary culture. Some of the sherbets were brought to the palace from the provinces of the empire such as citron sherbet (*hummaz*) from Egypt, rhubarb sherbet from Damascus. Palace residents had the privilege of using ice and snow in their beverages to keep them cool. During warm summer days, snow gathered at snow deposits in Istanbul and snows brought from the peak of Uludağ mountain (in the province of Bursa) were used in drinks as coolers. *Boza* was a fermented beverage made of wheat, rice, or barley, and it was prepared and consumed in large quantities in the Ottoman palace during the sixteenth and seventeenth centuries. Coffee had been known and consumed in Istanbul since the sixteenth century. Since the first half of the seventeenth century, coffee was listed among the ingredients supplied to imperial kitchens (Bilgin 2008).

Banquets and Daily Meals in the Ottoman Palace

Food had symbolic meanings in Ottoman court ceremonies, with the Ottoman Sultan displaying his munificence and his splendor to his people through feasts. By feasting and entertaining his subjects, the Sultan received their homage, while the subjects enjoyed themselves while participating in the festival. The consumption of plentiful food and the various impressive spectacles during the imperial festivals symbolized the splendor of the Ottoman palace for the populace's benefit. The quality and the quantity of the dishes served during the banquets organized in order to celebrate the circumcision of an Ottoman prince or the wedding ceremony of an Ottoman princess was impressive in the Ottoman palace. Different types of dishes were served to different groups of guests according to their rank. For example, in 1539, during the imperial Ottoman festival organized to celebrate the circumcision of two Ottoman princes, Bayezid and Cihangir, a series of banquets were prepared for a large number of guests, which included the public, on the order of Ottoman Sultan Suleiman the Magnificent. In addition to the public feast where 5000 bowls of food were prepared and served – rice pilaf (*dane*), rice pudding with saffron (*zerde*), 600 boiled sheep, 40 roasted beef cattle and a 1000 savory pastries ç*örek*) – on each day a banquet was arranged for a special group of guests such as officials, clerics, ambassadors, and janissaries. Six hundred tables were prepared for these military and religious men. The menu was the same for each banquet and comprised nine dishes: rice pilaf (*dane*), rice pudding made with saffron (*zerde)*, chicken soup, three sorts of sweetmeat, roasted chicken, as well as roasted lamb and sheep. Another banquet was organized for the pashas and Ottoman notables. This menu of 12 dishes was richer than that for the janissaries (infantry units) and clerics (Kut 1987). Each banquet menu was arranged according to the social rank of the guests, with the most delicate and appetizing dishes prepared for the Sultan's table and the high Ottoman dignitaries. The menu for this banquet consisted of 41 dishes. The different sorts of pilaf were the most interesting part of the feast, as apart from ordinary rice pilaf, colored varieties of pilaf created a visual spectacle. Four soups and five sweetmeats were offered with different kebabs and stews. Alongside lamb, chicken, and mutton, duck, goose, partridge and peacock were among the delicacies presented at the table. During the henna night, the night before the wedding ceremony, in addition to the above-mentioned dishes, stuffed gourd, stuffed eggplant, quail kebab and 53 desserts including halva, fruit jams, candied fruits, fruit pastes together with different sweet pastries were served to the guests (Tezcan 1998). As portrayed in several miniatures illustrating the banquets given during the Ottoman imperial festivals, the dishes were served one by one in Chinaware or in copper plates on low tables. The food might be served also in one time, as in French service style during the feasts organized on military expedition or during the feasts offered to a large group of people (Figs. 1 and 2).

Compared to the menus served during the banquets, everyday meal served to the palace residents was modest. For example, an everyday meal for the viziers, served after a council session in the Topkapı palace during the seventeenth century, consisted of six dishes and included items such as rice pilaf, chicken soup layered pastry stuffed gourde, and meat kebab (Reindl-Kiel 2003). Kebab, rice pilaf, soup, savory pastry, vegetable stews, or stuffed vegetables, desert, and fruit compote continued to be basic types of dishes served to the residents in the Ottoman palace during the nineteenth century. Chicken dishes, fish, and offal were types of dishes served occasionally (Samancı 2015b).

Fig. 1 Banquets given to the Ottoman religious men during the imperial festival in 1720, *Surname-i Vehbi*, Topkapı Palace Museum Library, (Bilgin and Samancı 2008)

Feasting was a key element in the Ottoman palace ceremonies with respect to receiving foreign envoys. Numerous travelers' accounts from the fifteenth to the early decades of the nineteenth centuries depicting the reception of foreign envoys in the Ottoman palace imply that offering food to foreign guests was a constant and permanent part of the court ceremonies. Generally a very rich menu consisting of traditional Ottoman dishes was served to the guests. Special servants called "tablakar" carried the tray of dishes from the kitchens to the rooms where the dinner would be served. The dishes are served one by one on low table. The banquets were in fact political occasions during which two parties fraternized and exchanged ideas. The host of these feasts was the Ottoman sultan, who demanded the allegiance of his guests in return for his generosity (Samancı 1998).

Fig. 2 Banquet given by the Commander-in-Chief Lala Mustafa Pasha to the soldiers in İzmit in the sixteenth century, Nusret-Name, Topkapı Palace Museum Library (Bilgin and Samancı 2008)

Food and Beverage Habits in Istanbul

As the capital of the Ottoman Empire, Istanbul had the privilege of sourcing the best and most varied ingredients from each of its regions. Beyond the food items and products of its immediate territorial limits, the kitchens of Istanbul also used foodstuffs from distant geographical regions of the Empire. The production and provision of foodstuffs in Istanbul have always been under the control of the Ottoman state. The food supply of the capital was one of the priorities of the state. State authority manifested over the economy in many ways: regulation of production, fixing of prices, requisitioning of labor, merchandise and even capital, export prohibitions. These measures were taken in order to ensure the supply of the capital city. Products such as cereals, animals, dairy products, coffee, olive oil, butter, vegetables, fruit, and spices arrived at the ports of Istanbul from the different regions of the Empire. Larders such as Unkapanı, Balkapanı, Odun İskelesi, and Yemiş İskelesi along the Golden Horn were the places of distribution of these commodities. Most of the vegetables and fruits consumed in Istanbul were grown in the city. Istanbul vegetable gardens, vineries, and gardens supplied the markets of the city. Milk, yoghourt, and dairy products were supplied from the small dairy farms in Istanbul. All food merchants were attached to guilds such as bakers, butchers, confectioners, grocers, fishers, kebab makers, halva sellers, vegetable and fruit sellers, poultry dealers, etc. People could buy food as well as ready prepared meals (such as kebabs, halva, tripe soup) in the shops of these merchants. Street vendors also sold all types of food while traveling through the city or neighborhoods (Samancı 2015b).

The price lists of the foodstuffs sold in the market provide a detail picture of the food items available in the capital. The Ottoman cookbooks show that the food ingredients used in the Ottoman palaces and in elite households were very similar. The key items were: mutton and lamb, poultry and game, fish, cereals, milk and dairy products, dry pulses, animal fat and vegetable oils, sugar and honey, spices, fresh and dry fruits, and vegetables. One of the main differences between the ingredients available in Istanbul's markets and in the imperial cellars was the variety of fish and shellfish. Different kinds of fish and shellfish caught from the Bosphorus were remarkable. The markets of Istanbul offered a great variety of fish such as the goby, the eel, the sea bass, the mullet, the red pageot, the swordfish, red gurnard, scorpion fish, the mackerel, the saurel, the common mendole, bluefish, and the bonito. Lobster, oyster, crab, scallop, shrimp, and mussels were sold also in the markets. Shellfish and fishes constituted the main food items of the Christian population – both Armenians and Greeks – during Lent (Yerasimos 2008). During the nineteenth century, the consumption of fish and shellfish increased among the Muslim population as the Ottoman cookbooks witness.

The most popular hot beverage consumed in the Ottoman Empire was coffee. Coffee had been known and consumed in Ottoman society since the sixteenth century. Tea was not a common beverage in nineteenth-century Istanbul until the twentieth century, when it outpaced coffee. Another hot beverage that was common in nineteenth century's Istanbul was *salep,* which was a hot beverage of milk, thickened with salep powder (flour made from the tubers of the orchid) and sugar. The three main types of fruit juices consumed were compote, sherbet, and cordials (Samancı 2018a). Although the consumption of alcohol was forbidden in Ottoman society by Islamic religion, accounts of travelers and memoirs written in the nineteenth century show that Istanbul inhabitants, both Muslim and non-Muslim, drank wine and *raki* in the city's taverns (Georgeon 2002). These alcoholic beverages were served with appetizers called *meze* such as salads, nuts, fruits, and seafood.

Food Culture in Ottoman Religious Communities

For centuries, Ottoman territories had been a house for all religions where Muslims, Christians, and Jewish mingled and co-habited. The interaction between different cultural groups had an impact on the formation of a hybrid and rich cuisine in time. The cuisine of the different communities in the empire (Muslim, Jewish, Christian) shared the characteristics of the same regional cuisine, dictated mainly by geography. However, the normative rules of each religion constituted the barriers between the culinary cultures of each community. Pork was illicit food for Muslims and Jews, but allowed for Christians. Seafood and fish were widely consumed by Christians, especially during Lenten days. The Jewish community, whose religion did not allow the use of meat and butter in the same dish, favored the use of vegetable oil. Consumption of alcoholic beverages was forbidden for the Muslims but allowed for the rest of the society. Cookbooks published in Turkish using the Arab and Armenian script during the second half of the nineteenth century exemplified the existence of a cuisine shared by both Ottoman Muslim and Armenian communities in Istanbul (Samancı 2015b).

Food and Medicine

Ottoman medicine and Islamic medicine were based on Greco-Roman medicinal traditions, which relied mainly on Hippocrates and Galen. Dietetics was, along with surgery and pharmacology, one of the three basic branches of ancient medicine. The principles of healthy and balanced nutrition in Ottoman medicine are based on the theories of “humors” (Sarı 2008). According to this theory, the macrocosm consists of four elements: air, fire, earth, and water, whose qualities are wet, hot, dry, and cold. To the four elements corresponded the four humors of the human body: the yellow bile, the atrium, the blood, and the phlegm, that is to say respectively the hot dry, the cold dry, the hot wet, and the wet cold. Dietetics was one of the major methods of treatment of health. Each food having qualities associated with the four humors (hot, cold, dry, and wet), the doctors recommended to their patients a specific diet corresponding to their temperament. It should be noted that there is a direct relationship between cooking and medicine in Ottoman culinary culture until the nineteenth century. Recipes written by Shirvani in the fifteenth century and Ottoman medicinal manuscripts from the fourteenth to the seventeenth centuries reflect all the dietary concerns in Ottoman cuisine. Dietary rules based on the theory of humors have played a decisive role in the formation of taste preferences in the Ottoman culture, because they determined the combination of ingredients used in the preparation of dishes (Samancı 2015b).

Ottoman Cookbooks

An Ottoman physician, Shirvani in the fifteenth century, wrote the earliest cooking manuscript known in the Ottoman world. Originally, this manuscript was the translation of a medieval Arab cookbook written in the thirteenth century by

Muhammad Ibn al-Kareem al-Baghdadi; however, the Ottoman author, Shirvani, added 80 recipes that were not in the Arabic version (Argunşah and Çakır 2005). This manuscript highlights the culinary exchange between Ottoman haute cuisine and medieval Arab cuisine. It also indicates the relation of food and traditional medicine in the Ottoman culture. In the manuscript, Shirvani, who was a doctor, explained each dish according to its medicinal quality. Two Ottoman cooking manuscripts were written in the eighteenth century. These manuscripts constitute the basic sources for cookbooks that would be published during the nineteenth century (Samancı 2015b).

Between 1844 and 1900, a series of Ottoman cookbooks published in Istanbul illustrate the colorful richness of the Ottoman cuisine. The first cookbook, entitled *Melceü't-Tabbahin* [The Refuge of Cooks], was published in 1844. After its initial publication in 1844, *The Refuge of Cooks* became so popular that it was reprinted nine times in the following years until 1889. The author, Mehmed Kamil, a professor at the Ottoman medical school in Istanbul, wrote in the introduction of the book that he decided to write it in an attempt to revive old recipes that were forgotten or practiced incorrectly by the cooks of Istanbul. The two main sources used by Mehmed Kamil were the eighteenth century Ottoman cooking manuscripts. The book included 273 recipes. An Ottoman gentleman Türabi Efendi translated *The Refuge of Cooks* into English in London in 1864.The *Refuge of Cooks* became a reference for other cookbooks published in Istanbul such as *Yeni Yemek Kitabı* (The New Cookbook) of 1880, *Ev Kadını* [The Housewife] of 1882, and *Aşcı Başı* [The Chef] of 1900 (Kut 1990). Between 1871 and 1926, seven cookbooks in Armenian script were also published in Istanbul. The recipes in two Armenian cookbooks published in Istanbul, *Keys of Cooks* (1876) and *New Cookbook* (1889), have similarities with the above-mentioned Ottoman cookbooks published during the nineteenth century. Another Ottoman cookbook, which reflects Istanbul style cuisine, was published in 1870 in Bulgarian. Titled *Every Type of Dishes Prepared in Istanbul (Tsarigrad) Style*, this book reflected the interest of Bulgarian elites in Istanbul cuisine (Detchev 2018).

According to the cookbooks, the types of the dishes known and prepared in Ottoman cuisine can be categorized as soups (ç*orba*), kebabs-stews-grills (*kebab-yahni-külbastı*) prepared with mutton, lamb, poultry, and fish, meatballs (*köfte*), vegetable stews flavored with meat (such as *bastı, kalye, türlü*), vegetables stuffed with minced meat or with spiced rice (*dolma)*, vegetables cooked in olive oil (*zeytinyağlı*), pickles (*turşu*), salads (*salata*), egg dishes (*yumurtalı yemekler*), pilafs (*pilav*), savory pastries (*börek*), sweet pastries (such as *baklava, kadayıf*), *helva*, milk puddings, fruit desserts, jams (*reçel*), compotes (*hoşaf*), sherbets (*şerbet*), and cordials (*şurup*).

The broth of meat and of chicken was used generally in preparing the soups. Flour, almond, or vermicelli was used to thicken it. Lemon juice, unripe grape, or bitter orange juice provided the sour flavors. The use of parsley and of mint was widespread. Kebab can be defined as a dry-cooking method. Spit roasting in front of hot fire (called ç*evirme*), grilled meat on skewers, roasted meat in oven constitutes some of the examples of kebab. Following kebab, stewing (*yahni)* was the second common method of cooking meat or poultry in the Ottoman cuisine. Apart from onions, dried fruits were also used in preparing meat stews. Honey, vinegar, molasses of grape, prunes, apricots, and almonds were also used in meat stews (Yerasimos 2005). The meatballs called *köfte* were prepared with minced mutton meat, grated onion, and spices. The *köfte* were roasted, griddled, fried, or braised. Fish and mussel stews cooked in olive oil were named *pilaki*. *Pilaki*s prepared with mussels, fish, or oysters were delicacies in the cuisine of the Christian communities of Istanbul. Like the stuffed vegetables cooked in olive oil (*yalancı dolma*) and seafood dishes, *pilaki* was among the special dishes Christians prepared in Istanbul especially during their fasting periods (Matthaiou 1997).

Savory pastries and sweet pastries were essential dishes in the Ottoman cuisine. Dough made with flour, water, and salt formed the basis of the thin sheets of *yufka* used in the preparation of savory pastries. Rice pilaf was one of the dishes served to the table of the elites during every meal in Ottoman society. Pilaf was mostly eaten at the end of the course and was accompanied by fruit compote. The pilaf made of cracked wheat was regarded as an inferior dish and not a part of the elite's culinary culture. *Pilaf*s were also prepared with pieces of lamb, chicken, bluefish mussels, or with vegetables such as eggplant and tomatoes. Pasta called "*makaronya*" was a new dish that was introduced into Istanbul's cuisine around the 1850s (Samancı 2015b).

The Ottoman recipes of the nineteenth century include a large range of vegetable dishes. Vegetables were braised in clarified butter with pieces of mutton, onions, and with the addition of a little water. Stuffing vegetables, leaves, and even some fruits with minced meat and braising them was another frequent method used for cooking vegetables. Vegetables such as zucchinis, gourd, okra, eggplants, or fresh beans were stewed with pieces of mutton and onions in butter. Verjuice or lemon juice was used to give such dishes a sour flavor. Cinnamon, fresh mint, garlic, and sometimes sugar were other condiments used in braising vegetables. Recipes after the 1880s also include tomato juice as a condiment used in braising vegetables (Samancı 2018a).

Stuffed vegetables called *dolma* were prepared in two ways, with minced meat and with spiced rice. Eggplants, zucchinis, cucumbers, turnips, vine leaves, and green tomatoes would be stuffed with a mixture of chopped meat, rice, salt, pepper, and onion. Vine leaves, hazelnut leaves, quince leaves, spinach, or mallows were wrapped around a small amount of minced meat. Stuffed melon and pumpkin were two varieties of savory-style dolma with a sweet flavor. Another kind of stuffed dish was prepared with rice mixed with onion, salt, cinnamon, pepper, pine nut, raisin, allspice, and fresh herbs. These *dolma*s were called "fake *dolma*s" because they did not include any meat. Olive oil was used in braising these "counterfeit" stuffed vegetables in a small amount of water with, lemon, sour plums, or sour cherries.

Salads, pickles, spiced meats, and seafood are just some of the appetizers described in the Ottoman cookbooks of the nineteenth century. Salads were simple, prepared with just one or two different herbs or vegetables. Another salad dressing used was *tarator*, a purée made of nuts, olive oil, lemon juice, salt, garlic, and bread crumbs. Desserts had a very special place in the Ottoman culinary culture. They were served during celebrations of circumcisions, weddings, and religious feasts as a symbol of joy. Desserts such as halva were also served during funerals in order to offer comfort against the pain of the loss of a loved one. The various kinds of desserts described in the cookbooks of the time can be grouped as follows: sweet pastries soaked in sugar syrup (*baklava, kadayıf*), halva, puddings, fruit jellies, fruit desserts, cookies, jams, and candies. Fruit juices made of dried or fresh fruits such as compotes, sherbets, and syrups are also included as varieties of desserts (Samancı 2018a).

Food and Drinking Habits in the Ottoman Territories

The border of the Ottoman Empire stretched from the Northern Carpathians and Southwest Ukraine and the Caucasus to Southern Arabia, Upper Egypt, and along the coast of North Africa to Tunisia and Algeria in the 1600s. The Black Sea coast, the steppes of Anatolia and Syria, a large part of the Mediterranean Sea, and the deserts of Arabia and North Africa were part of this huge empire that ruled on three continents. Considering the long-shared history across the vast territories of the Ottoman Empire, the formation of food cultures in the Middle East, Anatolia, and the Balkans reflects a synthesis of multiple culinary heritages in which migrations, wars, political domination, trade, and religions played an important role (Fragner 1994). Despite the geographical diversity in the Ottoman Empire between different regions, today it is discernable to notice a kind of a common gastronomic language in old Ottoman territories. The Balkans, Greece, Anatolia, and the Middle East share today a common culinary culture, with regional differences. The diffusion of a common gastronomic language that covers comparable culinary techniques and dishes in Ottoman territories is not easy to explain. The long historical background, in which migration, trade, and population exchanges played a role in the mutual dissemination of cultural practices including the culinary one should be considered. The Ottoman Empire has ruled the Balkans and Middle East throughout the centuries and thus deeply affected these territories in various areas such as politics, economy, culture, religion, society, etc. These effects have inevitably turned into legacies on various levels and in various fields including culinary legacies. The presence of Ottoman governmental officers in the Ottoman provinces from the very beginning of the empire contributed to the transmission of Ottoman elite food culture to the remote reaches of the Empire (Samancı 2019). Ottoman public kitchens (*imarets*) opened in Ottoman cities where free meals distributed on behalf of Ottoman palace also signaled the Ottoman presence throughout the empire (Fig. 3).

Based on the information gathered from the notes in travelers' accounts as well as the account registers of Ottoman hostelries founded in Ottoman cities, it will be possible to give a general but incomplete picture of food and drinking habits in the territories of the Ottoman Empire. The everyday food in the modest houses in cities or in rural areas differed from the Ottoman haute cuisine by the simplicity and monotony of the foodstuffs. Local food products dictated most of the time the food habits of the Ottoman peasants, as in rural regions in the Balkans (Samancı 2018b).

Bread was the main foodstuff in Ottoman geography. Bread in Anatolia was made mostly of wheat flour. Barley bread was also consumed especially during food scarcities. In his travel book, Evliya Çelebi (seventeenth century) describes the

Fig. 3 "Dinner at Crisso" (Dodwell 1819)

local types of breads made in Anatolian cities. The bread was baked in the oven, in a tandoor, or on a hot plate. Apart from bread, different types of savory pastries were available in the food system. Rice consumed in Ottoman palace cuisine was a luxury for ordinary people in Anatolia and Balkans. Rice cultivation was limited in Anatolia and the Balkans. Apart from special occasions, the public was only able to taste the rice soup and rice pilaf served in the Ottoman hostelries. Compared to rice, bulgur is an easily accessible food item in Anatolia. Lentils, broad beans, black-eyed peas, chickpeas, and mung bean are the legumes known in the Ottoman geography. Dried beans were introduced into the Ottoman geography during the nineteenth century (Yerasimos 2011).

The most preferred type of meat, the prestigious food in the Ottoman geography, was sheep and lamb. Veal, beef, and goat meat consumption also existed. The meat was consumed by the Ottoman elites in their daily life, but common people might consume it only during special times like weddings, Eid al-Adha, and other special occasions. Pork, which was forbidden for Muslims in the Ottoman world, was consumed by Christian communities, especially in the European provinces (Blaszczyk and Rohdewald 2018). Poultry, which was consumed widely among the Ottoman elite, considered to be easy to digest and more nutritious than red meat, was consumed occasionally by the rest of the society. Turkey, known as Egyptian chicken, was known in Ottoman territories since sixteenth and seventeenth centuries. Partridge, quail, snipe, pheasant were types of fowl hunted in some of the regions in the empire. The diversity of fish and seafood offered by the sea and rivers in the

Ottoman geography was quite high. The consumption of fish and shellfish depended on their availability. As mentioned earlier, the consumption of fish, shellfish was more popular among the Christian communities during Lent period.

Butter, clarified butter, animal fat like tail fat, olive oil, and sesame oils constituted to be the types of fat and oils consumed in the Ottoman Empire. Clarified butter with fat obtained from the tail of sheep were the main kinds of fat. The consumption of vegetable oil was popular among the Jews, who did not consume meat and dairy products at the same time. Vegetable oils became also important among the Christians during their abstinence periods when they could not consume animal based food items. Olive oil production was limited in the Ottoman Mediterranean world including the Aegean cost in Anatolia, Greece, south of Anatolia, and north of Africa. Sesame oil constituted the basic kind of vegetable oil in Anatolia. Cheese and yogurt were the basic dairy products produced and consumed by the Ottoman population. Sugar was a luxury food item in the daily food habits of the common people; thus honey and treacle of grape were used in the preparation of desserts and sweet beverages. Spices and dried herbs used for medicinal purposes were also important ingredients used in cooking in Ottoman cuisine. Vegetables and herbs offering a rich variety in different regions of the Empire constitute also important ingredients used in cooking. In the eighteenth century, corn, green tomato, and fresh peppers, and in the nineteenth century red tomatoes, beans, and potatoes entered the Ottoman cuisine. Different kinds of fruits cultivated in Ottoman geography constituted also important food items in Ottoman diet (Samancı 2016a).

New Table Manners and New Food Habits in the Nineteenth Century

The eating habits of Ottoman society remained largely unchanged up until the nineteenth century. The meal was eaten around a low table (*sofra-sini*). People sat cross-legged on cushions and ate from the same plate. Spoons and fingers were the only eating utensils used. Knives and forks were unknown. Meals were not served in a special dining room, but people of all classes chose to eat wherever they wanted and a table was brought to them. Generally speaking people ate twice a day. They had a morning meal around 10 o'clock in the winter and around 11 o'clock in the summer and the evening meal before sunset.

During the nineteenth century, European lifestyle as well as culinary habits became sources of inspiration for those among the Ottoman elites who supported reform. During the second half of the century, a new style of eating called *alafranga* (alla franca, in the European style) became fashionable within Ottoman elite circles. European-style table manners, having meals on a high dining table, sitting on a chair and using individual knives, forks, spoons, glasses, as well as European porcelain tableware were increasingly in use among Ottoman elites. Having three meals per day as breakfast, lunch, and dinner would become also a norm in urban culture toward the end of the nineteenth century (Fig. 4).

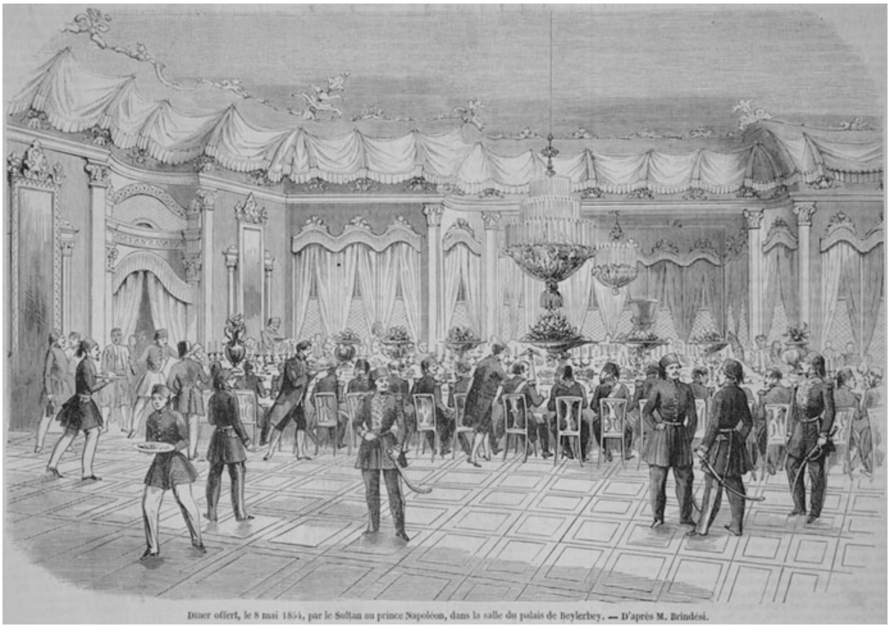

Fig. 4 Dinner given for the honor of Prince Napoléon by Sultan on 8 May 1854, Beylerbeyi Palace, Istanbul (L'Illustration: Journal universel, Tome: XXIII, Paris 1854)

Parallel to the novelties adopted into the Ottoman culinary etiquette, European cuisine, especially French, started to influence the cuisine of Istanbul's elite during the second half of the century (Samancı 2003). Starting since 1830s, the Ottoman palace adopted also the European style of banqueting for receiving its honorable guests. During Sultan Abdülmecid's reign (1839–1861), these banquets also started to reflect European tastes, in contrast to the typical meals served to the residents of the Ottoman Palace. Dishes served during these official banquets included both Ottoman and French-inspired dishes. The French influence, which was gradually introduced to the Ottoman palace and related circles through official dinners and feasts, soon trickled down to the Istanbul elites, leading to the adoption of new tastes outside the imperial cuisine. These new dishes were also promoted in European-style restaurants, cafés, and patisseries, which opened in the districts of Pera and Galata in Istanbul after the 1850s (Samancı 2015b) (Fig. 5).

Ottoman cookbooks published since the 1870s, such as *The New Cookbook* (1880) and *The Housewife* (1882), included new recipes inspired from French and European cuisines. The foreign dishes in these late nineteenth-century cookbooks included new soups such as vegetable soup, Hungarian soup, pea soup, oyster soup, prawn soup, pastes, broths, sauces, pates, some meat dishes as roast beef, grilled cutlet, beef steak, and *ragout* as well as garnishes, pasta, and canned food. The recipes stated as sauces were egg sauce, lobster sauce, mussel sauce, spiced sauce, or tomato sauce. Mushrooms, tomatoes, potato, glazed onions, bread, spinach, sorrel,

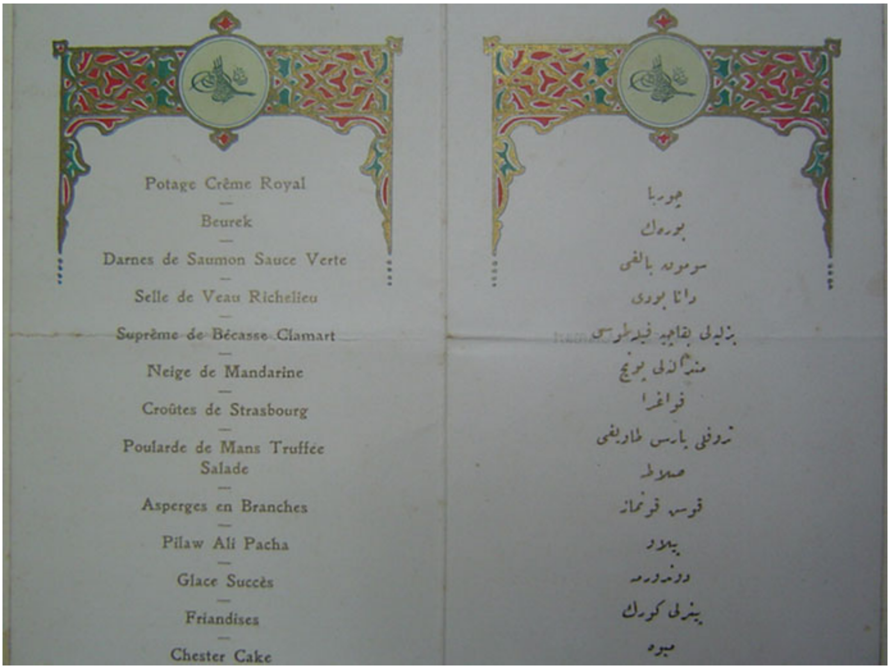
Potage Crême Royal
Beurek
Darnes de Saumon Sauce Verte
Selle de Veau Richelieu
Suprême de Bécasse Clamart
Neige de Mandarine
Croûtes de Strasbourg
Poularde de Mans Truffée
Salade
Asperges en Branches
Pilaw Ali Pacha
Glace Succès
Friandises
Chester Cake

Fig. 5 Ottoman palace banquet menu at the beginning of the twentieth century

peas, asparagus, chicory, and French peas were some of the garnishes mentioned in the cookbooks. Different types of paste, which were essentially paste made of game, poultry, and fish, were also among the French dishes that entered the Ottoman cuisine. Crèmes (*krema*), cakes (*pasta*), biscuits (*bisküvi* or *gevrek*), cakes such as savarin, and a new type of ice cream (*kalıp dondurmaları*) were some of the European desserts mentioned in these cookbooks (Samancı 2018). Apart from wine and rakı, during the nineteenth century, new alcoholic beverages enriched also the drinking habits of urban elites: beer, champagne, and spirits imported from Europe.

Eating and Drinking Habits in Modern Turkey

In republican Turkey (since 1923), founded on the remains of the Ottoman Empire, the culinary tradition has continued to represent both traditional and new "modern" features both in urban centers and rural areas. The different regions, which make up Turkey each offer their culinary individuality linked to their ecological heritage and the various influences these receive or have received in the past. The cuisine of Istanbul continued to serve as the urban model par excellence (Sauner 2008).

The dichotomy of traditional (*alaturka*) and modern (*alafranga*) cuisines, which emerged since the second half of the nineteenth century in Ottoman culture, became evident in the urban centers during the first decades of Republican era. The cookbooks published since 1930s clearly demonstrate this dilemma. While eating and drinking habits in urban areas adopted new modern table manners and some of the new culinary techniques, food culture including table manners in rural areas remained for a long time traditional. Modern table manners as well as new dishes inspired from European cuisine have become widespread in society through the educational institutions such as girls' schools and institutes (Samancı 2016b).

During the Republican period, the culture of eating out in the cities has been developed. European-style restaurants, which started to be opened in Istanbul since the second half of the nineteenth century, became widespread during the Republican period. As a result, the culture of restaurants in the European style has been recognized along with the traditional ones such as eatery shops called "*esnaf lokantasi*" and street food sellers. The migration movement from rural areas to cities accelerating since the 1950s has brought new tastes to the culinary culture in the cities; examples of South-east Anatolian cuisines such as spicy kebabs, kibbeh, or *lahmacun* (a kind of flatbread topped with minced meat mixture made of parsley, onions, red peppers, tomatoes) became widespread then in Istanbul.

The food industry, which was developed during the Republican era, influenced the dietary habits of the Turkish population. New consumer goods such as tomato paste with the development of the canning industry, margarine with the development of the oil industry, and sparkling and noncarbonated drinks with the development of the beverage industry entered into the daily life of Turkish people. Generally speaking, the change in eating habits reflects the opening up of the country, and its growing industrialization. Eating habits have undergone a certain number of changes since the 1960s. The development of transport and the increasing importance of the urban model have led to the arrival of fruit and fresh vegetables in regions which previously did not eat them (Sauner 2008). These changes have introduced a greater diversity in the diet, which was previously based on local products and linked very strongly to family economics. Vegetable oil (sunflower or maize oil) or margarine have almost entirely replaced traditional tail fat and butter, while the habit of drinking tea all day long has become established over the last 40 years (Sauner 2008).

The period since the 1980s constitutes a decisive era where changes in eating and drinking habits became more evident in Turkey. This period corresponds notably with a big opening towards the exterior, the generalization of the market economy, the concrete implications of massive urban migration, and the participation of women in the business sector and the large-scale development of the media. Global food chains as well as restaurants serving international cuisine started to be opened in cities. The urban population, which represents 70% of the population, started to buy the basic ingredients, which would previously have been home made. On the other hand, regional cuisines have gradually integrated also the variety of ingredients available in the city. Numerous dishes prepared in Anatolia were little known in Istanbul until recently. The opposition between an urban diet and a rural one continues to represent an important factor of social difference. The urban centers continue to attract rural populations affected by the economic crisis. Even though emigrants preserve their main food habits in their new home, they also quickly adopt some aspects of urban food culture (Sauner 2008). Food publications and media programs, which have been increasing since the 1990s, have brought urban and rural culinary cultures closer to each other and led to the emergence of a more homogenized culinary culture in the country. After 1990, the traditional food production and culinary practices were subjected to a rapid change in both rural and urban areas in Turkey with the impact of globalization, urbanization, and a decrease in agricultural production.

Today's regional cuisines in Turkey are defined as the Black Sea (iconic foods are anchovies, maize and kale), Mediterranean (represented by citrus fruits, tahini and pomegranate), south-east Anatolian (famous for kebabs and *lahmacun* and baklava), Aegean (renowned for fish, shellfish dishes, olive oil and wild herbs), central Anatolian (homeland of wheat, bulgur and a savory pastry called *börek*), eastern Anatolian (land of butter, meat and wheat), and Marmara cuisines (representing the Ottoman culinary heritage). These regional cuisines tend to accentuate their differences in tastes and culinary practices from the national Turkish cuisine represented in Istanbul (Samancı 2019).

Conclusion

Food and drinking habits in Turkey as well as in Balkans, Greece, and Middle East reflect still today an Ottoman culinary heritage. Despite the changes that occurred in food production and consumption patterns in Turkey because of various factors such as industrialization, population growth, and migration from rural to urban areas and globalization, traditional food habits in terms of food preparation techniques still continue. The basic types of dishes prepared in today's Turkish cuisine such as kebab, stews, *köfte*, pilaf, halva, baklava, savory pastries, stuffed vegetables, and various desserts have existed since the Ottoman era. New culinary techniques adopted from European cuisine since the nineteenth century such as sauce, garnish, French fries, cake, creamy pastries like profiterole became acculturated today in Turkish cuisine. Regional differences in Turkish cuisine in terms of use of ingredients, food rituals, and culinary techniques continue to exist, but each day food culture in Turkey becomes more homogenized representing a national cuisine.

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History of Spices

4

Paul Freedman

Contents

Abstract

Spices had an important place in ancient and medieval cooking. Medical theories about diet and health overlapped with taste preferences. The recipes of classical Greece and Rome favor sharp flavors, while those of the Middle Ages result in dishes that are sweeter and more perfumed. Spanish and Portuguese colonization of the Americas circulated the chili pepper whose acceptance was considerably greater in Asia and Africa than in Europe. The origins of modern European cuisine can be identified in changes led by France during the seventeenth century. Among the key shifts was the displacement of spices in sauces and their general decline in all manner of recipes. Britain and North America retained a certain affection for spices through the cuisine of foreigners – Indian and Mexican restaurants, for example. Some of this love of the piquant has now spread through culinary globalization.

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Introduction

This essay looks at the history of spices, particularly in Europe and North America. Most of the spices used in cooking come from tropical countries that have extensive and complex culinary cultures. From the ancient and medieval European perspective, the places that supplied precious and expensive spices were distant and exotic, even magical. India was the most important of the Asian lands where spices were reputed to be abundant. This version of India combined real and imagined attributes, rivers of jewels, hot climate, naked wise men, and proximity to the Garden of Eden, but also cobras and semi-human people, some with dog heads, others with no head at all but faces in their chests. A venerable legend, going back to the seventh-century AD, has it that there are vast pepper forests in India infested with poisonous snakes. The only way to obtain the pepper is to burn the trees, driving out the snakes. This explains why pepper is black and shriveled and why it is costly, because in order to have another harvest, a completely new set of trees has to mature (Freedman 2008, pp. 133–134). The coexistence of attractive and disturbing exoticism is typical of the image of Asia in European eyes and the allure of its precious aromatic products.

European attempts to discover where spices came from constituted a long research campaign that would transform the world, beginning in the sixteenth century. European colonization of the Americas resulted in some incremental additions to the list of spices, most importantly the many kinds of chili peppers. These would have a greater impact on India, Indochina, and Africa than on Europe where by the eighteenth century, the use of all spices in cooking was declining because of changes in gastronomic taste and the image of spices as luxuries.

The Repertoire of Spices

Spices have historically been distinguished from herbs. While employed in similar ways as spices, herbs are domestic European products. Gathered from gardens, forests, and hedgerows, herbs fetched modest prices. Spices, however, were once valuable mainstays of international trade. In the medieval era, they were sold in small amounts at high prices by apothecaries rather than alongside routine cabbages or fish in food markets. Indeed, their value was so great as to stimulate extremely risky expeditions to find their native habitat.

Spices were imported aromatics derived from roots, resins, fruit, or bark. Because of the distance they had to traverse, they had to be nonperishable, at least in the short to medium term. Some spices such as nutmeg or black pepper release their flavor when ground so that they will keep a long time until they are pulverized. A pharmaceutical text of the eleventh century known as Circa *instans* and its later French version, the *Livre des simples médecines*, states that nutmeg will last for 7 years and peppercorns for 40 (Freedman 2008, p. 123). In other cases, such as ginger, the spice must have arrived in Europe dried up and deteriorated in comparison with its condition when it was harvested. Saffron was exceptional as it was among the most valuable and durable spices but could be grown in Europe. In the Middle Ages, when the use of saffron was all the rage, the major saffron suppliers were Catalonia and Tuscany.

If we look at products the term “spices” covered, we find that many are not the familiar edible substances we would expect but any relatively nonperishable commodity valuable enough that was profitable to transport even small amounts over long distances. Thus, what appear as spices in merchant manuals might include medicinal substances, perfumes, and even materials used for dyeing textiles. *La pratica della mercatura,* a medieval handbook of commerce composed around 1340, lists 288 so-called spices, classifying, for example, 14 kinds of alum, an inedible mineral used as dye fixative. The Florentine Baldassare Pegolotti, author of this manual, mentions some now mysterious spices such as *vescovo* (literally “bishop”) (Lopez and Raymond 1955, pp. 109–114). Marvelous drugs include “mummy” (*mumia*), a solidified secretion of embalmed corpses, considered a sovereign remedy for dysentery and bleeding, especially useful for treating wounds (Camille 1999, pp. 297–318). This too was a nonperishable import, usually but not exclusively from Egypt. Anything valuable in small quantities from far away might qualify as a spice, but here, since the discussion is about food and drink, we will limit ourselves to edible products.

Gastronomy

Classical literature has many descriptions of feasts, but only one complete cookbook survives, that attributed to Apicius, a first-century Roman gastronome of whom Pliny the Elder said: “Apicius, the most gluttonous gorger of all spendthrifts, established the view that the flamingo’s tongue has a particularly fine flavor” (Pliny 1983, p. 133). The book, known as *Apicius de re coquinaria*, may have been put together around a core of recipes going back to the era of Apicius, but he seems to have been famous as an aficionado rather than as an author of recipes. The Latin style of the book indicates a considerably later compositions, probably at the end of the fourth or the early fifth century (Wilkins and Hill 2006, pp. 208–209). From the Greeks, there are no complete cookbooks, but information can be reconstructed from the discourses about food composed by Athenaeus of Naucratis who wrote in Greek and flourished around 200 AD. His *Deipnosophistae* (*The Learned Banqueters*) is an immensely long series of witty conversations about food, purportedly during a single banquet, the apotheosis of the sometimes-annoying habit of talking about other meals and food while dining. Athenaeus’ opinionated gentlemen recite snatches of poetic and philosophical texts that have allowed later scholars to put together pieces of otherwise lost works of Greek literature. For example, Athenaeus includes 62 excerpts from the lost cookbook of Archestratus, *The Life of Luxury* (Archestratus 2011).

Classical connoisseurs favored sharp, pungent herbs such as rue, thyme, and myrtle. Their favorite spices were pepper and silphium, a latter a plant that grew in what is now Libya. Silphium was a wild shrub, never domesticated, whose extinction by the first-century AD was due partly to bringing land under cultivation and partly to its excessive popularity. Its taste appears to have been strong, sharp, and sour as can be deduced from its replacement by the Indian spice asafetida, which Roman gourmands considered an adequate if imperfect substitute (Dalby 2000, pp. 17–19).

If silphium was the great exotic spice of ancient Greece and Republican Rome, pepper was the most sought-after spice of the Roman Empire. Archaeological exploration of sites along the Egyptian Red Sea coast has revealed extensive pepper importation from western India and aided by the predictable monsoon winds of the Indian Ocean. This trade was sometimes seen as disadvantageous to Rome, and critics bemoaned the love of luxury that induced the Empire to part with its treasure for gourmet frivolities. Pliny, again in the role of advocate for culinary simplicity, asked, "Who was the first to try it (pepper) with food? Who was so anxious to develop an appetite that hunger did not suffice?" Pepper (he continues) is neither sweet nor beautiful, merely pungent; nevertheless, men travel to India and spend gold and silver to acquire it (Pliny 1968, pp. 28–29). Goods from India were sold in Rome at 100 times their original value, Pliny estimated (Pliny 1947, p. 101).

The *De re coquinaria* mentions a large number of Mediterranean herbs along with imported spices such as ginger, peppers, coriander, and cumin. The recipes are exotic, even for their time, including unusual ingredients like flamingos, parrots, and sea urchins. There are six recipes for sow's womb. The various sauces usually include herbs as well as pepper. A wine sauce to serve with truffles consists of pepper, lovage, coriander, rue, and honey along with the wine (Apicius 1936, p. 56).

Medieval culinary taste in comparison to that of the ancient world was for sweet rather than sharp spices. The medieval spice dossier was larger than that of the Roman Empire and included cinnamon, nutmeg, cloves, and sugar. Although not aromatic, sugar functioned as a spice because it was expensive, imported, and credited with medicinal as well as gastronomic uses. Information about these new spices as well as their supply was obtained via the Islamic world, which by 900 controlled North Africa, the Middle East, and the former Persian Empire and would soon incorporate much of India. Islamic traders handled the spice trade from Indonesia and South Asia as far as the Mediterranean.

Spices were not the only luxuries picked up by elites in Christian Europe from their perceived religious enemy. Silk clothing, inlaid metalwork (e.g., "damascened" steel), and perfume substances such as musk and ambergris were brought from Islamic civilization by Crusaders, Venetians, and other intermediaries to become items of high fashion. The use of spices as well as dried fruit, rosewater, almonds, and sugared sweets such as nougat suggests Islamic origin. There are very few actual correspondences between Arabic cookbooks and those of the medieval West, however. Wine and pork, forbidden to Muslims, were basic to Christian European cuisine. Even when the name of a dish was adopted, the European version often differed radically. North African *ma'mūniyya* was boiled rice with chicken and sugar, sometimes scented with camphor or musk. Across the Mediterranean, *mawmeny* or *mamonia* was a cold pudding made with almond milk and wine that contained raisins, spices, sugar, and ground chicken or mutton (Laurioux 2005, pp. 313–316).

Considerable Islamic influence seems, nevertheless, undeniable. Medieval cuisine tends to be more fragrant than that of the classical period and more oriented toward meat. Fish remained important in Catholic Europe because fasting regulations forbade meat during a considerable part of the year, almost half of the days according to some scrupulous observations, but meat was preferred. The prestige accorded in the Middle Ages to lamprey, which tastes like beef but qualified as a fish for fasting purposes, suggests how much esteem meat received (Freedman 2020).

Medieval cuisine depended on aromatic ingredients now almost unknown in Europe and North America such as Indian long pepper or African malagueta (a peppery spice more often known as "grains of paradise") or spices such as galangal, familiar today through Thai or other East Asian food. In Geoffrey Chaucer's *The Canterbury Tales* (written shortly before 1400), the cook, one of the pilgrims, is said to be expert in the use of galangal as well as a spice mixture called *poudre marchant*:

> A Cook they hadde with hem for the nones,
> To boil the chiknes with the marybones,
> And powdre-marchant tart and galingale.
> Wel coude he knowe a draughte of London ale.
> He coulde roste, and seethe, and broille, and frye,
> Maken mortreux, and wel bake a pie. (Chaucer 1962, p. 423)

The tart *poudre marchant* is mysterious because it does not appear anywhere in medieval cookbooks.

The fourteenth-century *Le Viandier*, the most widely circulated medieval cookbook, lists what a chef should to have on hand by way of spices: long pepper, ginger, grains of paradise, mastic, saffron, "round" (i.e., black) pepper, cinnamon, cloves, cassia, and nutmeg. Individual recipes in the *Le Viandier* employ other spices such as cubeb, cardamom, and zedoary (Laurioux 1989, p. 40).

Pepper, ginger, sugar, and cinnamon were the most common imported spices during the Middle Ages, making up over 90% of those brought to Venice between 1394 and 1405, for example (Wake 1979, p. 396). What distinguished the truly wealthy from the merely comfortable classes was consumption of the most expensive spices such as cloves, saffron, nutmegs, and grains of paradise.

As is the case today in most countries whose cuisine includes a range of spices, mixtures were made up by spice merchants and used in recipes. Various combinations such as *garam masala* in modern India or *ras-el-hanout* (literally "the best of the shop") in Morocco include certain defined ingredients, but each person's blend is different. The skill of the cook is measured by expertise in mixing spices and timing their use while cooking. Although Chaucer's *poudre marchant* is otherwise unattested, there were a number of widely recognized standard mixtures. *Poudre blanche* blended cinnamon, nutmeg, and ginger; *poudre fort* involved black pepper or even more pungent long pepper in combination with sweet spices such as cinnamon and ginger; and *poudre de duc* (supposedly named after the Doge of Venice) used sugar in the same way as pepper in *poudre fort*, as a medium to be mixed with sweet spices, especially cinnamon (Scully 1988, p. 357; van Winter 2007, p. 384).

Medieval culinary preferences included combining sweet and sour ingredients, paying attention to color and employing sugar to flavor entrées. Recipes make considerable use of such products as almond milk while ignoring butter and present a repertoire of sauces that were primary vehicles for the use of spices.

There is some debate as to the quantities of spices used as the recipes are not specific. The immense amounts of spices bought for state occasions do not mean they were all to be applied to preparing dishes – many were given away as presents – yet the numbers are nonetheless impressive. For the marriage in 1475 of George, Duke of Bavaria-Landshut (known to contemporaries as "George the Rich"), 386 pounds of pepper were ordered, along with 286 lbs. ginger, 207 lbs. saffron, 205 lbs. cinnamon, 105 lbs. cloves, and 85 lbs. nutmeg (Freedman 2008, p. 6).

A household advice book of the late-fourteenth century known as the *Ménagier de Paris* is an unusual source of culinary information because the author was a member of the upper bourgeoisie, not a man of the highest rank, while most other medieval cookbooks are by court chefs. The author of the *Ménagier* wrote a private compendium intended for his young wife's instruction rather than a work of public circulation designed to impress others. What is striking about the over 400 recipes in the *Ménagier* is not so much the quantity of spices as their ubiquity. Spices now relegated to dessert in European cuisine (cinnamon, cloves, and nutmeg) appear in meat, fowl, and fish recipes. The author of the *Ménagier* is by no means recklessly extravagant. He recommends making *sauce moutarde* with spices that have already been used to flavor wine, aspic, or other sauces, showing thrift as well as enthusiasm for spices (Brereton and Ferrier 1994, p. 748).

A Catalan cookbook written shortly before 1500 by Mestre Robert, chef to the king of Naples, gives about 200 recipes of which 154 contain sugar, 125 cinnamon, 76 ginger, 54 saffron, and 48 pepper (Mestre Robert 1977). The presence of these ingredients in non-dessert dishes contrasts greatly with what would become the norm for European cuisines after about 1700 at the latest. Clearly, spices were consumed by the higher ranks of medieval society in great quantities, variety, and in all manner of preparations.

Medicine and Cooking

Although the focus of this article is the use of spices in gastronomy, something should be said about the overlapping considerations of health in relation to diet. In the ancient Mediterranean and in medieval Europe as well, spices, diet, and health were closely linked. The greatest classical authority on medicine, Galen (129–ca. 200 AD), was the author of *On the Powers of Food*. He distinguishes himself from mere cooks in that his primary aim as a physician is health and not pleasure. Many delicious things are bad for you, but Galen acknowledges that in order to induce people to follow a healthful dietary regimen, what doctors recommend must be at least moderately appealing (Wilkins and Hill 2006, pp. 10–11).

The distinction between cookery and medicaments remained uncertain, and it is sometimes hard to decide whether we are dealing with medical or culinary recipes. The *Opusculum de saporibus* of Maino de Maineri, dating from between 1330 and 1340, provides recipes for all manner of highly spiced sauces for meat, but it is what we would consider a medical handbook with warnings against excessive use of sauces by healthy people who really do not need them (Thorndike 1934, p. 186; Scully 1985). The author admits, however, that sauces were invented by those more interested in pleasure than health, so that although there is a border between medicine and cuisine, it is constantly being crossed.

The intersection of cuisine and health considerations is evident in the prevailing medieval theory of humors, the four fundamental bodily fluids that corresponded, it was thought, to the four basic elements (earth, water, fire, and air) and the four physical qualities, hot, cold, moist, and dry. The four humors were blood, yellow bile (also known simply as bile), black bile, and phlegm. Blood is linked to air and has warm and moist qualities. Yellow bile's element is fire and it is hot and dry. Phlegm is cold and moist, just as water is. Black is cold and dry and corresponds to earth. Individuals must balance these, although no one is perfect. Everyone has a particular temperament favoring one of the four humors, but too much imbalance results in disease as well as distortions of personality (Scully 1995a, pp. 41–51).

Foods themselves possessed humoral properties, and so diet was supposed to be adjusted to the individual temperament. Some spices such as pepper were regarded as extremely hot, while others such as cinnamon were only moderately so. Spices were for the most part considered medically hot and dry, countering the excessive moisture and coldness inherent in many meats and fish and tempering other ingredients.

A person of melancholic humor should consume more hot and dry spices than one of bilious temperament who must avoid too much spice because he is already sufficiently or even excessively hot and dry. As already mentioned, lamprey, a migratory eel-like creature, was classified as a fish. As with eels (to which in modern scientific taxonomy it is not, in fact related), lamprey was supposed to be dangerous as well as delicious. Cold and moist in the fourth degree, lamprey needed to be cooked in such a way as to neutralize its perilous humoral properties. Black pepper sauce was recommended because pepper was hot and dry in the fourth degree (Flandrin 1999, pp. 320–327).

In the *Opusculum de saporibus*, there are classic culinary preparations such as green sauce (parsley, rosemary, breadcrumbs, white ginger, cloves, and vinegar) useful on boiled mutton, kid or veal, and black pepper sauce, which includes verjuice, pureed liver, toast, and, of course, pepper, appropriate for roast geese and aquatic fowl. The definition of "appropriate" for sauces involved both complementary taste and humoral balance.

In order for the tempering process to achieve equilibrium, the ingredients had to blend (Scully 1995b). Meat was better complemented by sauces when minced or ground up, one reason for the highly processed nature of medieval food preparation. Recipes seldom involve simple treatment but rather call for many steps that often render the ingredients unrecognizable. Typical of complex poultry dishes is a recipe from a fifteenth-century English cookbook for *blaunche de sorre*, which involves blanching and grinding almonds and combining them with sweet broth into which is put ground cooked capon. This mixture is then boiled in milk, sugar, and sweet wine (Hieatt 1988, p. 58).

Spices such as nutmeg or cinnamon that we associate with cooking were also key ingredients in medicines and preventives (Matthews 1980; Whittet 1968). The word "recipe" was applied to pharmaceutical as well as culinary preparations, and in most European languages other than English, the word for "prescription" and "recipe" is the same. Medieval pharmaceutical manuals offer directions for filling pomanders, portable openwork metal balls that carried aromatic products in order to counteract bad odors that were not only unpleasant but also thought to carry disease. Edible spices like nutmeg and cinnamon were included along with perfume ingredients. On the other hand, substances we think of as medicinal or cosmetic – ambergris, musk, camphor, or sandalwood – were added to food in imitation of Arab, Persian, and Indian practice. As late as the English Restoration era, eggs with ambergris were a luxurious and (supposedly) healthful favorite (Macaulay 1849, p. 442).

A longer-lasting aspect of the dual role of spices as both food and medicine is in the origins of candy. Like cordials (flavored alcohol distillations), candies began as digestive aids to be consumed after a meal. Sharp medicinal herbs could be rendered pleasant when made into a kind of brandy, as with some of the modern descendants of monastic concoctions such as Chartreuse or Bénédictine. Similarly, sugared spices, known as comfits, originated as ways of consuming spices directly, rather than as sauces to accompany food. Pharmacists made up medicines with sugar paste called electuaries, and one finds these being eaten as what might be considered after-dinner wellness treats. In Chrétien de Troyes' twelfth-century romance *Perceval*, the hero arrives at the mysterious Grail Castle where a meal whose main course is peppered venison is followed by candied fruit, nutmegs, cloves, gingerbread, and electuaries. An example from real life, just before retiring into a conclave to elect a new pope, the cardinals at Avignon in 1371 ate 12 pounds of candied spices (Chrétien de Troyes 1991, pp. 421–422; Aliquot 1984, pp. 132–133).

Spices and Modern Cuisine

Modern European cuisine differs from that of the Middle Ages, rejecting the spectrum of complex and piquant flavors in favor of intensity and simplicity. Many Asian spices such as zedoary, long pepper, and galangal, all familiar to medieval cooks, were discarded. Modern cuisine and its turn away from spices began in seventeenth-century France with the development of what would become classic haute cuisine that was based on new principles. In particular, sauces were now rich, buttery meat reductions flavored with shallots, herbs, and truffles rather than the thin, sweet and sour spiced sauces of the Middle Ages. France, the trendsetter, became by the middle of the eighteenth century the undisputed guardian of culinary orthodoxy, a position it held until the end of the twentieth century. An important aspect of what has rightly been called a culinary "revolution" was to devalue spices.

Seventy percent of the English medieval recipes collected in a modern adaptation entitled *Pleyn Delit* call for some sort of spice, usually in combinations, and 27% of its recipes specifically require cinnamon. Compare this with François Massialot's *Cuisinier roial et bourgeois*, published in 1691, which has cinnamon in only 8% of its recipes and is altogether lacking in such medieval requisites as saffron or grains of paradise (Hieatt et al. 1996; Flandrin 1992, pp. 177–192; Peterson 1994, pp. 195–196).

Sugar was segregated into a dessert course, but it would break out of the confines of conventional cooking and dining, accompanying chocolate, coffee, and tea, all unknown to the Middle Ages. No other edible commodity would have such a cataclysmic effect on world history as sugar. Insatiable European demand fueled the first great trans-Atlantic slave trade and made New World colonization tremendously profitable (Mintz 1985).

Black pepper also was an exception to the eclipse of spices, retaining some modest importance in French cuisine for savory dishes. Saffron shows up in a few Spanish preparations, in *risotto alla Milanese* and in the French monkfish recipe *lotte au safran*. Nutmeg is still used in Italian sauces. Modern European cuisine, however, relies on culinary effects that have nothing to do with spices.

The reformed French cuisine of the seventeenth century stressed harmony and smooth combinations of natural flavors. Simplicity, authenticity, intensity, and vividness were placed above what was seen as an unpleasant medieval fondness for the exotic, unusual, and complicated. In the cookbooks published by François Pierre La Varenne (*Le cuisinier françois*, 1651) and Nicolas de Bonnefons (*Les délices de la campagne*, 1656), "delicate" and "natural" cooking meant, in the first place, simplicity that depended not on spices or other distractions but on the actual quality of primary ingredients. This might include vegetables, which had been largely despised or ignored by medieval chefs. Typically, the new French simplicity was rather expensive and elaborate. The garden expert Jean-Baptiste de La Quintinie identified 47 varieties of pears that, with the aid of hothouses and strategically positioned garden beds, could produce fruit every week between July and February. Bonnefons in *Le Jardinier françois* shows how to have cabbages ready to pick during 10 months of the year (Pinkard 2009, pp. 67–78).

Amidst all this attention to primary constituents of cooking, spices were attacked as covering up natural tastes, as childish, and even as "Arab." The first criticism is part of a consistent oscillation in Western gastronomic history between nature and artifice, between simplifying in order to experience the beauty of fine ingredients and innovation in order to create never-before experienced taste sensations. Each in turn produces a counterreaction, rediscovering basic products or putting together daring and novel concepts.

The seventeenth century saw a turn toward natural flavor. In another treatise by Bonnefons, meaningfully entitled *Les délices de la campagne* ("The Delights of the Countryside"), the author instructs his reader: "Each food in its natural taste is more agreeable." Thus, "A cabbage soup should taste entirely of cabbage, a leek soup of leeks. . .." (Pinkard 2009, p. 120).

"Childish" meant use of sugar in meat or other courses where it was now deemed inappropriate. Medieval taste had mingled sweet and savory flavors and spices in a way that resembles current Middle Eastern or North African cuisines. In seventeenth-century Europe, as has been mentioned, sugar was separated from savory courses, while spices considered sweet, such as cinnamon, cloves, and nutmeg, were likewise restricted to desserts.

Finally the supposedly "Arab" aesthetic reflects the degree to which medieval cookery had been influenced by the complex, perfumed, high-end cuisine of the Caliphate and its successors, but now this was a source of contempt for the reformers. The cookbook author known to posterity only by the initials L. S. R. in his *L'art de bien traiter* of 1674 criticized his predecessors for mixing fruit, meat, and spices (e.g., turkey with raspberries, frog legs with saffron). His withering judgment was that "[these] would be more willingly tolerated among the Arabs. . .than in a refined atmosphere such as ours, one of propriety, delicacy and good taste" (Wheaton 1983, pp. 150–151). The implications of this condemnation go beyond the historical connection between prestige cuisines during the Middle Ages to an identification of Europe and modernity itself with a virtuous yet elegant culinary aesthetic.

The modern sauces of seventeenth-century France were thickened with roux, egg yolks, and butter. Glossy and rich, they were not spicy and so differed in texture and flavor from the thin, grainy aromatic medieval sauces that used breadcrumbs as thickener. French sauces now incorporated juices produced by principal ingredients, supplemented by liquids such as bouillon, wine, cream, and they were flavored with herbs. Textured, silky, satiny, and velvety, these sauces were voluptuous because they included a lot of fat which magnifies flavor so that peas or asparagus in French sauces could still be said to taste of peas and asparagus. Rather than a humoral corrective as was the medieval practice, sauce here is supposed to enhance and intensify.

The triumph of French cuisine was not immediate, and much of the rest of Europe clung to the medieval and Renaissance practice of using spices extensively. In the second half of the seventeenth century, the French expressed contempt for other countries' old-fashioned culinary customs. Criticism centered on excessive or inappropriate use of spices and sugar. Gaspard d'Hauteville resided for several years in Poland in the mid-seventeenth century, but never got used to its exotic and archaic food replete with saffron, sugar, cinnamon, and nutmeg. French cookbooks sometimes described chicken with saffron as prepared "in the Polish style" (Pinkard 2009, p. 125). Italy and Provence too were suspect for their spicy and sweet sauces, and the Spanish, according the Countess of

Aulnoy writing in 1691, were hopelessly addicted to perfumed food and saffron (Gillet 1985, pp. 159–167).

There are a number of possible reasons for this French revolt against more than a millennium of spiced foods and particularly spiced sauces, but no single cause is in itself convincing. Disenchantment with spices may have something to do with the arrival of new beverages coffee and tea from Asia and Africa, and chocolate from the New World. Unlike spices, these produced psychological effects through caffeine. Tobacco, not an edible but certainly a psychoactive New World product, might also have cut into the appeal of spices as a rather different aromatic delivery system. This would not, however, explain the continued attachment to spices outside of France, in places such as England whose aristocracy adopted most French innovations enthusiastically. The real counterexamples are the Ottoman Empire and the Islamic world generally where coffee had been known for centuries, and tobacco was rapturously welcomed, yet in these lands spices remained vital culinary ingredients.

New World Chilies and Their Diffusion

Western European disillusion with spices coincided with the worldwide influence of the major New World contribution to the world of spices, the variety of flavors from chili peppers. The European explorers were disappointed not to have found in the Americas the Asian spices like nutmeg and black pepper that they had set out for, and indeed, the new colonies were relatively poor when it came to aromatic products in comparison with Asia. Allspice is one of the few New World spices commonly sold in Europe and America. Others, like achiote or epazote, have not travelled.

Chili peppers, varieties of the *Capiscum* genus, were first domesticated 7000 or 8000 years ago, probably in central Mexico. The extent and history of their diffusion in pre-Conquest America is unclear, but they were an important flavoring and nutrient and a food associated with religious rituals among many people and nations (Kraft et al. 2014). A physician on Columbus' second voyage, Diego Álvarez Chanca, observed the significance of chilies in the diet of the "Indians," commenting also on the versatility of chili pepper and its many varieties (Olson and Bourne 1906, pp. 311–312).

The chili pepper has influenced only a few aspects of European cuisine. Smoked paprika is a specialty of the Estremadura region of Spain. Although most Italian food eschews piquant flavors, Calabria makes extensive use of dried red pepper, including even in *grappa*. Hungary developed a range of paprikas from mild to hot, and this variety of *Capiscum*, dried and ground into powder, has become the prime symbol of Hungarian cuisine. The use of paprika was extended with the development of mild varieties in the nineteenth and early twentieth (Anderson 2016, pp. 46–55). Apart from these exceptions, however, highly spiced cuisine remains alien to Europeans or has only recently been introduced through global trends such as Thai or Mexican food.

Chili peppers were spread by the Spanish and Portuguese expeditions and conquests. Peppers were adopted not only in places actually colonized by the Iberian powers, but through intermediaries, so that, for example, the presence of hot peppers in China results from diffusion via Portuguese Macao or perhaps India. No area was as quick to adjust its cuisine to the new ingredient as India, almost all of whose cooking styles now employ chilies. Within 50 years of Vasco da Gama's arrival on the west coast of India in 1498, chilies were so familiar that many authorities came to believe they were indigenous (Collingham 2006, p. 11).

Chilies were made into various spice combinations, sauces, and relishes from the piri piri of Portuguese Africa to harissa in North Africa to sambals in Indonesia. The use of chili pepper is not uniform: in China, only in Hunan and Sichuan is it essential to cooking. In Thailand and Indochina, many dishes are infused with pepper, and sauces such as Sriracha give added hot flavor. In Indonesia, hot spices are more often an external relish rather than integral to food preparation.

All of this culinary transfer and activity left the arbiters of European cuisine almost unaffected by chilies save for the above-noted exceptions. During the eighteenth century, French cuisine took over as the international standard of sophisticated food consumed by the wealthy and the aspiring classes.

Spices were largely anathema to the French authorities, but other countries reached compromises with tradition. Margaretta Acworth's manuscript cookbook, dating from the mid-eighteenth century, reflects the tastes of the English lesser aristocracy, the sort of people described in Jane Austen's novels. Acworth offers a recipe for spiced beef in red wine, flavored with pepper, mace, and nutmeg, which maintains a connection to medieval antecedents (Acworth 1987, p. 66). The persistence of spices is visible in puddings, pies, and other desserts. In France, even desserts include spices as only a light flavoring, but the medieval complex of spices, sugar, and dried fruit is characteristic of beloved, if now slightly archaic, English sweets like plum pudding and fruitcake. Gingerbread remains popular in northern Europe while it has disappeared from France and the Mediterranean. Italy is an exception as *panforte*, a flat, fruitcake-like specialty of Siena, reflects a medieval heritage. Christmas treats in particular retain an earlier era's idea of appropriate spices: *Pfeffernüsse* (sweet spiced biscuits) in Germany, *Lussekatter* (saffron-covered buns) in Sweden, and plum pudding in Britain are Christmastime requisites. In the United States, the Thanksgiving holiday menus offer some of the same comforting archaism with highly spiced pumpkin and mince pies. The current American fad for "pumpkin spice" led by such companies as Starbucks and Trader Joe's indicates the persistence and reworking of essentially medieval tastes.

All this notwithstanding, the story of spices in Europe and America in the nineteenth and twentieth centuries was one of decline, in contrast to most of the rest of the world. The hostility toward "Arab" spices expressed by the seventeenth-century French reformers became a broad mistrust of Asian, African, and Latin-American cuisines that were perceived as excessively spicy. In the first place, such use of spices was deemed unpalatable, but it was also believed that spices covered up the use of deteriorating primary ingredients. This partly explains the durability of the false but to this day widespread impression that medieval taste favored spices because of the poor quality of the meat or fish.

In the late-nineteenth-century United States, nutritionists, social workers, and home economists tried to “reform” the food habits of the working classes and to Americanize immigrants from Southern and Eastern Europe. They extolled a simple diet based on meat, dairy products, refined sugar, and modern processed foods and viewed spices as distractions from nutrition. Worse, spices, pickles, and other sharp flavors were thought to lead to indigestion and increase susceptibility to alcoholism (Biltekoff 2013, pp. 24–36; Elias 2017, pp. 32–42).

In addition to suffering from a poor international culinary reputation, Britain and America had a contradictory attitude toward spices. As seen in any number of cookbooks, Anglo-American food was bland, a tendency accentuated by the early embrace of industrially produced bread, canned and later frozen vegetables, and the like. Processing offers convenience, but at some sacrifice of natural flavor. The tasteless primary ingredient encouraged using spices to make things more interesting. Condiments such as Tabasco and A1 Sauce in the United States or Worcestershire sauce and HP Sauce in Britain routinely accompanied all manner of dishes. Barbecue sauce, a combination of sweet and hot tastes, is widely used in the United States, and barbecue flavor was one of the first variations on the standard potato chip, followed by jalapeño, Cajun, and other spice options. Tandoori crisps remain popular in Britain. Until recently, such peculiar tastes were unknown to Continental Europe.

Some of this latent Anglo-American predilection for spiciness comes from colonial or neocolonial empires. Curry was an English adaptation of Indian cuisine widely disseminated as far back as the eighteenth century. In the early nineteenth century, the curries served at the Oriental and East India clubs in London were famous for their fiery flavor (Forrest 1968, p. 53; Prasch 2008, pp. 597–598). By a process that would be repeated with other imported cuisines, curry became progressively milder as every club and hotel dining room in Britain came to offer it. Until the 1960s, English curry was a creamy and only lightly spiced stew, but the pendulum swung back again toward a formula in which chili pepper was predominant and tough guys held “vindaloo” contests to see who could eat the hottest curry. In Martin Amis’ 1989 novel *London Fields*, a small-time criminal patronizes a restaurant called “The Indian Mutiny” where he challenges the waiters to make a mutton vindaloo that is too hot for him (with “napalm sauce”). This insular, xenophobic character considers eating curry as typically British, like playing darts in a pub (Buettner 2008, pp. 881–885). Spicy immigrant restaurant food might be regarded with affection by the nonimmigrant population, but the people who run the restaurants and members of their ethnic group can simultaneously be regarded with contempt, even fear, as is the case with Mexican restaurants and Mexican immigrants in the United States.

In recent decades, the taste for spices has returned to Europe and North America. This is only partly due to immigration and the proliferation of international restaurants. Thai and Tex-Mex food, which are all the rage in Germany and Scandinavia, have little relation to emigration to those countries and more with global popular culture. Restaurants opened by immigrants are, of course, popular in the United States, but the passion for spicy dishes such as Buffalo chicken wings, Nashville hot chicken, or blackened redfish results from the popularization of domestic local specialties.

The change toward a greater appreciation of spice in Western cuisines is furthered by the globalization of taste, a complementary phenomenon to the spread of Western fast foods. Globalization has both homogenizing effects (the same KFC formula in Beijing and Buenos Aires) and eclecticism – the availability of dozens of international cuisines. Fondness for safe versions of unfamiliar cuisine, once a peculiarity of the United States and Britain, has now spread everywhere. Spices remain both cherished ingredients in local products and universal flavorings for an indistinct global assortment of tacos, pizza, and sushi.

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5 Simplicity and Performance in Roman Agrarian Foods

Charles Feldman and Prudence Jones

Contents

Abstract

In this chapter, traditional, local, and simply prepared Roman agrarian foods are discussed. While these rustic comestibles were revered by some elites for their symbolically embodied history and cultural capital, they were in stark contrast to the more ostentatious fare dressing other aristocratic tables. The degree of respect for agrarian fare was contingent on the social philosophy of the consumer. For the poor and destitute the food choice was easy, they ate almost anything. For the elite ancient Roman conservative who espoused values from a heroic past, rustic foods offered a venue for political gain. Though, this noble may not have been as principled when eating in private. An aristocratic debate, sometimes against consuming whole animals, sometimes against eating parts of animals, sometimes

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against the whole and the part, seemed representative of deeper social issues. The confluence of local and foreign ideology had its effect on consumer preferences and culinary fashion. As long as an ancient Roman food remained intact, recognizable, or natural, it could summon rustic history. When comestibles were masticated or transformed their symbolic meanings moved outside the context of local simplicity, into novelties ascribed to foreign influence. While rustic foods in themselves did not necessarily represent luxury, the local comestible could be manipulated through the artifice of culinary preparation. It was these manipulated foods in particular that evoked mixed messages: traditional by nature, novel through preparation, local yet foreign. The end result, however, would obfuscate historic meanings and, as such, a clear sense of Roman aristocratic identity.

Introduction

> *In earlier times the inhabitants of Italy, said Posidonius, even those who were very well off, used to train their sons to mostly drink, and eat whatever they happened to have. He tells us a father and a mother often would ask a son whether he preferred to have pears or nuts for his dinner. After eating some of these the son was contented and went to bed* (Ath. VI.274).

Posidonius' commentary as relayed through Athenaeus in the third century implied that some ancient Roman foods were imbued with integrity by way of their simple wholesomeness. These rustic foods (*agrestes*) could have been farinaceous products, locally grown fruits, legumes, nuts, or vegetables, or they could have been produced from animals that were hunted or domesticated. On the compendium of processed foods, these foods were simple in that they lay closest to their natural state, requiring a minimum of preparation. Rustic foods could be consumed whole or in part, without any necessary additions, grinding or mixing. These were not the complicated transformed dishes, the stews and the sauces seen among the surviving Roman recipe treatise *De re Coquinaria*.

The context of social conflict in ancient Rome is particularly relevant to understanding these rustic simple foods during the later Republican and earlier Imperial periods (generally the second century BC to second century AD – the era when the textual data on food is most evident). Unequal access to resources precluded choice for many Romans, making consumption of simple foods a matter of necessity for those who were barely surviving, living on whatever they could find. One should assume, for example, that Ovid's fictive peasant couple, Philemon and Baucis, consumed radishes, cream cheese, eggs, nuts, berries, and eggs, because they could not afford to do differently (*Met.*VIII.665–685). At the other extreme, a rustic meal afforded a moral dimension for Roman aristocrats that worked well with the ancient Stoic principles of frugality and self-control (Garnsey 1999). Where an ancient Roman stood regarding social issues was often manifested in the foods he or she chose to eat, report on, or complain about. Roman moralists filtered the values of tradition and national pride through simple foods as an expression of conservatism. To the elite moralist, the idealized Roman past was unified, simple, and uncorrupt, and so was the food. These values were affronted by foreign influence, the influx of riches and ideas from the acquired colonies and its attendant corruptions. Exotic food ingredients and complex, masticated culinary products were topics for many a tirade.

Rustic foods offered the aristocrat a sense of elation that exceeded the food's intrinsic properties. Pliny the Younger, for example, attached to the unpretentious beet, gourd, and shallot the values of, "*unrestrained cheerfulness, simplicity and freedom*" (*Ep*. I.15.2; cf Mart. V.78). These foods were most appropriately served on earthen vessels. Tablecloths, couches on which to recline, or slaves to serve them were not necessary (Mart.V.78; Dion. of Hal. II.23; Hor. *Sat.* I.7.115–18). This lack of pretension was in contrast to an opulent culinary experience, which was a more intense performative occasion. From an alimentary perspective, simple eating was sometimes connected to fitness and well-being (Horace *Sat.* II.2.70–4). Celsus, for example, writing in the early part of the first century AD, dedicated an entire treatise to simple alimentary remedies (*Med.* II.31; cf Orib., V.1, VIII.1–5; Anthim.).

Ingredients of Public Banquets

Although the evidence is limited, historical data attest that the foods served at larger feasts were simple, perhaps as a matter of efficiency. It certainly is difficult to envision ancient Roman chefs creating, opulent stews and sauces in the field for thousands of congregants. Though, some extravagant banquets reportedly included elaborate servings of fish and fowl (Plut. *Caes.* 55.2; Pliny *HN* IX.44; Donahue 1996). In his study of second- and third-century funerary inscriptions, J.F. Donahue (1996) uncovered engravings mentioning the service of mostly simple and local foods at public and private festivals. An extant list of dishes served at a first-century BC priestly inauguration listed only a few imported dishes, with no rare ingredients and while the comestibles were not necessarily simple, there were no overly extravagant preparations. The banquet included sea urchins, raw oysters, scallops, mussels, and cockles, an assortment of meats, fish, fattened fowl, game, hare, and Picentine bread (Macrob. *Sat.*III. 13.12–13; cf Suet. *Iul*. XXXVII.9; Cic. *Phil.* II.116; Pliny *HN* IX.17.1.; Friedlander 1908). Another occasion of record was Julius Caesar's celebration in 46 BC to mark his military triumphs. On this occasion, 6,000 eels (*murena*) were reported to have been served, along with fine Falarian and Chian wines (Pliny *HN* IX.81; cf Varro *Rust*. III.17.3; Cic. *Phil.* II.116; Dio. LXXIII.13.1; Suet. *Iul.*XXXVIII.1, 2; Plut. *Caes.* 55.4). However, the logistics of thousands of fresh fish, from sea to plate, without refrigeration, would have been staggering. Therefore, the reckoning of this event might have been propaganda, to be considered with a measure of skepticism.

Of the other public feasts of which we know, cake and honey wine (*crustulum* and *muslum*), bread and wine (*panis* and *vinum*), and handouts of meat (*viserationes*) were the bill of fare. Dionysius recorded a solemn celebration in which each family contributed a honey cake (II.23). For a feast in the Amphitheater during the Saturnalia (the festival in honor of the god Saturn), Domitian provided sweet meats, plums, figs, pastries, fruit, and must-cakes (a cake made from wine sediment and fillings – Stat. *Silv.* I.6.43; Mart. VIII.78; Donahue 1996; Killeen 1959). A notable exception to banquet simplicity was a feast given for emperor Vitellius to honor his return to Rome in 69 AD. Vitellius reportedly had his captains bring food from the extremes of the empire including 2,000-choice fish and 7,000 birds. In addition, a platter of enormous size that Vitellius called the Shield of Minerva contained a blended mixture of pike liver, peacock and pheasant brains, the tongues of flamingoes, and the milt of lampreys (Suet. *Vit.* XIII.2; Tac. *Hist.* II.62). Again, we should tread lightly in the assessment of these events, which may have been more boastful than real (Corbier 1989).

The elite Roman endorsement of simple foods may have been a devious plan of social stratification and domination. Pierre Bourdieu's high-low argument provides a contemporary understanding of this stratagem. Bourdieu suggested that elites generally design covert plans to maintain class boundaries. In our example, entry to the ranks of the elite would have included an appropriate style of eating. At face value, an elite penchant for rustic foods represented a simple morality, but underneath these foods marked an aristocratic border that excluded foreigners and elite pretenders by rejecting their broader culinary ideas (Edmunds 1980; Bourdieu 1984). That is, certain Roman aristocrats supported their social position through a contrived association with simple living. It was pretense after all, these were nobles of great wealth and influence. To some Romans, consumption of these rustic foods afforded a simple dignity and a connection with the past. Other Romans employed these foods to express prestige and power. From this standpoint, moderation and refinement were held in a precarious balance.

A theme of moral decline over time was a common one in the ancient literature going all the way back to Hesiod in the eighth century BC (*Op.* 109–201). This theme carried over to Imperial Rome when pundits increasingly decried a contemporary decay of virtue and decency. The honor of an elite Roman agriculturist was enhanced by a venerated image of an agrarian past along with spiritual associations. Among the many examples, Romulus, founder of Rome, was portrayed as a rustic. His hut on the Palatine (*Casa Romuli*) was a tourist attraction of the time (Dion. Hal. *Ant. Rom*. I.79). Augustus wore homespun clothes, in deference to a rustic tradition (Suet. *Aug.* 71). The first-century writer Vergil mourned the passing of the idealized rustic life of the small farmer (*Ecl.* 1; 9), while his contemporary Ovid provided a mnemonic description of idealized ancient Roman history when foreign influence and fashion had yet to take its grip (*Fast.* VI.169–82).

Rustic food prescriptions were indemnified in the second century BC agricultural manual of Cato the Elder, *De re Rustica*. They had the virtuous overtones of a pious, self-sufficient Republic that smacked of local agricultural integrity. For example, among Cato's treatise is a recipe for porridge, another for olives and vinegar (*Rust.* LXXXV; CXIX) and his recipe for honey cake made out of cheese and groats (*placenta* – LXXVI) was redolent of a sacrificial cake (cf Hor. *Epist.* I.10.10; Varro *Rust* I.2.28). Two centuries later Athenaeus explained the connection of simple local foods to religious piety, by contrasting the absurdity of indulging of foreign extravagance (IV.274), a theme that had been laced through the ancient Roman literature. The Imperial Roman satirists symbolically contrasted simple agrarian foods with more decadent behaviors in their social commentaries. Persius, writing in the first century, emphasized this point by juxtaposing of simple nettle and pig's cheek to the more opulent goose's liver in a tirade over profligate behaviors (VI.67–74).

Roman writers often portrayed antiquarians as mostly vegetarians who preferred simple meals. For instance, Plautus had his Greek characters call the early Romans *fodder-eaters* (*Pseud.*810; cf Juv. XIV.170–171). Varro told us that the most ancient of Romans meals consisted of grains (*Ling.* V.105). Vergil idealized the Corycian gardener for his traditional self-sufficiency by loading his dinner-table with home-grown delicacies (*G*. IV.116–148). Pliny informed us that the Roman meal *pulmentaria* was so-called, because since the earliest of times Romans lived only on porridge (*puls* – Pliny *HN* XVIII.84; Garnsey 1999; Wyetzner 1995), and Cincinnatus was romanticized for forsaking his toga when plowing his fields (Livy III.26). While beans were sometimes held in high sanctified stature (they held the souls of the dead – Pliny *HN* XVIII.119; cf Ath. II.65c), at other times, they were ascribed to a lowly station, reserved for simple service in clay vessels (Mart. XIII.7, V.78; Hor. *Sat* I.6.116–20, II.6.59; Gell. *NA* IV.11). In a further affront to beans lowly status, the Latin word *fava* was used to signify both the broad bean and the worker (Corbier 1999).

A pantry containing grains, fowl, fish, and pork provided a basic inventory for rustic comestibles (Cic. *Fin.* II.8.23; Varro *Rust.* III.3.4; D'Arms 1999). Cicero mentions fruit and omelets (*Fam.* IX.20). Pliny wrote about a gruel made of pounded emmer wheat (*alicae* – *HN* III.6). Horace employed vegetables, grapes, vetch, long oats, dried raisins, and bits of bacon in developing a heroic context (*Sat*. II.2; II.4.85). His protagonist Ofellus personified this rustic virtue, as he dined on greens, smoked ham shank, chicken, or kid, followed by a dessert of raisins, nuts, and figs (*Sat.* II.2.116–125). Martial, in his Epigrams, provided a fairly complete list of local *agrestes*: cauliflower, chestnuts, pulses, fruit, tunny-fish, sliced eggs, broccoli, sausage, and pease-pudding (V.78) and herbs, squat lettuce, tender young sprouts, leek, mint, and rocket. Add to the preceding a chicken and a ham that has already survived three dinners (X.48). The *De re Coquinaria* provides a number of simple, rustic preparations such as artichokes and eggs (III.19.I) and lentils and chestnuts (V.2.2). Inclusion of agrarian foods in this treatise attests to the versatility of these comestibles within a high-status context.

Honor of Agriculture

The agricultural pursuit to the ancient Romans was more of a sacred art than a job, as the landed gentry did not work. Farming was one of the most dignified Roman professions (Pliny *HN* XVIII.1.5; Sen. *Prov.* III.6). Not only did generals pursue this art, but so did at least four kings of classical antiquity (Pliny *HN* XVIII.4.19–20). Cultivated vegetables were so highly honored that families of the highest rank such as the Lactucinos (of the lettuce) adopted their names (XIX.19.59). The third-century

B.C. senators Curius (Juv. XI.78) and Fabricius were generally known and admired for cooking vegetables gathered in their gardens (Sen. *Prov.* III.6; Dion. Hal. *Ant. Rom*. II.23). This appreciation of rustic identity served as a mark of refinement and a vehicle of performed status for the landed gentry. For example, the elite fashion of "refined starvation" (*famem mundam*) had the haughty crowd hauling vegetables, eggs, fruit, and cheeses to their adorned villas (Mart. III.58.43). Horace provided simple how-to instructions (*Sat.* II) in what appears to be guide for aristocrats returning to their roots:

> *Serve eggs of an long shape, they are sweeter than the round* (19–20) . . .*You will be wise to plunge a tough fowl into diluted wine: this will make it tender* (24–26). . . *Mushrooms from the pastures are best* (20). . . *After dinner, eat the blackest mulberries* (30–32)

Descriptions like these belied a feigned appreciation of rusticity, a message that rings loud and clear in a confession by Juvenal "*I am secretly at heart a glutton: I openly announce to my slave to bring me porridge, while I whisper to him, 'bring me cheesecakes'*" (XI. 60–62). Horace would be unhappy in either direction, for he found extremes of both frugality and gluttony to be distasteful (II.2.65).

Suggesting that a Roman aristocrat ate frugally is perhaps a misconception that attests to the political exploitation of rustic foods (Friedlander 1908). The food that a noble reportedly ate or served reinforced his or her worldview, an image that was often controlled. For example, particular aristocrats were depicted as eating frugal regimes at least on occasion, though it is clear that nothing, certainly not economics, compelled them to do so. Julius Caesar, it was said, made a suckling pig or a hare last for three days and he was content to dine on cabbages and beans without meat (S.H. A. *Did. Iul.* 3.8). Augustus liked light meals of dates and bread or bread and raisins (Suet. *Aug.* LXXVI.3). Seneca ate figs as an accompaniment to some bread, or figs alone serving as bread if the latter were lacking, and Vespasian ate with an air of frugality that was clearly contrived to be in marked contrast with his gourmandizing predecessor Nero (Tac. *Ann.* III.55; Cass. *Dio.* LXV.10.3). As reported, the third-century emperor Tacitus served only country produce and sacrificial meats at his daily table, while the service of a single bird, pig's jowls, and eggs for were restrained to festive occasions (S.H.A. *Tac*. XI.5).

In ancient Rome, an impassioned call for simplicity was often heard when gluttons were blamed for an economic imbalance. A few Romans like Pliny suggested that the purchase of vast quantities of foreign goods was leading directly to the insolvency of Italy (*HN* XII.41; cf Tac. *Ann.* III.53; Sen. *Prov.* III.6; Cato in Ath. 274–5). Reactionary distaste for foreign products made for good rhetoric, but many a tirade was skewed by ethnocentrism. By harnessing the social capital of cultivated ingredients, the Imperial Roman aristocrat began to assert an element of control over foreign and ethnic intrusion. The Roman idea of rustic agriculture was a mixed bag of ideas that worked well symbolically with a unified Roman image. Society once had been self-sufficient, devoid of foreign products, when loyalties were due first to country. Horace and Juvenal used the city of Rome itself as a symbol of societal corruption. Its diversity not only tainted Rome's purity, but also sapped its strength. Juvenal complained about the hoards that had poured into the city of Rome from the likes of Rhodes, Sybaris, and Miletus (Juv. III. 312–114, VI.298; cf III.305; Braund 1989). Horaces's city-country tale metaphorically described the travails of two mice in an urban-rural antithesis (*Sat*. II.6.77–118). As the tale goes, a country and city mouse were eating the leftovers of an opulent feast (ostensibly in the city of Rome) when they were accosted by two dogs. The country mouse then retreated to his home, to the comfort of simple food and the distance from extravagance.

The topic of virility certainly came to play among the juxtaposition of the noble Roman agriculturist to the more urbane city dweller. The former was a warrior, a true man who embraced the land at its natural bounty. His face, which emboldened many ancient coins and sculptures, was weathered, beaten, and hardened. In contrast, the urbane dweller, we are led to believe, was more effeminate in his profession and lifestyle (Grant 1987; Gruen 1992).

The depreciating value of Roman virility was also linked to changing elite food preferences, an idea remorsefully put forth by Persius: "*When this fake philosophy entered the city along with dates and pepper, our farmers have ruined their porridge with gross oils*!" (*Sat.* VI.40–41). The agrarian, removed somewhat from the urban morass, was left to uphold the standard of *Romanus*, its honor, strength, and integrity. The Roman country gentlemen was expected to eschew the most lavish of comestibles in favor of the manlier fare, such as that of a soldier (cf Sen. *Ep.* XCV.27).

Simplicity as Source of Strength

The traditional connection of simple Roman eating and strength can be explained through an analogy about Rome before the travail brought forth by the general Marcellus. The general's sack of Syracuse in 211 B.C. was a major turning point in Roman attitudes, behavior, and diet. Up until this point, Romans had been accustomed to only war and agriculture; a reliance on simplicity had always assured them victory. Then Marcellus carted back to Rome a trove of luxurious objects and ideas from foreign lands that presumably set Rome on a path of degradation (Polyb. IX.10; Plut. *Marc.*XXI.4–5). The sources make it clear: Rome would have been stronger had it not been introduced to foreign art, attitudes, and, as a point of our concern, exotic food (Gruen 1992). Although we cannot be certain, archeological evidence seems to support that the Roman warrior, whether soldier or noble, ate simply. This harked back to the ideal Roman of the Republic who was a citizen, a soldier, and a farmer (Livy III.26–29).

Literary sources lead us to believe that the Roman warrior would not have been satisfied with anything but simple food. In addition, the logistics required to make refined culinary products for soldiers in the field may have hampered their use. A study of remains discovered at ancient Roman military sites in Britain and Germany uncovered a number of rustic food products, including deer, ox, poultry, hare, and especially beans and lentils (Davies 1971). The ancient tablets found at Vindolanda provide a record of military provisions that support this evidence (Vind. Inv. 88.839). One of the lengthiest existing accounts, a several-day record of an officer's provisions, lists mostly barley and Celtic beer. Although on one exceptional occasion, the officer obtained a bottle of fine imported wine (Bowman 1994). At least when on campaign, the noble would be expected to eat at a common table with the troops. Vitellius was an exception who was roundly despised for gourmandizing in the field (Suet. *Vit.* XIII.2; Tac. *Hist.* II.95). Seneca rhetorically asked if the Roman general Fabricius "*would have been more content if he stuffed himself with fish from a distant shore and with birds from foreign lands?*" (*Prov.* III.6). The implied answer was no.

At times the Roman aristocrat preferred foods that were produced locally, which could also garner desirability and ideological worth. Juvenal's account of a meal he served to Persius provided a lesson in the economics of local food value. He promised that the meal would please, consisting only of courses supplied by Juvenal's farm at Tivoli (XI.64–5). As in the "*old days*," peasants produced bacon at home instead of buying it in the market, we are told by Varro, and they fared well without products sent from town (*Rust.* II.43; Horace *Sat.* II.2.118–125).

The question of whether to serve simple versus elaborate foods was symbolic of the societal tensions developing in the late republic: the idealistic connection to Rome's origins (e.g., the hardy roman farmer) versus the desire for status symbols as increasing wealth flowed into Rome from the provinces (Horace *Ep.* II.1.156–157). The establishment of value among a local foreign dyad rested not only on an aristocrat's politics, but also on his or her keen sense of taste and distinction (Varro *Rust.* I.2.6–7; I.2.43; Horace *Sat.* II.2. 118–125). It was likely that many aristocrats had to tread a fine line between fashion and politics. Petronius provided a complex and comical version of the interplay of these values in his imaginary portrayal of a banquet given by the crude freedman Trimalchio. Everything was grown locally on my estates, Trimalchio boasted, "*I don't buy my wine. My wine and everything else that makes your mouth salivate grow on an estate of mine*" (*Sat.* XLVIII.2). Though, Trimalchio was not above serving exotica such live birds buried inside a pig or sealed inside fake eggs. This confusion must have seemed perplexing yet familiar to Petronious' contemporaries (Schmeling 1970).

Foods Embodying Conflicting Values

The Roman agrarian classified animals in terms of wild, domesticated, or half-wild attributes. Wild foods (foraged grains and undomesticated animals) epitomized the prestige of the hunt, a reminder of a simpler, more heroic past. Though these commodities were not universally appreciated. For example, Galen the late second-century physician denigrated these foods in the following passage:

> [Wild] *foods possess little that is nutritious, are full of bad juices, are bad for the stomach, and are unpleasant to taste, since they are food rather for pigs – wild pigs that is, which live in the mountains, because only wild pigs derive any nourishment from these . . .* (*Alim. Fac.*, trans. Grant 2000)

Strabo, the first-century historian and geographer, used the metaphor of wild pigs to demonstrate the incivility of the tribal Gauls: "*Most of them sleep on the ground and eat their meals seated on hay . . . 'Their swine run wild'*" (IV.4.3, C.197). From Strabo's view, wild pigs seem to go with wild people. Human civility, in part, was marked by the level of their consumption of trained animals. Strabo's perspective holds suit with other Roman aristocrats who saw life as an ordered affair. Pliny, for example, believed that natural divisions of civility demarcate both the animal and human kingdoms:

> *Not only in pigs but in all animals as well, when there is a tame variety there is also a wild one of the same species. This is also true for man, as an equal number of savage races can be predicted to exist*. (Pliny *HN* VIII.79)

As Pliny expanded his analogy from pigs to people, we see an affirmation that aristocratic Romans viewed life as a conflict between domesticated and denatured and virile, wild elements. Ultimately, the domesticated animal, the one that subsumed, was most demonstrative of an owner's prestige. Eating a wild animal was sometimes all right and even esteemed, but eating a "tamed" edible was more refined. It was more efficient to produce a domestically raised animal product as it herded and directed to slaughter with certain efficiency. One could say that domestic food production was generally a more ordered, controlled, civil affair, than the hunt.

The wild animal was strong, free, and heroic, but it made a more or less crude rustic product that, at least to some, was barbaric. A farm-raised, or domesticated, animal embodied a traditional rustic value, and by exercising control over this animal, a Roman could attach to it a modicum of civility. Then again, certain farm-raised products (e.g., farm-raised fish) symbolized corruption and gluttony. Romans considered this the realm of the "half-wild," the midpoint between wild and domestic animals. The *glis,* or dormouse, fell under this category (Pliny *HN* VIII.57). It was not especially wild (specimens were raised in captivity), but it was not tamed or domesticated either. Varro tells us the dormouse could easily be raised in jars inside a villa (*Rust.* III.XV). While the dormouse lacked the prestige of foreignness or rarity, it had an esteemed value that may have rested in its novelty and its perceived ability to transverse wild and tame attributes (Mart. XIII.59; *De re Coq.* IX.396; Pliny *HN* VIII.57). Food of this sort was inconsistently symbolic of both local rustic and opulent hospitality (Hor. *Sat.* II.6.77–118; Petron. *Sat.* XXXI) and at times was a bridge between the two extremes.

Animals: Whole and More than Whole

Chicken and eggs were often eaten in concordance with a rustic morality, offering the tradition of a simple, local, and wholesome meal. The mother of the Roman egg, of course, was the chicken (cf Plut. *Quaest. conv.* 636a). Its egg was round and white, whole and uniform and it had strong symbolic value. The center of the egg was bright yellow, an attribute of the sun (cf Cic. *Nat. D.* II.24) or the stars (Ath. II.58c) and the symbol of fertility (cf Plut. *Quaest. conv.* 636e; Hor. *Sat.* II.4.17–20; Ath.

II.57c). Although Horace tells us that "*cheap eggs*" still had a place in the feast of kings (II.2.45), this had little relation to the pretensions of elite culinary extravagance. While the *De re Coquinaria* has three simple recipes for eggs listed in an opulent banquet (VII.19.1,2,3), the mixed victual and foreign edible garnered the most prestige. Chicken and eggs were most appropriately served at a modest dinner, perhaps with a roast kid and wild asparagus (Juv. XI.65–75; cf Hor. *Sat.* II.4.17–29) or a locally caught *lupus* (Mart. X.48).

There were attempts to appreciate rustic food values by, in effect, increasing their size. The use of fattened fowl in public festivals seems to attest to an elite Roman preference for engorged poultry over natural, free-range, or wild varieties. The aristocrat was generally more appreciative of the flavor attributes of fat, which was often more present in farm-raised animal varieties, as Seneca described:

> *After much feeding and being fattened by force these edibles barely retain their own lard and nearly melt... The delicate flavor of these dishes is what you like.* (*Ep.* CX.11; cf Mart. XI.52)

Fattened fowl were reputedly served at the pontifical banquet given by Metellus and at the feasts given by Caesar (Macrob. *Sat.* III.13.12). Cato provided detailed instructions for engorging or "cramming" of poultry that underscored how this science necessitated a precise knowledge:

> *Cram into the [chicken's] mouth wheat or barley meal soaked in water* (Rust. LXXXIX). *For squabs, blow beans that have been boiled and toasted from your mouth into its mouth.* (XC)

Two centuries later, Pliny shared some of his tips on fattening:

> *Feeding poultry with food soaked in milk makes them much more acceptable* (*HN* X.71). *Castrating roosters makes fattening them easier* (X.25.). *When the liver has been taken [from a goose], it grows larger after being soaked in honeyed milk.* (X.27)

Fattening was not limited to poultry (Pliny *HN* X.23; Macrob. *Sat.*13.13). Slaves at neighborhood shrines routinely sacrificed engorged pigs. A method for their fattening with dried figs and mead was attributed to Apicius (*HN* VIII.209). Dormice were fattened on nuts, acorns, and chestnuts in the darkness of a barrel (Varro *Rust.* III.15.2; Pliny *HN* VIII.82). Hares were taken from the preserves, placed in hutches and fattened (Varro *Rust.* III.14; Macrob. *Sat.* III.13.13). Snails were crammed with must or spelt (Macrob. *Sat.* 13.13) or slime (Sen. *Ep.* XCV.25), and fish were bred to large size (Varro *Rust*. III.1–10; Macrob. *Sat.* III.15.7).

Cattle ate in the fields and fell under a different category from the fattened animals, who were fed in the farmstead (*villaticum*-Varro. *Rust.* III, 2.13). Cattle "*who enhance cultivation as a result of their labor*," Varro instructed, fell under the dominion of the farmer. Cattle not utilized for cultivation came under the auspice of the herdsman (*Rust.* I.2.20–21). The divide between herdsman (*armentarius*) and farmer (*arator*) was more than technical. Since early antiquity, agriculturists tried to distance themselves from pastoral meat eaters, so it is not surprising that there was a hint of disparagement when Varro, the consummate agriculturist, remarked that "*cattle that graze do not produce what grows, they rip it off with their teeth*" (II.4–6); these beasts did not know how to act properly. Pliny in a sardonic moment compared cattle to the lower classes (*HN* XIX.19.51–60). In sum, we can deduce that some Roman cattle worked in the farmstead in accordance to the life and honor of the farmer and that other types were associated with the uncivilized pastoral existence of the herdsman (Daubeny 1857).

By shifting of emphasis from a sacrificial to a performative celebration of meat, the Roman aristocrat was exercising his or her control over this commodity. The demonstrative prestigious consumption of meat affirmed that it was not readily available for popular use. As such, beef from cattle was distributed in a number of Roman grand celebrations. For example, we are told that 120 oxen were sacrificed in the triumph of Aemilius Paullus in 168 BC (Plut. *Aem*. 33.2), and an "enormous quantity" of beef was sacrificed in Judea for the victory of Titus in 71 AD (Joseph. *BJ* VII.16; Corbier 1989). However, the literary accounts of private opulence rarely mention beef. Why, we might ask, was meat from pig (*porcinus*) extensively mentioned in the primary classic literature but meat from cattle (*bubula*) hardly mentioned at all? The explanation according to Ovid was that the ox was spared because it was man's companion in labor (*Fast.* I. 360; 380).

The wild boar and its tame cousin the pig were other animals whose consumption was associated with mixed meanings. The symbolic association of pork products with simplicity and wholesomeness is clear and can be seen throughout ancient literature (Varro *Rust.* II.4.10). The connection of pork products to religion and sacrifice cannot be understated. Varro tells us that the Greek name for the pig was ὕς, from the Greek verb θῦειν, that is, "to sacrifice." It seems as Varro advised, since the origin of sacrificial ties, the victim almost always came the swine family (*Rust.* II.4.9). The boar was a product of a rural and religious simplicity that at times was manifest in the shared meal, but the boar was also representative of luxury (Ath. III.76b) and social differentiation (Juv. V). It is mentioned in connection to a number of performative presentations set in opulent surrounds (Mart. VII.78; Petron. *Sat.* XLI; Macr. *Sat.* III.13.10). The boar became the comestible *par excellence* of a meal, so integrally related to celebration, Martial tells us that one did not dine or entertain without it (VII.59).

The impact of cooked boar's presentation may have been enhanced by its traditional use. It had the virtuous overtones of the hunt and celebratory meal of Rome's good old days (Hudson 1989; *De re Coq.* VIII.1). The sources sometimes connected the opulent service of a boar to mythology as a meal worthy of epic heroes. In Petronius' satire, we find a burly man in hunter's garb cutting open the side of a whole boar (41). Live thrush flew out of the boar, in a meal later described by Macrobius as *Porcus Troianus* (*Sat*. III.13.13), a clear reference to the Trojan Horse (Courtney 2001). A number of mythological references in the literature connected the *Aetolian Boar* to food opulence. Ancient legend has it that Meleager killed this wild beast in a famed hunt (*Hom.* II.9.567). Martial mentioned the *Aetolian Boar* a number of times (VII.27.1–2; XIII.41; XIII.93; Coleman 1990), and Juvenal describes a "*steaming hot boar, worthy of the steel blond Meleager*," in association with the tyrannical station of his fictive patron Virro. The boar was served among the finest of edibles: fattened fowl, truffles, and goose liver (V.114–6).

Fish

The metaphoric conflict and mixed messages inherent to the Roman societal struggle were symbolically mentioned in the ancient discourse about fish. Representative of poverty and simplicity, fish became one of the most prestigious symbols of ostentation. Pliny recalled the name of three dishes used to denote the most luxurious possible banquet: the lamprey, the pike and a mixture of fish (*HN* XXXV.46). As far as traditional capital was concerned, the fish products Athenaeus reported exceeded the qualities of meat eaten by Hercules and the figs eaten by Plato. That is why the term *opsum* (fine relish) was used to connote fish (Ath. VII.276).

At the other extreme, fishing stood akin to gathering and hunting in that it was a trade for peasants. This is because fishing did not require ownership or extensive resource management. Roman prestige emanated primarily from the land, produce and, to a lesser extent, the products of domesticated animals (Purcell 1995). It was relatively easy for Romans to subjugate and control those things. The sea, however, was a different world that was wild, hostile, and uncontrollable. In addition, the sea was considered poor, so poor that only in times of famine or extreme poverty did Romans turn to fishing for survival (Str. VI.2.252; Just. *Epit*. XL.43.5; Purcell 1995).

The image of a Roman selling fresh fish in the market was an anomaly. Lacking effective transportation and refrigeration facilities, it was nearly impossible to import fresh fish from afar, relegating trade to local seaport markets. Thus, Rome's inland location made fish an exceptional part of the local diet and a symbol for extreme ostentation (Lucil. *fr.* IV.2; Juv. IV; Mart. XIV.97; Evans 1890). It was said that the reputed chef Apicius, for example, skillfully packaged fresh oysters to be sent to Trajan while he was in Parthia (Ath. I.7d). We are told that Elagabalus commanded respect by his ability to eat fish regularly, no matter where he was located (S.H.A. *Heliogab.* XXXVII.3). Though even royalty learned to live without fish, as Athenaeus reports in a parable about Nicomedes, the king of Bithynia. So great was his desire for fish, and so lacking was this commodity that the king dispatched a cook to make an imitation of out of a turnip (Ath. I.7e). Consequent to the relative rarity and perishable properties of fish, most ancient Roman trade involving fish was related to its packaging and preservation. Salted and fermented fish products lasted longer and could be imported or distributed over great distances.

The apposition of farm-raised and wild caught fish in the culinary repertoire resulted in abstract meanings, dependent on the worldview of the ancient source. For example, Columella described the tension of both domestication and wildness inherent to fish in ponds when he recommended placing seaweed-covered rocks in the water. "*Though they are prisoners*," he wrote, "*fish should feel their captivity as little as possible"* (*Rust.* VIII.17.6). Farm-raised fish were culinary prizes that commanded astonishingly high prices (Pavlovskis 1973). However, the lamprey was a paradox. It was a locally spawned fish that was not rare, but it had attributed culinary value. Apparently, depending on who was reporting, the lamprey evoked luxury, modest, or rustic value, or no value at all. Lucilius, through Macrobius, mentioned a local variety, *Lupus Tiberinus*, appearing at banquets as early as the late third century B.C. (Macrob. *Sat.* III.16.17; cf Lucil. *fr.* IV.5; Evans 1890). Martial described a meal where an imported Spanish lamprey is served within the modest proximity of beans (*Ep.* VII.78; cf Pliny *HN* XXXII.53), and, in another modest dinner of his recollection, a nondescript variety of lamprey was served together with the rusticity of chicken and eggs (*Ep.* X.48).

Farm-raised and imported varieties of lamprey were held in the highest esteem (Macrob. *Sat*. III.15.9). A particularly fine variety of lamprey from the Sicilian narrows was served to Juvenal's literary patron Virro. The Sicilian lamprey was easily caught, Macrobius recalled, for it was fat and floated to the top. This kind of lamprey was so highly valued that it was imported to the fish ponds of Rome (*Sat.* III.15.7). The variety that Lucilius mentioned, *Lupus Tibernius*, grew locally. He called it the licker of excrement (*catillo* – Macrob. *Sat.* III.16.17). Pliny confirmed that the best lamprey were in fact found between the two bridges, the *Pons Senatorius* and the *Pons Sublicius* of the Tiber River (*HN* IX.79; cf Gal. *Nat. Fac.* VI.714; Colum. *Rust.* VIII.16.2–4; Varro *Rust.* III.3.9–10). This was the most polluted part of the river where the sewers emptied (Evans 1890). It is probably safe to assume that a lamprey caught in sewage was not an appealing edible to most ancient Romans. Though, in the literature the lamprey was sometimes used symbolize how low gluttons would go for their pleasures (Macrob. *Sat.* II.2.31; III.16.11). For Juvenal, the *Lupus Tibernius* was as revolting as it was undignified (V.103–104; cf Gal. *Nat. Fac.* III.30). Because the lamprey lived on sewage (*pinguis torrente cloaca* – 105), Juvenal was able to use it as a metaphor for oppression. This was not just a disgust of taste, but also a disgust of Roman elite degradation.

Then, why did the lamprey achieve such high esteem and be served at the elite table? It would seem that a local, common, and disgusting food product would have been exclusively associated with the lower quarters of Roman society. Like the dormouse, the value of the lamprey may have lied in its ambiguity or its ability to traverse two environments. In its natural environs, the lamprey was an estuarial fish, as it swam from salt to fresh water (Varro *Rust.* III.3.9). Thus, the lamprey, as it was able to thrive in both environments, may have accrued prestige. So, the opportunity to control, domesticate, or improve on this product may have contributed to its value. As a disgusting food product, the local lamprey was unconventional. It would have taken the most adventurous gourmand to overlook its revolting qualities. Though, its repulsive attributes may have contributed to its quality as exotica, garnering this fish prestige for its "funkiness." The explicit contrast between the *lupus*' offensiveness and its social impressiveness, both of which appear in the sources, implies that its image was subject to those who wanted to exploit it for social gain and those who wanted to prevent this. This social imbroglio could be seen with in the symbolic context of conflict surrounding other local varieties of food. One could suggest that to some ancient Romans, even the most disgusting local product was more esteemed than a foreign counterpart. Nevertheless, the paradox of the lamprey, the ambiguity of its prestige and disgust, seems to have contributed to its value.

A discussion on fish would be incomplete without mentioning the sturgeon, the mullet, and the turbot. The display of these fish ushered an aura of extravagance to a meal that was fundamentally based on their relative rarity and size. The overall opulent imagery at a banquet was in direct opposition to a traditional spartan meal of fish. The defining comments about a sturgeon's value came from Cicero (*Fat.* IV) and Macrobius, reporting four centuries later who reminded that "*sturgeon is a meal for the very few*" (*Sat.* XVI.4). The tradition of pomp and honor given to the sturgeon was attested by its service to Publius Scipio, the victor of Africa and Numantia (Cic. *Fat.* IV; cf Pliny *HN* IX.27; Mart. XIII.91; Macrob. *Sat.* III.16.1). A spirit of Roman nobility radiated from this fish that transcended the mundane. Macrobius, for example, observed a crowned sturgeon brought to the table by servants to the accompaniment of music: "*An entry that suggesting the worship of a god rather than the debut of a tasty dish*" (*Sat.* III.16.7). The sturgeon's spiritual value was so high, Cicero informs, that it had the ability to lift one's spirits in times of grief (*Tusc.* III.43).

Aristocratic power and prestige was also expressed through the size of the fish served. Only a powerful ancient Roman noble could command the resources needed to obtain a very large fish. Reluctance to providing a very large fish to the emperor was practically treasonous. Seneca conveys this point in an anecdote about a huge mullet, purchased for an outrageously high amount by the culinarian Octavius for delivery to emperor Tiberius, a gift of which he thought only a Caesar worthy (Sen. *Ep*. XCV.42). To Juvenal, the turbot also was fish too big for the private kitchen. As such, it was a symbol of power. Juvenal devoted his fourth satire to turbot as a symbol of tyranny (IV.65). However, the size of a fish had nothing to do with its taste. Horace makes this clear when he sarcastically chastises those who prefer the larger varieties: "*You praise a three-pound mullet, but it needs to be cut up into smaller portions*" (*Sat.* II.2.35). It would be hard to imagine the pomposity of a Roman fish if it had been cut into pieces. For a grand appearance, an intact large fish was best, a point emphasized by both Horace and Martial, as follows:

> *I'd love to see a big fish on a huge dish* (Horace *Sat*. II.2.39).
>
> *Huge Mullets of cover your dishes of yellow inlaid gold... Do not insult the large gold dishes with a small mullet; it should at least weigh two pounds* (Mart. II.43; XIV.97).

This idea of an ancient Roman "whole" food product is in direct opposition to an edible that in some way had been cut, separated, or disemboweled, in effect losing its natural recognizable integrity.

Whole, Part, Disemboweled, or Cut Up

Ancient Roman aristocratic consumption of certain integral foods, as we have seen, conjured the traditional symbolism of earlier times. As long as a food remained intact and natural, it could summon rustic history. For example, the image of a whole boar roasting on a spit or a fish served whole embodied a sense of Roman times gone by. By being able to recognize its features, one knew that this animal had once been alive and had been involved in a fundamental struggle for survival. Traditional values, however, became mired and complicated when these foods were cut up or, at the furthest extreme, masticated so finely that they lost all of their natural form. No longer looking like it once had been, the food's signifying meaning became abstract, the relationship to the idealized past not as apparent.

While preferences for the specialized part of animal: the gland, the viscera, was an exclusive expression of status, unusual preferences of this sort did not define the eating habits of early antiquity, as Athenaeus reported (III.101a). Rather, it was a rising passion of later Imperial decadence. Value was accrued by the very nature of conspicuous waste of food in a society marked by disparity. It took a very rich noble to afford the purchase of an animal merely for the consumption of a small part. A cooked whole animal generally implied the tradition of the shared meal. The consumption of a particular part of an animal eliminated sharing, for there is not enough to go around. By limiting the amount available to be served, a food product gained exclusivity and, hence, value. In addition, an appreciation of a particular animal part required a refinement of taste: One needed to know which parts were the best. To slaughter an animal for the purpose of consuming a small part of it was a clear act of ancient avarice. The more wasteful the behaviors, the more utility the squandered comestible had in influencing cultural capital, status and prestige. A case in point was Cleopatra's consumption of a valuable pearl at a banquet. By extension, this act not only demonstrated her nonchalance over this wastefulness, but her vast wealth, power, and control over Antony (Jones 2010).

When whole-cooked products no longer differentiated the elite, Seneca recalled, they turned to flamingo tongues and similar absurdities (*Ep. CX* 12–13). Among the many examples are the teats, a glandule, a rib, the tongue, and the spleen from a boar (Ath. III.96; Mart. II.37), and the testicles of capon and preparations for wombs, trotters, livers, and udders (*De re Coq*. IV.3.3; VII.1.1–6; VII.2.1–3; VII.3.1–2). Horace's character Fundanius described a large platter that contained limbs of crane, liver of a white goose, pigeons without rumps, and hares with limbs torn off (*Sat.* II.8). We are also told that Elagabalus, in imitation of Apicius, had a preference for camel-heels, cock-combs taken from living birds, tongues of peacocks and nightingales, visera of mullets, flamingo and thrush brains, and the heads of parrots, pheasants, and peacocks (S.H.A. *Heliogab*. XXX.6). Aristocratic debate continued from the late republic onward over whether or not eating a small part of an animal's body was preferred or suspect. The outcry, sometimes against the whole, sometimes against the part, sometimes against the whole and the part, seemed representative of the broader issues discussed earlier (Pliny *HN* VIII.78; Suet. *Tib.* XXXIV; Tac. *Ann.* III.52).

Conclusion

In this chapter, foods that were generally revered for their natural features and integrity were contrasted with more ostentatious varieties. The sumptuous Roman dining occasion was not always about foreign exotica. The degree of this respect for food integrity was contingent on the social philosophy of the food's consumer. For the poor and destitute, the food choice was easy, they ate almost anything. The Roman conservative aristocrat, one whose values emanated from the past, would likely prefer a food product that expressed that ideal: a rustic or wholesome food that required a minimum of preparation. Rustic foods in themselves did not necessarily represent luxury, but the local comestible could have been manipulated through the artifice of culinary preparation, taking it outside the context of simplicity. It was these manipulated foods in particular that evoked mixed messages: traditional by nature, novel through preparation. The end result, however, would obfuscate the historic meaning and as such, a clear sense of Roman aristocratic identity. The generally worldlier Roman social opportunist would, perhaps, identify himself or herself with an edible that evoked this progressive image; a fattened hen or a farm-raised lamprey might do. If he or she opted for a little more dazzle, perhaps a masticated product or spiced concoction from the *De re Coquinaria* would work best. Then again, we must be aware of an aristocratic divide between the public and private persona. What the Roman aristocrat did or said in public may not have been an indication of his or her life at home. This was particularly true when it came to food.

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Part III

The Biological Sciences

Food Intake and Physiological Regulation: The Means and the End

6

France Bellisle

Contents

Abstract

The independent life of animals requires the active regulation of many critical parameters of the internal status of the organism, in other words, their maintenance within a narrow range of defended values. From the early days of research into homeostatic mechanisms, it appeared that food intake (FI) is not one of such parameters. FI is one of many effector mechanisms that contribute to the regulation of several internal parameters, such as glycemia and adipose stores. The science of the last century has clarified the fine machinery of regulatory processes, both at the periphery and in the brain. Beyond the early notion of feedback loops triggering regulatory responses to existing need states, research has documented how efficient regulation rests on learned anticipatory responses, both

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physiological and behavioral, that are highly plastic and continuously shaped by the experience of environmental contingencies. Studies of eating patterns in free-living humans have revealed the significant influence of numerous factors, among which signals of physiological needs exert a modest role. In spite of the massive influence of environmental and social factors, regulatory adjustments can be detected in the FI of humans, including obese humans. These impressive developments in knowledge have paralleled an unprecedented increase in the frequency of obesity. In this field, knowledge does not equate power. Even in the obesogenic world, FI matches energy needs perfectly in many individuals. Understanding why regulation mechanisms allow body adiposity to drift upward in so many others remains a crucial question.

Introduction

Obtaining and ingesting sources of nutrients from the environment are critical behaviors that all animals have to perform in order to sustain life processes. This simple unquestioned observation raises the question of the signals that trigger and then inhibit ingestive responses. The worldwide "epidemic" of obesity questions our understanding of the critical mechanisms that should permit adequate nutritional status.

Scientific interest in the triggers of food intake (FI) is not novel. As early as the mid-nineteenth century, the physiologist Claude Bernard proposed key concepts in this area: the stability of the "internal milieu" is an essential condition for an animal's "free and independent live" (Bernard 1879). The "internal milieu," the internal environment of the organism, refers to the status of many crucial parameters (including body temperature, the fluid balance, blood pressure, and glycemia) that have to be maintained within narrow limits in order to maintain life functions. The notion of "homeostasis," proposed by Cannon in the early twentieth century (Cannon 1932), refers to the convergent action of many physiological regulatory mechanisms that maintain the internal environment in a stable state.

Regulatory mechanisms are well known not only in physiology. The thermostat that regulates the temperature in a room is a simple example of a regulatory system. A regulatory mechanism requires at least three elements: sensors that monitor the regulated parameter, a control center that compares fluctuating parameter values with the "optimal" one that is to be maintained, and effectors that can bring the deviant parameter back to "regulated" levels via a feedback loop. In physiology, all three elements can be immensely complex. Among the effector responses in particular, some are purely internal, such as the hormonal mechanisms that regulate the level of glycemia (insulin and glucagon) or the shivering response to cold. In some cases, their action is sufficient to restore the regulated status of the internal milieu, at least for a while; in other cases, however, their action is limited. When the organism needs energy, nutrients, fluid, or even oxygen, no internal response will adequately insure regulation. In those cases, behavioral responses are elicited by the control center, the brain, to obtain the required life-sustaining substances from the environment so that the vital parameters of the “internal milieu” can be maintained.

This rough sketch of a classic regulation system reveals that FI itself is not “regulated”. In fact, it cannot possibly be. Ingestive responses are the behavioral extensions of internal effector processes. Rather than being “regulated parameters” themselves, they are a set of tools among many in the effector tool box that the body uses in order to maintain its “free and independent life.”

If ingestive behaviors are effectors in regulatory mechanisms, what do they regulate exactly? This is a vast question to which the science of the last century has brought a large number of answers, well beyond the few classic parameters initially envisaged by the pioneers of homeostasis research. Actually, one increasingly pressing question, in the context of the worldwide epidemic of obesity, is whether FI actually regulates or dysregulates physiological processes.

Even scientists who believe that ingestive responses are organized by the brain to serve physiological regulation are not so naïve as to believe that this is the whole story. Studies of spontaneous ingestive patterns in free-living humans have revealed that a large number of factors, sometimes quite unexpected, exert a significant influence on eating and drinking (de Castro 2010; McKiernan et al. 2009). Not only is FI not “regulated,” but it is constantly affected by a host of stimuli that often have nothing to do with the maintenance of critical vital parameters, when they do not simply antagonize it.

In this chapter, two sources of scientific information will be examined. Firstly, the concept of homeostasis and its plethoric developments in the recent decades will be reviewed in order to illustrate the role of ingestive behaviors in physiological regulation mechanisms. Secondly, studies investigating the spontaneous eating patterns of free-living humans will be reviewed in order to identify the determinants of behavior, among which markers of homeostatic regulation. The converging lessons from these two fields of science will help us analyze the regulatory and dysregulatory influences on ingestive behaviors and the reasons for our continuing failure to cope with obesity.

Birth of a Notion: Early Views on Regulation and the Role of Ingestive Behaviors

Pioneer studies examined the role of ingestive behaviors in physiological homeostatic mechanisms. Early intuitions held that drinking was essential in the regulation of the body fluid balance and that eating was triggered by hunger in response to bodily needs. The nature of the “thirst signal” that triggers drinking was debated from the early twentieth century. The nature of the “hunger signal” also stimulated much research and debate. Early models proposed that a single factor was responsible for the periodic onset of eating.

According to Brobeck’s thermoregulatory hypothesis (1948), a low temperature of the body, caused either by low external temperatures or starvation, stimulates eating which stops when the heat generated during digestion inhibits the eating system. Mayer's glucostatic theory, based on the observation that blood glucose has to be regulated within narrow limits in order to maintain brain function, proposed that food consumption is triggered periodically by decreases in the rate of glucose utilization (Mayer 1953). One common observation is that experimental animals, after imposed periods of food deprivation or overfeeding, tend to return to their initial body weight as soon as the intervention has ended (Le Magnen 1971), which concurs with the well-documented difficulty of human dieters to maintain their weight loss after the end of their diet. These robust phenomena suggest that a homeostatic mechanism actively maintains the body reserves of energy. According to the lipostatic theory, originally proposed by Kennedy (Kennedy 1953), the amount of fat in the body is the regulated parameter that stimulates or inhibits eating in order to maintain the body fat mass constant at a physiologically determined level, or "set point."

For all of the above hypotheses, and a few others, experimental demonstrations confirm that acute or chronic changes in the hypothetic "hunger signal" trigger or inhibit eating in animal models or human subjects. From a simply homeostatic perspective, eating can be triggered by a variety of changes in the internal milieu.

The early homeostatic hypotheses stimulated the search for brain structures that could detect a critical deviation in one regulated parameter, compare it to a regulated value, and trigger the adequate physiological and/or behavioral corrective responses. Using the crude instruments available in the mid-twentieth century, a "hunger center" and a "satiety center" were identified in neighboring nucleuses of the hypothalamus (the lateral and the ventromedial nucleuses, respectively), whose activation/inhibition stimulated or inhibited eating. Of interest to the present discussion of regulatory mechanisms, animal works (Hoebel and Teitelmaum 1966; Powley and Keesey 1970) revealed that experimental lesions of the ventromedial nucleus (VMN), the "satiety center" of the hypothalamus, caused a change in the regulated body weight level rather than of eating behavior per se, so that lesioned animals would overeat only as long as their weight was lower than the new "set point" level, after which they would merely eat enough to maintain their elevated weight. This was an early experimental demonstration that food intake, rather than being regulated per se, acts as an effector in the regulation of body weight or body adiposity.

Classic homeostatic views were used to account for the ingestive patterns of animals observed under laboratory conditions (Le Magnen 1992). Typically, animals with a continuous access to food do not eat continuously. Their ingestive patterns are organized in a series of discrete ingestive events (eating/drinking bouts) interspersed by intervals of variable duration during which no ingestion is observed. In addition, ingestion occurs mainly during the active phase of the species-specific activity cycle (night time in rodents, day time in humans). This pattern was termed the "dual periodicity" of ingestive behaviors (Le Magnen 1992). According to this classic view, at various moments of the activity phase, a critical "hunger signal," arising from some homeostatic deviation, triggers meal onset.

As consumption progresses, signals originating from various parts of the gastrointestinal (GI) tract cumulate and progressively counteract hunger and bring ingestion to an end. This process that brings eating to an end and therefore determines meal size is called "satiation." Gastric distension and the release of "satiation hormones" such as cholecystokinin (CCK) triggered by the sensing of nutrients in the GI tract were identified as candidates to play this inhibitory role. Finally, consumption was thought to be inhibited following an eating episode by various post-ingestive and postabsorptive metabolic signals determining the duration of "satiety." The succession of stimulatory and inhibitory influences was conceptualized in the "satiety cascade," first described more than 30 years ago and periodically updated to integrate new findings (Blundell et al. 2010). Animal studies suggested that, after the fuels consumed in one meal had been used up by the organism, the critical hunger signal occurred again, in an all-or-none fashion, and triggered the onset of another meal (Le Magnen 1992).

The analysis of eating patterns in laboratory animals quantified two important parameters of intake: the daily number of eating events and the size of these eating events. These two parameters could potentially vary in response to regulatory challenges in the environment, for example, when animals were exposed to cold temperature, to changes in palatability or energy density of their foods, or to forced physical activity (Le Magnen 1971). Laboratory rats housed in small individual cages with little else to do but eat, drink, groom, and sleep, were found very competent in energy regulation and generally maintained a stable body weight. Meal size was found to be highly sensitive to the palatability and variety of the available foods; in turn, larger meal sizes determined a longer duration of post-meal satiety so that longer satiety corrected for increased meal size (Le Magnen 1971). The "postprandial correlation" between meal size and duration of the post-meal interval suggests that animals with constant access to food adequately adjust FI to energy needs mainly by modulating the duration of post-meal satiety: animals do not return to their food before they have used up the energy consumed in their previous meal (Le Magnen 1992).

A number of experimental situations, however, defeated the animals' adaptation capacities: for example, lesions or stimulation of brain structures commanding ingestive behaviors induced either massive obesity or extreme life-threatening hypophagia, whereas exposure to a "cafeteria diet," which consists in a continuous access to a variety of palatable foods typical of the human diet, stimulated ingestion and "dietary-induced obesity." Domesticated animals notoriously show the same obesogenic sensitivity to their masters' diet, and so do wild animals exposed to high-fat, high-sugar, and high-energy foods (Zheng et al. 2009). In addition, the celebrated ability of laboratory rats to adjust intake to changing energy conditions and maintain a "healthy" weight has proved to be limited to the usual duration of laboratory tests (a few days or a few weeks). When laboratory rats are allowed to age, they also tend to develop body adiposity, even when fed a boring laboratory chow.

Advances in Knowledge and Changes in Concepts

In the recent decades, the identification of regulated parameters and associated mechanisms has accelerated, facilitated by the phenomenal development of measurement instruments, such as brain imaging techniques. These major advances are beyond the scope of the present paper. Many excellent reviews of the cumulative findings have been published and are updated regularly (Berthoud et al. 2017). As a result of convergent progresses, the classic views of homeostasis and the role of ingestive behaviors have been entirely revisited. The next short sections address a few areas of specific relevance.

Perception of the External and Internal Environments

The Head

The response to foods depends on the perception of their sensory characteristics by receptors in the head, but not only in the oral cavity. The perception of foods results from a complex integration of various sense modalities. The senses of taste and olfaction and also vision, audition, and proprioception (for the perception of texture and temperature) all contribute to the identification of foods and determine their rewarding or "hedonic" levels. Importantly, the responses of sensory receptors in the head contribute to both stimulation and inhibition of food intake. The stimulation due to palatability is highest at the beginning of ingestion. As foods are being consumed, habituation to the hedonic value of the ingested food develops. "Sensory-specific satiation" and "sensory-specific satiety" (Rolls and Hetherington 1989) are inhibitory processes that specifically reduce the reward value of the sensory characteristics of the ingested foods but spare the attractiveness of foods with other characteristics, thereby facilitating the consumption of varied food sources.

Potential differences in sensory responsiveness between persons of different weight status are a continuing field of research. While recent studies have generally confirmed older data showing no difference in appreciation of foods (appetite for sweetness in particular) between normal-weight and obese persons, some studies suggest that certain aspects of appetite may be different: for example, satiation for sweetness at the time of ingestion might occur more slowly in obese than in normal-weight individuals (Pepino and Mennella 2012), possibly stimulating larger intake.

Beyond the Mouth: The Digestive Tract

One area of very rich scientific developments is the understanding of the sensors that respond to various parameters of the nutritional status in the GI tract and could contribute to regulatory signals. The entire GI tract is equipped with mechanosensors and chemosensors which can sense the volume and nutrient content of consumed food. For example, the same receptors responsible for the perception of sweetness in the oral cavity are found in numerous locations in the GI tract and signal the presence of sugars (Iwatsuki et al. 2011). The GI tract is densely innervated by sensory afferents of the vagus nerve, which are positioned to directly communicate nutritional information from the gut to brainstem structures (Berthoud et al. 2017). In addition to neural signals, the presence of food within the GI tract elicits the production of peptides and hormones that act locally to influence nutrient absorption and metabolism, and also directly in the brain to alter feeding behavior (Berthoud et al. 2017). As neural and hormonal satiation signals from the gut are generated during a meal, their impact gradually cumulates, ultimately activating brain circuits that cause individuals to stop eating, i.e., satiation (Woods 2009).

Early views of gut signals insisted on their potent contributions to satiation and satiety. More recent developments established that the presence of nutrients such as glucose in the upper intestinal tract, and even in the circulation, can also act to condition food preferences and stimulate appetite and food intake. This phenomenon is called “appetition” to distinguish it from the satiation process by which nutrients in the gut suppress appetite and intake (Sclafani 2018). Importantly, the post-ingestive signals from the GI tract can be both stimulatory and inhibitory and require the brain to integrate possibly antagonistic influences.

Body Fat Stores

The brain is informed of the present status of the adipose stores in the body via the secretion of various hormones by the adipose tissue itself, among which insulin (Woods 2013) and leptin (Zhang et al. 1994), allowing lipostatic mechanisms to influence behaviors. The status of the adipose stores in the body modulates the response to sensory factors such as palatability. For example, after weight loss, regulatory processes enhance the attractiveness of sensory signals so that more is consumed, progressively restoring the original level of body adiposity. This process is reflected in the activity of the “hungry brain” after weight loss, in which activation patterns are enhanced in response to food, a change that can be antagonized by the administration of leptin (Zheng et al. 2009).

The Role of Learning and Plasticity

One important adaptive skill of animal life is the capacity to learn. Animals can learn from previous experiences and adapt their responses to environmental cues in order to anticipate situations of need and minimize the impact on their vital functions or to avoid them altogether.

Learning shapes both behavioral and physiological responses. The conditioned reflex, whose mechanism was demonstrated at the beginning of the nineteenth century (Pavlov 1927), is one extremely useful tool in an animal’s regulatory arsenal. The brain associates stimuli that occur in contiguity in the environment, so that one (e.g., Pavlov’s bell) reliably predicts another (e.g., the meat served to Pavlov’s dogs). As a result, predictive conditioned stimuli acquire the capacity to elicit adaptive, homeostatic responses in anticipation of the contact with unconditioned stimuli.

Animals in the wild and humans living in organized societies learn to anticipate eating occasions in their particular environment. The circumstances of habitual food intake, the time of day, the smell and sight of foods, become conditioned stimuli that trigger a set of anticipatory metabolic reflexes before ingestion has even started in order to facilitate the absorption of nutrients by the body. This phenomenon is known as the “cephalic phase” of digestion (Powley 1977). Among many aspects, a neurally elicited insulin secretion occurs before or at the very beginning of meals (Teff 2011). The cephalic-phase insulin secretion in humans is small in magnitude, but its occurrence at start of meals is sufficient to minimize the metabolic deviations that follow the meal and enhance nutrient assimilation (Woods et al. 2018). Un-signaled meals or snacks result in higher postprandial hyperglycemia due to the lack of a cephalic-phase insulin response (Chapelot et al. 2004; Teff 2011). Other reflexes of the "cephalic phase" affect many other hormones and enzymes that aid the digestion and absorption processes. A common feature of these conditioned anticipatory responses is that they occur in the absence of any major deviation of regulated parameters; they act to prevent it or at least minimize its effects. An efficient regulator, animal or human, does not wait for critical situations to develop and uses prior experience to avoid or minimize need states (Ramsay and Woods 2016).

At the behavioral level, learning shapes an individual's hierarchy of food likes and dislikes, based on the association of sensory characteristics of foods with post-ingestive effects. Importantly, in the context of a discussion of regulatory influences, the appropriate amount of a particular food to ingest under particular need states, present or anticipated, is learned based on repeated experiences of the nutritive properties of the food: appetite and satiety are conditioned responses (Booth 1977). Ingestion stops long before most nutrients are digested and absorbed: learned associations between sensory cues and post-ingestive satiety allow an individual to stop eating with the assurance that sufficient calories have been acquired (Woods 2009). In much the same way, instrumental responses are learned to allow an animal or human to make optimal use of the resources of the environment and obtain a supply of food (via hunting, gathering, or shopping) before vital parameters deviate from life-sustaining levels.

Ingestive responses to homeostatic deviations do occur, for example, when blood glucose is severely reduced (Langhans 1996). However, eating most often happens at glucose levels considerably above critical values (Woods 2009), and most regulatory responses occur without using negative feedback (Somjen 1992).

As any learned responses, anticipatory regulatory responses are plastic as opposed to hard-wired reflexes (Woods 2013). Even the satiating action of digestion-related hormones (such as CCK) is actually a plastic conditioned response rather than a hard-wired unconditioned response. It is therefore subject to the process of extinction or modulation if ingested substances do not contain the expected amount of energy (Woods et al. 2018).

The Complex, Hierarchical Organization of Brain Function

The progresses of brain imaging techniques have allowed major advances in the identification and understanding of brain regulatory mechanisms. The hypothalamus together with the corticolimbic system and the hindbrain can be seen as the core processor in the control of appetite (Berthoud et al. 2017). The brain receives a continuous stream of diverse signals regarding the energy status throughout the body and monitors the entry of nutrients into the blood and their utilization by most tissues (Woods 2009). At the time of meal, the brain integrates signals reflecting energy input with the present and anticipated state of need and acts as a "homeostatic regulator," adjusting intake to needs in a flexible, largely anticipatory manner. Brain mechanisms at times must arbitrate among multiple possibly conflicting regulatory responses. For example, if chronic glucopenia is created in experimental animals, energy intake increases to maintain blood glucose even if the augmented energy intake induces significant weight gain (Langhans 1996): although both body adiposity and blood glucose are regulated parameters, protecting acute blood glucose levels takes priority over body weight control (Woods 2009).

The reward or hedonic value of food is represented in the brain. Food reward is a composite process that includes "liking" (hedonic appreciation), wanting (incentive motivation), and learning (reward value based on associations and predictions). All occur together, but the three components have separable brain systems (Berridge et al. 2010): conscious liking in humans is encoded in the prefrontal cortex; wanting is encoded by the mesolimbic dopamine system mainly projecting to the nucleus accumbens in the ventral striatum. Liking is relatively independent of the prevailing nutritional state. By contrast, wanting is greatly amplified by hunger (Berthoud et al. 2017), and satiety dampens the stimulatory impact of food cues (Berridge et al. 2010). Several brain regions and neurochemical systems mediate conditioned preferences based on postoral nutrient sensing (Sclafani 2018). Dysfunction in reward circuits might contribute to dysregulated eating and the rise of obesity, although it is still unclear whether the possibly faulty circuits are hypersensitive or hyposensitive to food reward.

Eating can be triggered by metabolic need, hedonic drive, or an interaction between the two, and there are several neural circuits that represent this interface. Metabolic signals of energy status modulate processing of cognitive and reward functions in corticolimbic systems (bottom-up processing), which influence regulatory processes including ingestive responses (Berthoud 2011). In turn, cognitive functions are capable of organizing food acquisition and consumption in order to optimize nutritional benefits, for example, when planning meals or finding information about the nutritional value of foods. In other circumstances, however, the cognitive and emotional brain can override homeostatic regulation (top-down processing) to yield an energy imbalanced state (Berthoud 2011).

As a result of these major scientific developments, it is now recognized that, in order to be efficient, an animal's vital regulatory system requires complex and redundant nutrient sensing and monitoring mechanisms, a flexible integrative mechanism that can learn from and adapt to changing external and internal conditions, and powerful effector mechanisms for energy intake and metabolism (Berthoud et al. 2017). The human organism is equipped with such highly competent mechanisms.

Regulatory Responses and the Control of Ingestive Behaviors in Free-Living Humans

The modern vision of regulatory mechanisms acknowledges that FI participates in the regulation of numerous internal parameters of vital importance. The ingestive responses are triggered, however, not only by simple feedback loops that correct an acute state of need or excess but, more generally and more efficiently, in an anticipatory fashion, after an organism has become accustomed to a predictable environment. States of need or excesses can be anticipated and partially or totally avoided, thereby insuring the stability of the internal milieu. How do actual ingestive behaviors in free-living individuals respond to these various mechanisms?

A number of methods developed over the years have investigated ingestive patterns in free-living humans and identified conditions or factors affecting the number of daily eating episodes, their size or duration, and their satiety effects. In particular, they examined the influence of thirst and hunger or other factors potentially reflecting regulatory needs. These methods require consumers to report all their consumption episodes over a number of days. In addition to what typical dietary surveys include, these methods obtain information about various circumstances of consumption, for example, time of day, day of the week or month, company sharing the meal, context, and palatability. In many cases, visual analogue scales (Stubbs et al. 2000) or other validated instruments that assess facets of appetite (hunger, thirst, fullness, desire to eat or drink, etc.) provide insights into subjectively experienced states of need.

The "Weekly Food Diary" method examines ingestive patterns over a whole week and computes a correlational analysis of the relationships between ingestive events (de Castro 1994). A different approach consists in gathering hourly appetitive ratings and dietary recalls for 7 consecutive days (McKiernan et al. 2008b). Such reports quantify the number of daily eating events (meals or snacks), the amount of energy/nutrient/fluid ingested in each event, the duration of consumption, and the duration of pre- or post-intake intervals.

Hunger and Thirst

These studies reported many unexpected observations. First, they provided little support for the intuitive notions that thirst is a major stimulus of drinking and that eating is a response to hunger states. A weak coupling appeared between the sensations hypothesized to signal biological need states and ingestive behaviors distributed over the waking hours. In a review covering 39 dietary surveys, it appeared that most (64%) did not observe any significant association between appetite ratings and actual intake (McKiernan et al. 2008b). Hourly reports revealed that patterns of hunger are only weakly predictive of energy intake ($r = 0.30$) and patterns of thirst fail to predict energy intake or fluid intake ($r = 0.08$ and $r = 0.03$, respectively) (McKiernan et al. 2008b). In Weekly Food Diaries, the intensity of hunger sensations recorded at the beginning of a meal and the duration of the interval since the previous episode of intake (an objective measure of food deprivation) show significant but very modest associations with the size of the meal, accounting for only 4–9% of the variance in meal size (de Castro and Elmore 1988). One internal factor, the estimated stomach contents at the beginning of consumption, shows a negative correlation (de Castro 2010) with the size of the meal. The correlation, however, accounts for less than 6% of the variance in meal size.

About 75% of all fluid intakes occur at the time of eating (McKiernan et al. 2009). The sensation of thirst at meal time is only weakly associated with total fluid intake. Relatively rare drinks occur independent of eating and are correlated with the degree of thirst (de Castro 1988). Drinking without eating leads to a decrease in thirst sensation whether or not the beverage contains energy; however, drinking without eating does not induce any reduction of hunger even when the beverage contains energy (McKiernan et al. 2009).

Environmental Influences

Beside these modest correlations with appetite sensations, the amount of energy consumed in one eating event is significantly affected by external factors such as time of day and day of the week and by the number of persons sharing the meal (de Castro 2010). The "social stimulation" of eating is a robust observation that varies qualitatively as well as quantitatively. Different social interactions (parental, friendship, work, etc.) affect meal intake in potent and complex ways (Herman 2015). Meal size appears to be a power function of the number of persons present. However, the magnitude of the correlation remains modest, accounting for 9% of the variance in meal size (de Castro and Brewer 1992).

Time of day is a major factor affecting daily eating patterns. Energy intake is not distributed evenly over the waking hours: meal sizes increase from morning to night. Breakfast, which occurs after the long overnight fast and in the most acute state of need, is often a relatively small meal. Satiety, the inhibition of ingestion induced by prior consumption, is not a stable phenomenon over the waking hours but rather seems to decrease in efficiency from morning to night. Breakfast produces relatively long-lasting satiety. As the day progresses, average meal size increases and intermeal intervals get shorter.

Short-Term and Long-Term Adjustments

Importantly, there is no evidence of adjustment of energy content, or compensation, on a meal-to-meal basis: no significant correlation appears between the size of a particular meal and the size of subsequent meals (e.g., a large lunch is not necessarily followed by a small diner) (McKiernan et al. 2008a; de Castro 2010). Another important aspect of ingestive patterns relevant to regulation is that food intake varies considerably from day to day (de Castro 2010). If the internal milieu must be kept constant, homeostatic mechanisms should compensate for these variations and adapt intake in response to a prior day's deficit or surfeit. Many studies report that correlations between 2 successive days are not significant (de Castro 1998). However delayed compensatory adjustments can be observed after 2 or 6 days and appear to be macronutrient specific (De Castro 1998; Champagne et al. 2013). These observations are consistent with the 2–3-day delays in adjustments in FI following changes in physical activity (Edholm et al. 1955). Each macronutrient exerts a maximal negative relationship with subsequent intake of that same macronutrient with 2-day lag (de Castro 1998). The 2-day delay eliminates acute GI, plasma, and hepatic factors as intermediaries. Rather it suggests that feedback from a long-term energy storage depot (fat) may be involved (de Castro 1998). Once more, these significant compensatory effects are small and account for less than 5% of the variance in daily intake (de Castro 2010).

Putting the Pieces Together

According to the General Control Model proposed by de Castro (2010), external factors such as daily, weekly, or seasonal rhythms, social facilitation, dietary restraint, cost and availability of food, palatability, energy density, culture, beliefs, etc. contribute to the control of ingestive behaviors along with a large number of internal compensated factors with regulatory feedback loops, among which stomach contents, blood glucose, free fatty acids, leptin, body weight, body fat mass, temperature, insulin in the central nervous system, and hypothalamic neuropeptide-Y concentrations (de Castro and Plunkett 2002). Each of these factors exerts a minute influence, although it may be significant in correlational analyses. The influence of any one factor can only be understood when considered in combination with many, if not most or all, of the other influential factors (de Castro 2010).

Food Intake and Regulation in the Contemporary World

Dietary reports in America and many European countries show that two to three main meals plus two to four snacks or more occur on most days in most adults and children (Bellisle 2014). FI occurs every few hours, when no major state of need has developed. Humans also work, study, commute, watch various screens, enjoy diverse forms of leisure activities, and devote time to family and friends. Time has to be shared between numerous activities, obligatory and/or optional. When to eat appears largely dictated by environmental and social constraints, especially time of day (socially determined time of main meals, time when foods are available for snacking).

Actually, in the twenty-first century, it may be more appropriate to say that time used to be shared between so many different activities: nowadays eating is often done while doing something else (e.g., watching various screens) (Kahneman et al. 2010). Cultural differences modulate this overlap of eating with other activities: in America eating is often considered an accessory activity that is compatible with other “main” activities, whereas in France eating is reported as the “main” activity that sometimes can be contemporary with other compatible behaviors (Kahneman et al. 2010). While the influence of significant regulatory factors appears to be modest in studies of eating patterns, it is likely that this modest influence can be diluted if FI itself is just one feature, and maybe not the main one, of the attention-requiring activities. Ample evidence has been obtained of the deleterious effects of distraction at the time of eating on both satiation and satiety (Higgs and Spetter 2018).

Surprising as it may seem, the action of regulatory factors, among this plethora of diverse and often antagonistic influences, is detectable. It is evidenced by the modest energy and nutrient-specific compensation phenomena observed over several days (discussed above) and also by the relative stability of body weight over long periods of time in most adults. Weight stability reflects a state of energy balance at all levels of the body adiposity spectrum; in overweight/obese individuals, this is achieved at a higher level of body fat (Hall et al. 2012), confirming very precise regulation. In many populations, however, body adiposity has increased to unprecedented levels in recent years, suggesting a strong positive balance and faulty regulation. Using a population-averaged model, Hall et al. (2011) established that the development of the obesity "epidemic" in American adults resulted from a small persistent average daily energy imbalance gap between intake and expenditure of about 30 kJ per day, a very small positive but cumulative deviation.

How can obesity develop then, if adiposity regulation remains active? Animal and human studies show that body adiposity regulation is asymmetrical: while the procurement of sufficient energy and nutrients are strongly defended, preventing decreases of body adiposity, the homeostatic defense of upper limits of adiposity is under no such critical constraints (Zheng et al. 2009). The critical pressure against elevated body weight during evolution is thought to be vulnerability to predation, a problem that has lost its selection power as human societies developed very efficient protection (Zheng et al. 2009; Speakman et al. 2011; Rogers and Brunstrom 2016), allowing body weight to drift upward progressively. The long-standing and successful efforts of sapiens to secure protection from famine, on the one hand, and from predators, on the other hand, have led to a progressive increase in body size over, at least, the past 300 years (Caballero 2019). The obesity "epidemic" of the recent decades is not a novel phenomenon but rather the ultimate development of this trend, facilitated by major social and economic progresses (Caballero 2019).

Given the changing survival pressures in human societies, a genetic drift may have allowed a progressive increase in the adiposity set point (Zheng et al. 2009). In addition, numerous aspects of modern lifestyle contribute to making FI escape the moderating influence of regulatory factors. Clearly, many of these factors are associated with food and eating patterns, for example: increased availability of palatable energy-dense foods; increased exposure to food cues; increasing portion sizes; increased variety of food options, more frequent eating outside the home; low-cost of high-fat, high-sugar foods and sweetened beverages; reward from comfort food; distracted mindless eating while watching one of many screens. The general increase of obesity in the American population, affecting all ages and social strata, has been attributed to the sudden increase in food supplies that took place first in the USA in the second half of the last century (Rodgers et al. 2018). A "vicious circle" effect is possible: over-ingestion of high-fat diets can rapidly produce hypothalamic inflammation and damage, causing the adiposity set point to change (Thaler et al. 2013). Other suspected obesogenic influences derive from non-food-associated aspects of lifestyle: decrease in energy expenditure below the point where it can exert a moderating influence on intake, use of artificial light and disturbed sleep patterns, screen exposure, central heating, disturbance of the microbiota, and cumulative epigenetic vulnerability developed in successive generation of sedentary pregnant women, among others.

As a likely consequence of the above obesogenic influences, it is now common in most developed societies that at least half of the adult population is either overweight or obese. It should not be overlooked, however, that the other half is not obese, in spite of the shared environment and the plethora of anti-regulatory influences. Individual risk factors for obesity are the focus of very active research, among which the many genetic variants that differentiate the obese from the nonobese (Speakman 2007). Many genes affect food selection, food intake, absorption, metabolism, and energy expenditure, including physical activity. Genetic factors modulate the response to most of the internal and external factors identified in analyses of free-living ingestive patterns (de Castro 2010). Of interest also is the strong social gradient observed in developed societies, with decreasing rates of obesity as income and education increase (Pavela et al. 2019). What makes certain social strata relatively immune to obesity deserves to be investigated: food choices and habits are different according to socioeconomic factors, while other aspects of lifestyle (access to sports and medical care) have the potential to make a significant contribution. Such differences could, at least hypothetically, facilitate a higher sensitivity to regulatory influences.

Conclusion

The study of regulation mechanisms has stimulated spectacular developments in many scientific fields: sensory physiology, digestive physiology, behavioral science, psychology, and brain structure and function, among others. Much has been learned. Food intake, in its immense complexity, is one important effector in the regulation of several important parameters of the internal milieu. The naïve view that hunger triggers eating while thirst prompts drinking finds little support in scientific reports of present lifestyle, perhaps because states of physiological need can be prevented by anticipatory intake responses. Regulatory responses to energy or nutrients needs are not perceived at the scale of 1 day. However, evidence of regulation becomes clearer when intake and weight are followed over longer periods. The classic notion of a fixed body weight set point preventing and/or reversing weight losses and gains has been replaced by the notion of a flexible regulator that learns from experience and adapts to changing environmental conditions, resulting in a “floating set point” (Zheng et al. 2009) that resists adiposity decreases but is very prone to increases under the influence of nutritional and non-nutritional influences in the obesogenic world.

The obesity “epidemic” in modern societies does not rule out the action of powerful regulatory mechanisms acting in present lifestyle conditions. Procurement of energy and nutrient to cover bodily needs are strongly defended, while an asymmetrical regulation of body adiposity stores allows a progressive upward drift of body weight in large segments of contemporary populations. Clearly, numerous nutritional and non-nutritional influences make body adiposity regulation difficult and imprecise. An important question remains of the critical factors that allow so many people to maintain a healthy weight under the very same obesogenic conditions. The contribution of FI, under genetic or socioeconomic influences, to these differences remains to be examined in this context.

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Influence of Sensation and Liking on Eating and Drinking

7

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Contents

Abstract

Flavor is an integrated unified perceptual phenomenon that arises from inputs across multiple sensory modalities, including taste, smell, chemical touch (chemesthesis), and oral somatosensation. The flavor of foods influences the decisions we make about what foods to eat, and in an environment with abundant options, this primarily occurs by causing us to reject certain foods because we do not like the sensations they evoke. In general, bitter sensations

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tend to be disliked, while sweet sensations are liked; data on other taste qualities are less clear. Notably, there are substantial differences between people, both in their sensory and affective responses, and learning and exposure can decouple sensations from innate aversive responses. Further, dynamic changes in liking within a meal also influence the amount of food we eat.

Introduction

To the average person on the street, the flavor of a food is typically viewed as an inherent property of the stimulus (i.e., the food). That is, apple flavor comes from an apple, potato chips are salty, and sugar is sweet. A variant of this belief is also shared by many food chemists or product developers with in the food industry: if I wish to formulate a grape-flavored drink, I simply obtain a natural or synthetic flavor (like methyl anthranilate) from a supplier and add it to my product. However, this essentialist view misses a critical point: flavor is a perceptual phenomenon (i.e., a percept), meaning it occurs in the brain, not the bottle. That is, the percepts we experience from foods are not only the result of the integration of multiple physiologically distinct sensory systems but also prior experience and learning. If I have never been exposed to the odorant cis-rose oxide, I will likely struggle to describe it, but if I can, I will probably say it has a generic fruity odor. However, to other individuals, the sensation of cis-rose oxide is very clearly the characteristic flavor of lychee fruit or an Alsatian Gewürztraminer wine. As we chew the lychee, the overall flavor emerges from the volatiles sensed via olfactory receptors, but also the sweetness of the sugars and the sourness and astringency of the organic acids. A review of the biological and physiological processes that underlie these sensations is provided elsewhere in this handbook (see Duffy and Hayes forthcoming). The focus of this chapter is on flavor perception, the relationship of food sensations to liking and eating, and factors that complicate these relationships.

A General Framework Linking Sensation to Eating Behavior, via Affective (Hedonic) Responses

It is widely and broadly accepted that the sensory properties of food have a substantial influence on ingestive behavior: at home, parents add salt to cooked vegetables prior to serving; at the café, patrons add sugar and/or cream to their coffee; and in research and development labs around the globe, food companies spend millions of dollars each year to optimize their formulations. However, it is also fair to state that the sensory properties of food are only one small factor among many that influence behavior regarding the consumption of foods and beverages, as evidenced by numerous other chapters in this handbook. Still, a convincing argument can be made that the sensory properties of foods and beverages influence both food choices and termination of eating within a meal via changes in pleasure. This chapter provides a brief overview of these data.

When we add salt to our food, or sugar to our coffee, we change the amount of saltiness or sweetness in that food, and the lawfulness of these relationships has been studied for decades by psychophysicists, sensory scientists, and food technologists (e.g., Holway and Hurvich 1937; Schutz and Pilgrim 1956; Pangborn 1963). In turn, the observation that the pleasure arising from a sensation varies as a function of intensity or concentration is not new (e.g., Pfaffmann 1960). Indeed, in 1874, Wilhelm Wundt, the founder of experimental psychology, noted that pleasantness increased with sensation intensity, before peaking, and then falling as sensation continues to increase. For taste, this was first shown experimentally in 1928 by Engel for sourness and saltiness (see Pfaffmann 1980). Some have characterized the point of maximal pleasure, that is, the point at which the curve turns over (i.e., the second derivative) as the "bliss point" (Moskowitz 1981). However, in practice, this is probably a misnomer, as extant data indicate this region is more of a plateau in practice, as consumers are actually quite tolerant (i.e., insensitive) to formulation changes near this point (e.g., Li et al. 2014b; Rolon et al. 2017). Other data also indicates there are large and robust individual differences in the shape of the concentration-pleasure curve (e.g., Garneau et al. 2018; Iatridi et al. 2019a, b) that are largely obscured when only mean responses are considered (cf. Lundgren et al. 1978 and Moskowitz 1971). Still, if one assumes that humans are pleasure maximizing, or at least pleasure seeking, then it typically assumed that greater liking drives greater intake. This assumption is generally well supported by evidence in adults (de Graaf et al. 2005; Tuorila et al. 2008; Johnson et al. 2014; Byrnes and Hayes 2016; Park et al. 2018) and children (Caporale et al. 2009; Vosburgh et al. 2019) for both foods (e.g., Dinehart et al. 2006) and beverages (e.g., Lanier et al. 2005).

Collectively, the three pairs of relationships described above – concentration-sensation, sensation-pleasure, and pleasure-intake – result in a causal chain that links the formulation of a food product to consumption. However, the correlations of each step along this chain are far less than one, both due to statistical attenuation due to measurement errors (see Hayes 2015) and other factors that meaningfully modify these individual relationships (e.g., genetic variation, cost, availability, branding, dietary restraint, cultural factors, moral disgust, etc.). By one rough approximation, the total variance in intake that can be explained by formulation is actually quite low, somewhere between 2% and 22% (Hayes 2018). On the other hand, centuries of culinary traditions (including the historical quest for spices that quite literally drove exploration, colonization, and global trade), as well as the continual expenditure of substantial resources for formulation and reformulation over many decades by global food companies, imply the putative framework linking food formulation and sensation to intake via affective responses (see Fig. 1) must have some degree of face and predictive validity.

The following sections provide a discussion of various complications to the framework presented in Fig. 1. For additional information and discussion of this conceptual framework, the interested reader should also see Hayes (2015).

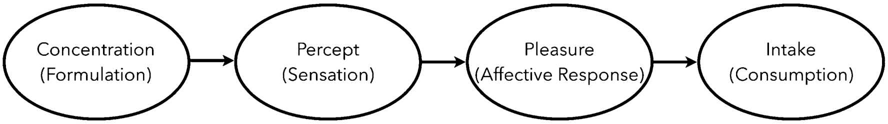

Fig. 1 A working model of how food composition is related to intake via pleasure

The Imperfect Relationship Between Food Liking and Food Selection or Intake

As noted above, most researchers accept that liking is positively (if imperfectly) related with intake. This has been repeatedly found by multiple researchers on multiple continents across multiple decades for multiple types of foods, with correlations in the literature ranging from +0.22 to +0.81 (e.g., Schutz 1957; Cardello and Maller 1982; Zandstra et al. 1999; Tuorila et al. 2008). For example, Lähteenmäki and Tuorila found the correlations between liking and use of chocolate, ice cream, licorice, flavored yogurt, cookies, and soft drinks were between +0.57 and +0.73 in Finish women (Lähteenmäki and Tuorila 1994), while Byrnes and Hayes found that the correlation between liking for the burn of a spicy meal and annualized intake of chili-containing foods was +0.58 in adults in the United States (Byrnes and Hayes 2013). These reports provide strikingly similar estimates to an early report from Schutz (Schutz 1957): he found that the now famous 9-point hedonic scale (Peryam and Pilgrim 1957; Meiselman and Schutz 2003) predicted both the amount taken and amount eaten by American military personnel in an ad libitum setting, with correlations between +0.51 and +0.77. More recent work suggests food liking questionnaires also predict dietary biomarkers (Sharafi et al. 2015) as well as aggregate measures of dietary quality in American adults (Zoghbi et al. 2017) and children (Sharafi et al. 2015) and Australian adults (Wanich et al. 2019).

As these examples illustrate, various studies have operationalized liking and intake in different and diverse ways – various consumption estimates include direct observation of amounts eaten or amounts taken, self-reported intake of specific foods, comprehensive diet records/food diaries, and data drawn from validated food frequency questionnaires, while affective responses are typically estimated from acute tasting of foods or longer surveys of multiple foods using some type of liking or pleasantness scale (i.e., so-called food preference questionnaires). While this heterogeneity complicates direct comparisons, it also provides some degree of convergent validity, which enhances the robustness and generalizability of the findings. Direct head-to-head comparisons of liking of sampled foods and surveyed liking (i.e., names on a list of foods) are far less common, although a few reports suggest this relationship is also positive, in the range of +0.43 to +0.64 (Hayes et al. 2010; Sharafi et al. 2012).

The consistent and robust positive association between various measures of liking and intake leads to the common conclusion that greater liking drives greater intake. At the extremes, this widespread assumption has led some to suggest that decades of optimization of foods by the food industry has somehow made these foods hyperpalatable or even addictive, thereby contributing to the obesity epidemic seen in industrialized nations (Kessler 2009; Moss 2013).

However, a deeper analysis of the liking-intake relationship suggests the common assumption that greater liking leads to greater intake, although extremely widespread, is incorrect, or at least, is insufficiently nuanced. Specifically, the relationship between liking and intake is heteroscedastic – that is, the data tend to have a cone shape when visualized in a scatterplot. As shown in Fig. 2, the variance in intake is quite small when liking is low, whereas the variance is much larger when liking is high. The data in the left and center columns show self-reported liking and intake data for a group of high-fiber foods (whole grains, fruits, and vegetables) and high-fat foods (fried foods, red meat, processed meats, oil and high-fat condiments, whole-milk dairy, cookies, cakes, and pastries) for 88 women from a worksite health promotion program in Connecticut (Duffy et al. 2009), while the rightmost column shows self-reported liking and intake data for chili-containing foods for 97 adults (18–45 years) in a laboratory study in Pennsylvania (Byrnes and Hayes 2013).

Practically speaking, the heteroscedasticity in these plots suggests that rather than being a driver of intake, affective responses act as a ceiling or break on intake – or to put it more simply, instead of the classical conclusion that more liking drives more intake, a better conclusion would be that *disliking drives nonuse*. Personally and intuitively, this should make sense. A person may really love large, well-marbled steaks and bold tannic Chianti wines from Italy, but still moderate their intake of each due to health concerns or cost or myriad other factors (e.g., Herman et al. 2019; Higgs and Ruddock 2019). Indeed, this point can be clearly illustrated in the bottom half of Fig. 2 by comparing the two shaded regions within each panel: when a food is disliked (i.e., is rated below neutral), almost no individuals consume it frequently (top left shaded region), whereas when a food is liked (i.e., is rated above neutral), many individuals still fail to regularly consume those foods (bottom left shaded region). For foods like fruits and vegetables, this discordance may represent cost or availability constraints or preferences of other members of the household. Conversely, for energy-dense foods, discordance between liking and intake may be an indirect measure (proxy) for dietary restraint in adults. Indeed, among American women, those who were discordant in this way (i.e., high liking/low intake) had significantly higher restraint scores on the Three-Factor Eating Questionnaire (Sharafi et al. 2018). In children, this same kind of discordance (i.e., high liking/low intake for high-fat/sweet/salty foods) associates with greater body mass index percentiles relative to the concordant low liking/low intake group, suggesting parents of these children may be restricting intake of foods they view as being unhealthful (Sharafi et al. 2015).

The idea that disliking discourages intake is not limited to self-reported assessments of chronic diet, as some controlled laboratory studies and naturalistic free-living feeding studies show similar effects on food intake and food choices. In one study of intake by US Army personnel under field conditions between 1995 and 1997 (de Graaf et al. 2005), the relationship between liking and intake was curvilinear, as is shown in Fig. 3. Critically, if a food was rated above neutral, greater

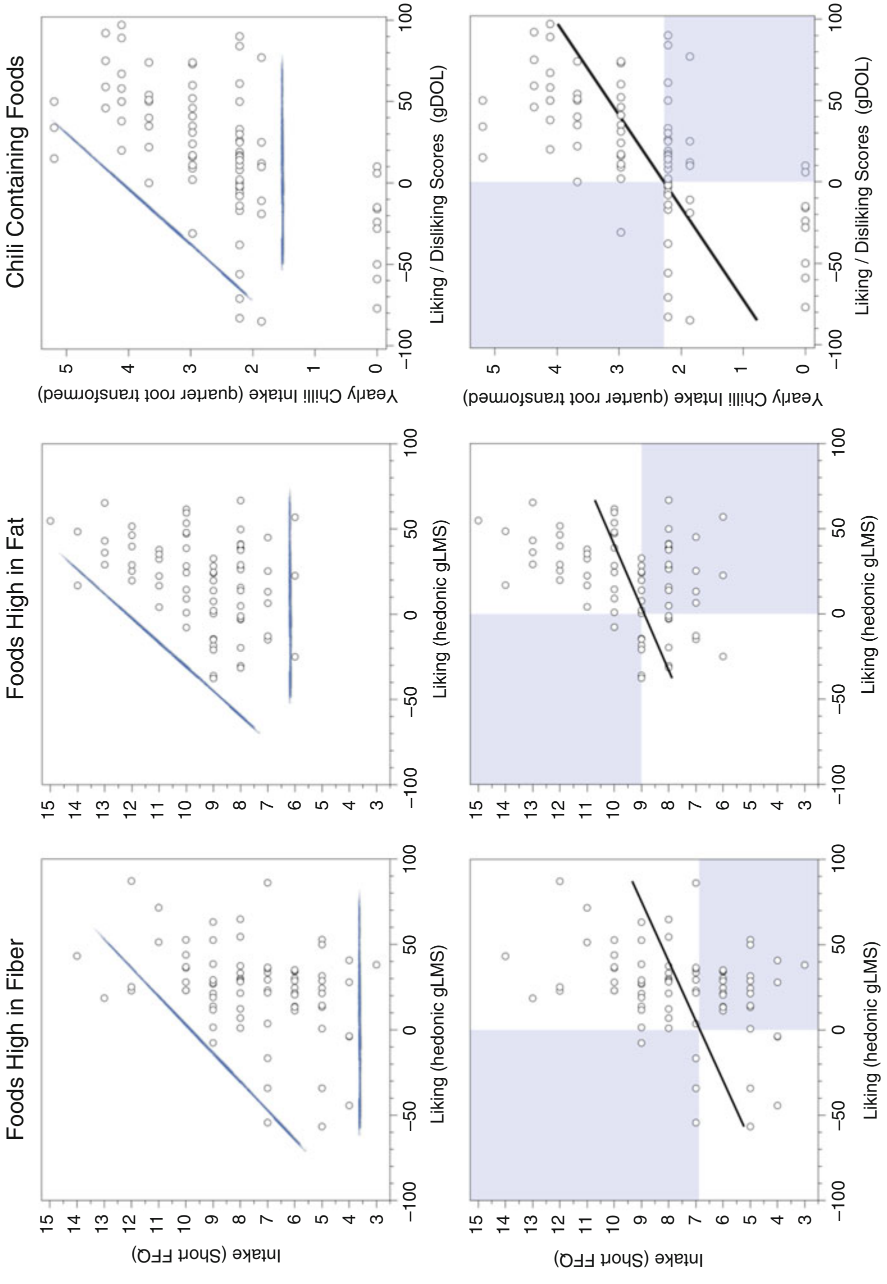

Fig. 2 (continued)

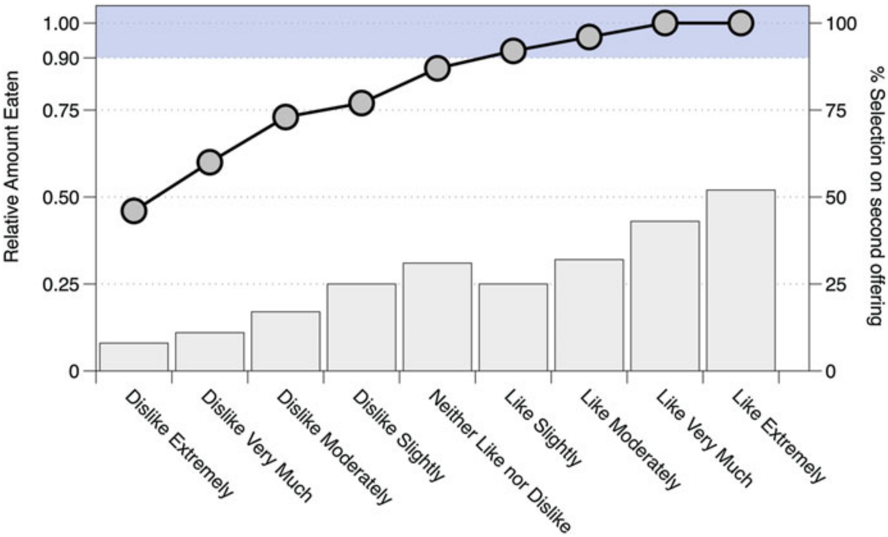

Fig. 3 Relationship between liking ratings and amount eaten on first offering (dots) and percentage of time selected on second offering (bars) under naturalistic feeding conditions with US Army personnel. The shaded region at the top indicates consumption of 90% or more of the food. (Data are replotted from de Graaf et al. (2005). See text for additional discussion)

liking was not a meaningful predictor of greater intake: for the top four categories on a 9-point hedonic scale (like slightly to like extremely), the average amount consumed exceeded 90%. Conversely, soldiers who rated a food as extremely disliked (i.e., a rating of 1 on a 9-point hedonic scale) consumed less than half of it (46%) on the initial offering. These data support the contention that disliking is more closely coupled with nonuse instead of greater liking driving greater intake – that is, disliking acts as a strong barrier to intake. One might argue that this represents a ceiling effect, as hungry troops may have eaten more of highly liked foods had they been available. Indeed, under laboratory conditions, Zandstra and colleagues did find a serving size effect on yogurt intake: under ad libitum conditions, almost all participants (Dutch students) stopped at the initial amount served (300 g), despite being told they could request more if they wished (Zandstra et al. 1999). However, for the soldiers, other data from subsequent offerings suggest that the curvilinear relationship shown in Fig. 4 is not merely an artifact due to serving size or availability. Specifically, when given the opportunity to select the same food a second time (from among several options), foods rated "dislike extremely" were

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Fig. 2 Self-reported food intake as a function of liking. (Data are replotted from Duffy et al. (2009) (left and center) and Byrnes and Hayes (2013) (right). The relationship between liking and intake is positive but heteroscedastic, as the variance in intake across the range of liking is uneven. Specifically, the top left corner is empty, meaning people do not eat the food they dislike, whereas in the bottom right corner, some people like those foods but still fail to consume them frequently)

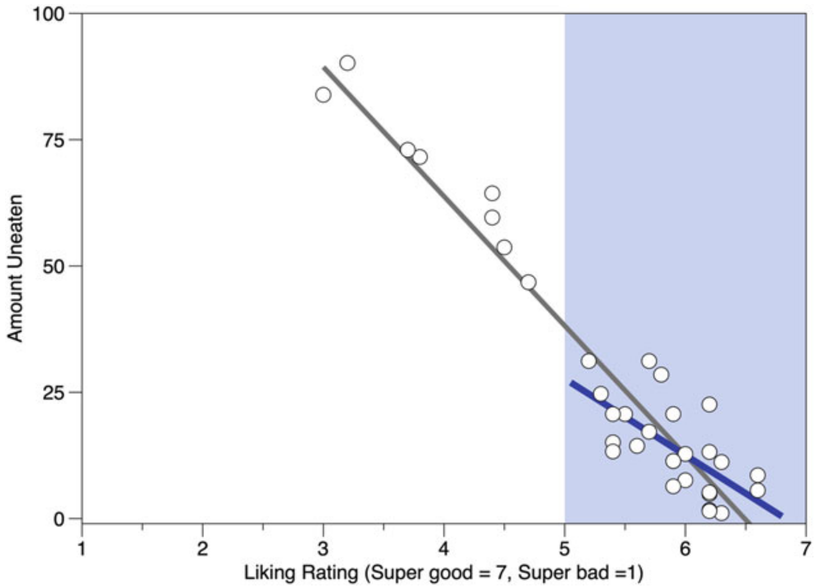

Fig. 4 Relationship between liking ratings and mean amount uneaten for 34 foods by 4- and 5-year-old Italian children under naturalistic feeding conditions (school lunch rooms). The gray line shows the strong negative relationship ($r = -0.96$; $n = 34$) between hedonic ratings and amount uneaten across all 34 foods reported by the authors. The blue line shows that that relationship is weaker, albeit still significant ($r = -0.66$; $n = 26$) when only the well-liked foods are considered (shaded region). (Data are replotted from Caporale et al. 2009)

only chosen 8% of the time, whereas even foods rated as "like extremely" were only chosen 52% of the time (de Graaf et al. 2005). The observation that highly liked foods were only selected about half of the time on a subsequent offering is wholly consistent with the idea that a food being highly liked is not, by itself, sufficient to drive choice or intake.

Nor are such effects limited to soldiers in the field. Mustonen and colleagues asked 62 Finnish women to rank 6 cheeses (full and reduced fat Edam, Emmental, and Havarti) for liking in the laboratory before having them choose three 150 g blocks of cheese to take home; their participants could select 3 of the same cheese, 3 different cheeses, or 2 of 1 and 1 of another. The two cheeses ranked as least liked were only selected ~12% of the time (Mustonen et al. 2007). As a final example, data from 4- to 5-year-old children in Italy also show a strong relationship between disliking and nonuse. Caporale and colleagues asked children to rate their liking of 34 different foods on a 7-point ("super good" to "super bad") scale and then monitored the amounts of these foods uneaten when served in the school lunchroom over the next 2 months (Caporale et al. 2009). Across all 34 foods, they observed a very strong linear relationship ($r = -0.96$) between hedonic ratings and amount uneaten. However, it also appears that the strength of this relationship was driven, in part, by massive underconsumption of the 8 least liked foods: the mean amount left uneaten for the

8 least liked foods was 68%, versus only 14% for the other 26 better liked foods. That is, as shown in Fig. 4, if the eight least liked foods are removed from the analysis, the relationship between liking and intake is weaker, although still significant.

In summary, simple correlations with group means can lead to the common but erroneous conclusion that higher liking leads to more intake, in part due the differential variance intake across the range of hedonic ratings. Instead, the data described here for both self-reports of chronic dietary intake and acute feeding studies under laboratory and naturalistic conditions each seems to suggest a better interpretation would be that disliking drives nonuse for both acute intake and food choices. And this disliking can often be related back to the sensations from the food.

Bitterness: A Signal for Pharmacological Activity and/or Toxicity

Chemicals humans describe as bitter are innately aversive, and stereotypical aversive responses are conserved across species (Ganchrow et al. 1983; Steiner et al. 2001); presumably, these innate responses help prevent ingestion of toxins (Scott and Mark 1987; Katz and Sadacca 2011). Indeed, numerous reports suggest bitterness leads to rejection and/or decreased intake in humans (e.g., Keller et al. 2002; Lanier et al. 2005; Dinehart et al. 2006; Duffy et al. 2010; Harwood et al. 2012a,b). The idea that bitterness is a gatekeeper that guards against toxin ingestion is not new. In 1975, Garcia and Hankins noted bitter stimuli are rejected in humans, and similar rejections are found in monkeys, birds, fish, invertebrates, and protozoa, causing them to conclude rejection of bitterness is a phylogenetically ancient response (Garcia and Hankins 1975).

However, other data challenge the common and persistent view that bitterness is a simple signal to reject a food entirely. In 1994, Glendinning noted many bitter stimuli are not actually toxic (Glendinning 1994), an idea that was recently revisited by Niv and colleagues. Using toxicity data and chemoinformatic tools (i.e., BitterDB (Wiener et al. 2012) and BitterPredict (Dagan-Wiener et al. 2017)), Niv and her team found only 60% of bitterants in BitterDB are toxic and that only 56% of toxic compounds are expected to be bitter (Nissim et al. 2017). This suggests classic assumptions about bitterness and toxicity may be an oversimplification. That is, instead of being a STOP sign per se, bitterness may instead be a CAUTION GO SLOW sign to allow us the opportunity to learn about the stimulus via controlled exposure. The potential medicinal properties of bitter stimuli have been noted for many decades (see Goodman's Pharmacopeia (Goodman and Gilman 1941)), and many beneficial phytonutrients are bitter (Drewnowski and Gomez-Carneros 2000). Likewise, folk medicines like woolly foxglove (digoxin) and cinchona bark (quinine) have a long history of use. Phlorizin, a phenol glycoside isolated from apple tree bark in 1835, was first used as an antimalarial due to its similarity in taste with known antimalarials (Ehrenkranz et al. 2005). The ability of bitterness to act as a marker of potentially desirable pharmacology (versus toxicity to be avoided) is even observed in nonhuman primates (Huffman et al. 2013) and other animals (Villalba et al. 2014). Such therapeutic self-medication by animals (i.e., zoopharmacognosy) presumably requires a mechanism by which the animal can learn to associate specific secondary plant compounds with the beneficial effects of their ingestion.

Similar learning can be commonly observed in humans, as should be apparent from the widespread consumption of black coffee and heavily hopped craft beers. That is, for coffee, the bitterness is aversive initially. But with repeated intake, positive response to caffeine decouples negative affective responses to the bitterness. That is, bitter coffee stops being aversive and may become desirable due to the pharmacological action of caffeine (e.g., Cines and Rozin 1982; Chambers et al. 2007). This process has been termed flavor-consequence learning (Yeomans et al. 2005). In summary, bitterness is innately disliked, and this appears to be evolutionarily important as it is found in multiple species; however, bitterness is not a simple break on intake, as innate aversions to bitter sensations can also be overcome via learning processes, including those involving reward.

Biological Differences in Bitterness Perception What Potentially Influence Food Liking and Consumption

In addition to experiential factors mentioned above, the influence of bitterness on food choice and eating behavior also varies across people due to normal biological variation. The systematic study of individual differences in chemosensation dates back almost a century (e.g., Blakeslee and Fox 1932), with the initial studies on diet and food liking coming later (Fischer et al. 1961; Glanville and Kaplan 1965). Multiple comprehensive reviews already exist elsewhere (Duffy 2007; Hayes et al. 2013; Keller and Adise 2016; Running and Hayes 2016; Ulla et al. 2016; Hayes 2018), so they will not be discussed here in great detail. As one example, the functional consequences of polymorphisms in the *TAS2R31* gene will be presented briefly here. Humans generally find sweetness appealing and desirable, but at the same time, consumers often do not want the calories that accompany bulk sweeteners like sugar, resulting in large commercial demand for various nonnutritive sweeteners (Sylvetsky and Rother 2016; Wee et al. 2018). The sulfonyl amide sweeteners saccharin and acesulfame potassium (Ace K) are widely used in tabletop sweeteners and diet beverages. However, these sweeteners also have a bitter side taste that is experienced by some individuals but not others (Schiffman et al. 1979; Horne et al. 2002); as would be expected, greater bitterness leads to lower liking ratings (Kamerud and Delwiche 2007). These phenotypic differences in sensation are caused by a single amino acid substitution (Arg35Trp) in the *TAS2R31* gene (Roudnitzky et al. 2011). Consequently, genetic variation in the *TAS2R31* associates with differences in suprathreshold bitterness intensity (Allen et al. 2013a,b) and differential liking of Ace K across individuals (Bobowski et al. 2016). The same gene variants also associate with substantial differences in the bitterness intensity of quinine, as well as the liking for grapefruit (Hayes et al. 2015). However, published data associating these variants with food intake is still lacking.

Notably, this specific genotypic variant and the resulting phenotypic differences are only one example of many. The *TAS2R31* variants are independent of variants in *TAS2R4* that are associated with stevia-derived sweeteners (Allen et al. 2013a; Risso et al. 2014) or *TAS2R38* variants that associate with liking and intake of vegetables (e.g., Duffy et al. 2010; Sandell et al. 2014) or alcohol (e.g., Hayes et al. 2011; Beckett et al. 2017; Hayes and Nolden 2017). Nor are such differences restricted to taste, as functional variants have been reported for starch breakdown (Perry et al. 2007; Mandel et al. 2010) and numerous odorants (Keller et al. 2007; Lunde et al. 2012; Jaeger et al. 2013; Mainland et al. 2014). This remains a highly active area of research (e.g., Trimmer et al. 2019), so it seems likely new relationships between genetic variation and eating behavior will continue to emerge.

Sweetness Is Widely Liked, but Optimums Differ Across People

Like bitterness, humans and other mammals show an innate response to sweetness, but unlike bitterness, this response is positive and presumably appetitive. When newborns only a few hours or day old are given sucrose solutions, they exhibit stereotypical facial responses that are interpreted as being positive (Steiner 1977; Steiner et al. 2001). Likewise, when given plain water or carbohydrate sweetener (i.e., glucose, fructose, lactose, or sucrose) solutions, healthy infants 1–3.5 days old drink more of the sweetened solutions than water, and the different intake increased as sweetener concentration increased (Desor et al. 1973), which has been interpreted to mean the newborns like the sweeter solutions more. Similarly, both healthy term and preterm infants increase their sucking rate and sucking intensity when sucrose is provided without any fluid intake (Maone et al. 1990). Other evidence indicates innate appetitive responses to sweetness even predate birth – if amniotic fluid surrounding a fetus is sweetened by injecting the nonnutritive sweetener saccharin into the amniotic sac, the fetus will increase their swallowing rate (De Snoo 1937).

As noted previously, affective responses to increasing concentration of a sweetener generally exhibit an inverted U shape. Notably, children tend to prefer higher concentrations of sucrose as compared to adults (Mennella et al. 2011; Garneau et al. 2018), and this appears to be a true affective shift rather than a mere cohort effect, as the same individuals show a decline in preferred concentration as they age (Desor and Beauchamp 1987). Within parent-child dyads, children also show greater liking for sweet foods (Vosburgh et al. 2019). There is some evidence to suggest increased liking for higher concentrations of sucrose is related to growth associated biomarkers (Coldwell et al. 2009), although other studies fail to confirm this effect (Mennella et al. 2014).

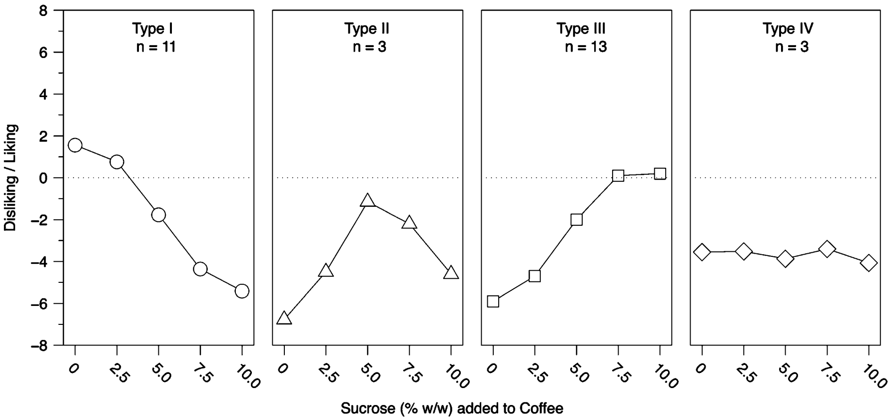

Fig. 5 Illustration of stereotypical patterns of hedonic responses: liking changes as increasing amounts of sucrose are added to instant coffee. (Data are adapted from Lundgren et al. (1978). See text for additional discussion)

While sweetness is innately liked, there are also a large body of work on individual differences in affective responses to sweetness (reviewed by Iatridi et al. 2019b) that dates back many decades (e.g., Pangborn 1970). Irrespective of the differences in sensation summarized in the previous section, individuals also show variation in their affective responses to stimuli. For sweetness, these types of studies have typically segmented people into two to four groups. One early example of this type of work is shown in Fig. 5 – for 30 participants in California in the 1970s, liking generally changes as increasing amounts of sucrose are added to instant coffee, but the patterns of responses also vary widely across groups (Lundgren et al. 1978). Specifically, Type I responders show a monotonic decrease in liking as more sugar is added, while Type II responders show an inverted U pattern. Type III responders show a monotonic increase, and Type IV responders appear indifferent to changes in sucrose, but also dislike all of the coffees. Critically, these data directly challenge the common belief that sweetness is universally liked. Indeed, the authors warn that individual variation needs to be accounted for in reporting sensory data, cautioning that "group averages may be misleading or even completely artifactual (Lundgren et al. 1978)." Regarding sweetness specifically, a recent review identified 71 different papers that segment individuals on the basis of hedonic responses using four major types of methods (Iatridi et al. 2019b). Contemporary methods have shifted toward using hierarchical cluster analysis rather than arbitrary groupings and typically identify three groups rather than four (Kim et al. 2014; Garneau et al. 2018; Iatridi et al. 2019a). The specific biological basis for differences in sweetness preferences has not been determined, but twin studies suggest it has a heritable component (Keskitalo et al. 2007). Several reports indicate that the phenotypic preference groups also differ in liking and intake of sweet foods (Kim et al. 2014; Garneau et al. 2018), and these differences cannot be attributed to simple differences in perceived intensity (Garneau et al. 2018).

Saltiness and Sodium

Using facial reactivity data from infants, multiple studies have found that human newborns do not provide clear affective responses to sodium chloride solutions (e.g., Rosenstein and Oster 1988; Zhang and Li 2006). When combined with older data that fail to show differences in intake for salt solutions versus water for newborns 1–3.5 days old (Desor et al. 1975), these observations are classically interpreted as indicating that responses to salty stimuli are not innate, in sharp contrast to the clear responses seen for bitter and sweet stimuli. Instead, it is assumed that preferences for salt depend on development, maturation, and/or learning, with a critical change occurring around 4 months of age. Specifically, when relative intake of salt solutions and water is compared for infants aged 2.5–6.7 months, it appears preferences for salt develops around 4 months of age (Beauchamp and Cowart 1985), a finding that has been replicated elsewhere (Schwartz et al. 2009). When exclusively breast-fed infants 4–6 months old are given salted and unsalted cereal, they eat more salted cereal (Harris et al. 1990). Similarly, when offered salted carrots versus plain carrots, 2-year-old children put more salted carrots into their mouths, and notably, preferences for saltiness appear to generalize, as the children who ate more salted carrots also consumed more salted foods, as intake of salted carrots was strongly correlated with greater intake of salted soup (Beauchamp and Moran 1984).

However, other data challenge the view that 2- to 4-day-old infants are indifferent to dilute salt solutions: when measures of sucking microstructure (i.e., mean sucks per burst) are compared for salt solutions and plain water, salt is less preferred, on average (Zinner et al. 2002). However, as noted previously, group means can be misleading, as a substantial number of the newborns appeared to prefer the salt solution to water, and strikingly, these preferences were related to both neonatal blood pressure and familial history of hypertension (Zinner et al. 2002). Indeed, newer data for infants tested at 2 and 6 months supports the existence of large individual differences in salt preferences, even prior to the critical 4-month window that is routinely cited (Stein et al. 2006). Looking more broadly across the lifespan, a preference for greater saltiness, like sweetness, appears to be elevated in children, who prefer higher salt concentrations than adults (Beauchamp and Cowart 1990); these shifted preferences may peak in the teenage years (Leshem 2009). In adults, adding salt to real foods like chicken soup or hash browns can increase liking (e.g., Hayes et al. 2010; Lucas et al. 2011), although as would be expected from Wundt, Engel, and Pfaffmann, there can be too much of a good thing, as liking drops when salt level exceeds some optimum (e.g., Hayes 2010; Drewnowski and Moskowitz 1985). There may also be sex differences in optimal levels of salt concentration, although data conflict as to whether men or women prefer higher levels of salt (cf. Hayes et al. 2010 and Leshem 2009).

When discussing salt and saltiness, it is also important to distinguish between the robust sodium appetite seen in some animals and the absence of similar behaviors in humans. Specifically, humans appear to consume salt for pleasure and not to meet a physiological need for sodium. That is, we fail to show clear sodium hunger: unlike many animals (including nonhuman primates), we do not increase our intake of salt when we are sodium deficient. In the words of Leshem (2009), "we will seek salt to please our palate, but not to save our life."

Sourness

Sourness is generally thought to be a negative taste quality (e.g., Desor et al. 1975; Rosenstein and Oster 1988; Steiner et al. 2001). As a consequence, it has received less attention than other taste qualities as a potential determinant of food preferences. However, sourness is seldom experienced in isolation, and sugar-acid balance is a major determinant of preference for a wide range of foods and beverages. For example, when liking of seedless table grapes by adults is modeled as a function of titratable acidity (which correlates with perceived sourness) and percent brix (i.e., sugar content, which correlates with perceived sweetness), liking rises with increasing sugar content and falls with increasing acid content (Jayasena and Cameron 2008). However, the ratio of brix to acid (i.e., sweetness to sourness) is a substantially better predictor of liking scores than either measure in isolation (Jayasena and Cameron 2008). Similar patterns have also been reported for chokecherry juice (Duffy et al. 2016).

Indeed, the global popularity of Margaritas, Caipirinhas, and lemonade suggests that sourness is not entirely negative, at least when paired with some sweetness. Liem and Mennella (2003) examined perception of and preferences for sour lemon-flavored gelatins in 5- to 9-year-old American children and their mothers. They found that 35% of the children selected the gelatin with highest citric acid concentration (i.e., the most sour sample) as being preferred, and this was not due to inability to sense the sourness, as almost all of the children were able to rank them from most to least sour. This aligns with data from 18-month-old Irish infants, where 23% readily accepted a blackcurrant-flavored drink (Ribena) with the highest levels of added citric acid; notably, fruit intake was greater in the sour-tolerant infants (Blossfeld et al. 2007). Similarly, in 8- to 11-year-old Dutch boys (but not girls), Liem and colleagues found that the preferred sour to sweet ratio for an orange-flavored drink was predictive of reported fruit intake (Liem et al. 2006). In one of the few studies on sourness preferences in adults, participants rated increasing concentrations of citric acid in water as less liked, regardless of age (Chauhan and Hawrysh 1988). Conversely, when presented within the context of an apple-flavored drink, liking first increased to an optimum and then fell as citric acid concentration increased (Chauhan and Hawrysh 1988).

Liking for Odors, Aromas, and Flavors

In direct contrast to the innate responses summarized above for prototypical taste qualities, affective (hedonic) responses to odors and aromas are almost exclusively learned, so no attempt will be made to systematically summarize them here. For more information, the interested reader should see numerous other works on this topic (e.g., Rozin and Vollmecke 1986; Rozin 1990; Birch 1999; Mennella et al. 2001; Sclafani 2004; Mennella and Beauchamp 2005; Yeomans et al. 2008; Prescott 2012; Yeomans 2012; Birch and Doub 2014; Nicklaus 2016). However, it should be noted that these effects are not entirely idiosyncratic and unpredictable across individuals, as shared environments from shared cultural contexts may also provide some degree of generalizability within groups from a specific region (e.g., Pangborn et al. 1988). For example, the affective responses to the presence of the odorant methyl anthranilate in wine appears to vary with geography (Perry et al. 2019). Also, the genetic variability mentioned previously can also interact with learning that may be culturally dependent. The ability to smell the odorants androstadienone and androstenone varies with two amino acid substitutions in the *OR7D4* olfactory receptor gene (Keller et al. 2007). Based on learned associations, some individuals describe these compounds as smelling like urine or body odor. Thus, it is quite understandable that normal variation in this gene can predict differential liking for cooked pork containing these odorants (Lunde et al. 2012).

Taste-Taste Interactions and Cross-Modal Effects

People generally eat foods, rather than tastants in water or simple model systems, and foods are perceptually complex stimuli. Even within very simple model systems with two components, perceptual interactions between sensations can substantially complicate attempts to predict liking (e.g., Lawless 1977). A detailed review of these interactions is beyond the scope of this chapter (and are available elsewhere; see Keast and Breslin 2003; Delwiche 2004). However, two key phenomena – mixture suppression and cross-modal enhancement – will be briefly discussed here.

When two qualitatively different stimuli like bitterness and sweetness are mixed, the perceptual intensity of each is lower in the mixture than the intensity that would be expected had they been presented separately. This is known as mixture suppression. One early example of this comes from Kamen, Pilgrim, Gutman, and Kroll: they found that sweetness from sucrose reduced the bitterness from caffeine, and a smaller suppressive effect was seen for the bitterness of caffeine on sucrose sweetness (Kamen et al. 1961). Subsequent work not only confirmed this effect but also showed that it was due to events in the central nervous system (Lawless 1979; Kroeze and Bartoshuk 1985) rather than being due to some chemical interaction in the mouth or some type of physiological interaction at the periphery. Notably, this effect is asymmetric, as sweetness suppresses bitterness more than bitterness suppresses sweetness (Lawless 1977; Green et al. 2010). Such effects are not limited to model systems, as they also occur in real foods (e.g., Hayes et al. 2011; Li et al. 2014a; Bakke et al. 2018). For example, sweetness suppresses sourness at moderate and high concentrations (Keast et al. 2003), so it should not be surprising that adding sucrose to overly sour chokeberry (*Aronia*) juice improves liking ratings (Duffy et al. 2016).

Taste-taste interactions are also extremely common, both in model systems and real foods (e.g., Frank and Byram 1988; Prescott 1999; Prescott et al. 2004). For example, in general, adding vanilla or vanillin tends to increase perceived sweetness (Lavin and Lawless 1998) regardless of whether participants are asked to use an analytic or synthetic strategy to assess products (cf. Wang et al. 2018, 2019), although these effects are not always observed for all stimuli (e.g., Labbe et al. 2006a; Green et al. 2012). Other odorants also appear to enhance sweetness (Frank et al. 1989; Stevenson et al. 1999; Labbe et al. 2006b; Bartoshuk and Klee 2013). Taste-taste interactions have also been explored as a possible means to facilitate sodium reduction (Lawrence et al. 2009; Nasri et al. 2011). This remains an active area of work, so additional progress is anticipated in the coming decade.

Food Liking Is a Dynamic and Transient Phenomenon

The previous sections have generally assumed that liking for a specific food is a static, stable phenomenon. However, this assumption is not always valid. In 1971, the physiologist Michel Cabanac reported that when a fasted participant was given a sucrose solution and asked to rate the pleasantness, pleasantness ratings dropped when the sucrose solution was swallowed, whereas pleasantness ratings did not change when the sucrose was tasted and expectorated and not swallowed (Cabanac 1971). Indeed, reports of this phenomenon are much much older – for example, the Christian bible notes: “He who is sated loathes honey, but to one who is hungry everything bitter is sweet (Proverbs 27:7).” Cabanac argued this type of shift was part of a regulatory mechanism related to the need state of the body. However, subsequent work by Rolls and colleagues demonstrated that the drop in liking that occurs with repeated exposure to a food within a single meal is due to the sensory properties of the food (Rolls et al. 1981) and not nutritional or metabolic signaling. This effect was thus termed sensory-specific satiety, although more precisely, it should be thought of sensory-specific satiation. (Satiation occurs during a meal and leads to termination of eating, whereas satiety refers to length of time before hunger returns.) This effect should be familiar to anyone who has survived an American Thanksgiving holiday (or any other large feast). After consuming a large amount of salty savory foods, any desire to eat is gone. However, if a sweet dessert like apple or pumpkin pie is offered, the desire to eat a sweet food is not depressed. In a laboratory setting, this is operationalized via a precise experimental paradigm. Moderately hungry participants are first asked to rate the pleasantness of small samples of a battery of foods that vary in their sensory profiles (e.g., sweet, savory, salty, etc.). They are then fed the test meal until the desire to continue eating is gone. Pleasantness ratings are then obtained again for all the foods in the initial battery. Thus, sensory-specific satiety is defined as the relative drop in liking for that specific food (Rolls et al. 1981), not the mere abatement of hunger.

Critically, careful experimentation using this paradigm indicates that these effects are specific to the sensory properties of the food, rather than metabolic signals as Cabanac had hypothesized. For example, pudding and gelatin (jello) sweetened with aspartame (a low-calorie sweetener) or sucrose each cause sensory-specific satiety (Rolls et al. 1988). Nor is this phenomenon restricted to prototypical tastes, as it also occurs for colors and even food shapes (Rolls et al. 1982). That it occurs for something like the shape of pasta is a strong indicator that the effect is cognitive and not physiological in nature and is presumably unrelated to the need state of the body. Separately, repeated exposure over multiple days can also alter liking ratings, as monotonous diets are known to depress intake (Hetherington et al. 2000; Meiselman et al. 2000; Zandstra et al. 2000).

Collectively, these data show that liking is not an immutable property of a food, even for a specific individual, but rather that liking of a food is a dynamic property that varies as a function of context and consumption frequency.

Overall Conclusions

Numerous studies over many decades suggest that greater food intake is positively correlated with greater food liking. However, this is misleading, as merely liking a food does not mean we will choose to eat it, even if we like it very very much. Rather, in an environment where diverse ample food options are available, it is more precise to say that we avoid what we dislike. This disliking is due, in part, to the sensations from food, and these sensations can differ across people.

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Biological Basis and Functional Assessment of Oral Sensation

8

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Abstract

When we eat or drink, separate sensory systems carry taste, smell, irritation, and texture signals to the brain, where these signals are packaged into a composite flavor sensation. Each sensory system has specialized receptors that respond to a specific stimuli that can be chemical (taste, odor, irritant) or mechanical (texture) in nature. Variability in these sensory inputs can arise from genetics, environmental exposure, diseases, and aging. This variability influences the separate sensory inputs and composite flavor sensations with downstream implications for what we like and chose to eat, such as the quality of the eating experience, and our overall health. In some cases, sensory inputs can be altered or distorted (e.g., phantom sensations). Simple standardized measures are available for screening, such as in-depth assessment of separate sensory systems and integrated flavor sensations.

Introduction

Every time we eat or drink, we experience the flavors evoked by foods and beverages. While our attention to food flavors varies with the eating context (e.g., savoring a gourmet dinner vs. eating a donut on the run), these percepts arise from the integration of multiple sensory inputs from anatomically and physiologically distinct systems. In turn, our affective and hedonic responses to these perceptual events can drive eating behavior (see Hayes chapter, *Influence of Sensation and Liking on Eating and Drinking*, in this handbook). This chapter provides a general overview on the chemical senses – smell, taste, and chemical touch (i.e., olfaction, gustation, and chemesthesis) – as well as oral somatosensation. While discussions of flavor are classically centered on the chemical senses, it is important to note that mouthfeel, texture, temperature, and astringency are also critical to the eating experience and are perceived via somatosensory inputs. Thus, some researchers include overall texture as part of flavor, while others may treat it operationally as a related but separate phenomenon (see Delwiche 2003). Also, it is important to keep in mind that even pure chemicals are not pure stimuli in terms of the sensations they give rise to, for example, concentrated table salt can elicit both salty taste and oral burn, while menthol can evoke cooling sensations and a minty odor.

This chapter is one of the three related chapters that explore connections between chemosensory biology, flavor perception, affective responses, food choices, and dietary behavior, including individual differences, and chemosensory dysfunction. Here, the biological foundations of chemosensation and flavor perception and assessment of their function are reviewed.

Mechanisms of Olfaction, Gustation, Chemesthesis, and Oral Somatosensation

We smell food odors through the nostril as we breathe or sniff (orthonasal olfaction) as well as through the mouth as we chew and manipulate substances in the mouth (retronasal olfaction) . With a functional sense of smell and some prior experience, one can detect subtle differences in wine varieties, recognize a specific off note in a dairy product, or identify the flavor of a gourmet jelly bean solely with the olfactory cues. This process starts when volatile chemicals reach olfactory sensory neurons located in the olfactory epithelium at the top of the nasal cavity. The olfactory sensory neurons have long hair-like extensions (i.e., cilia) to increase their surface area. Specialized receptors are expressed on these cilia. These specialized receptors are one type of G-protein-coupled receptors (GPCRs) that are a part of a larger superfamily of membrane proteins. In 2004, Linda Buck and Richard Axel received the Nobel Prize in Physiology for their work on the genetic basis of olfactory receptors and the pattern recognition system across cells (Buck and Axel 1991). In humans, there are ~400 different olfactory receptor (OR) genes (Malnic et al. 2004), and each of these is an uninterrupted region 1000 bases (1 kb) long. The number of OR genes in other species is even larger, as a substantial number of the potential OR genes in humans are nonfunctional pseudogenes, possibly due to the relaxation of selective pressure concurrent with the evolution of color vision. By some estimates, the OR gene family may comprise 3% of the entire human genome (Olender et al. 2008).

In humans, the OR genes have numerous common variants (polymorphisms) (Mainland et al. 2014), leading to a potentially unique olfactory repertoire for each individual (Behrens et al. 2018). In one study that examined 356 OR genes believed to be functional (selected from a total of 851 different locations in the human genome), an average of 273 were expressed in the olfactory epithelium, and of these, only 90 were found in all participants (Verbeurgt et al. 2014). Each olfactory sensory neuron is believed to express a single olfactory receptor (Buck 2005), and the olfactory sensory neurons that express a specific OR are spatially distributed across the olfactory epithelium. All the olfactory sensory neurons that express a specific OR then project via the olfactory nerve (cranial nerve 1) to a common glomerulus in the olfactory bulb. Thus, a single OR is finely tuned to a specific motif on a ligand, and the aggregate pattern of activation across the glomeruli encodes the sensation that gives rise to a specific percept.

The considerable number of receptors, coupled with this combinatorial code across the glomeruli, implies that humans can respond to an extremely diverse range of potential odorants. To be odor active, chemical stimuli must be of low molecular weight, volatile, and hydrophobic and be able to bind to GPCR ORs. Common flavors may be comprised of tens or even hundreds of different volatile compounds. For example, one recent estimate suggests that strawberry aroma/flavor contains 360 different volatile compounds (Yan et al. 2018). Historical attempts to systematically determine relationships between chemical structure and perception were further complicated by factors like chirality (i.e., molecular handedness). For example, two otherwise chemically identical stimuli (D- and L-isomers of carvone) have completely different percepts: the D-isomer smells like caraway, while the L-isomer smells like spearmint (Pickenhagan 1989).

Just as smell occurs when a volatile chemical (an odorant) reaches and activates a specialized receptor in the nose, the same general process occurs when a soluble chemical (a tastant) reaches an activates specialized receptors in the mouth. However, unlike smell, these receptors are found on specialized epithelia cells, not true neurons. These taste receptor cells (TRCs) are bundled in small grape-like clusters called taste buds that are found in papillae on the tongue or on other oral surfaces including the roof of the mouth and the throat. The taste buds contain 50–150 cells that form a discrete ovoid structure. These cells are divided into basal cells (from which new taste cells originate) and three types of elongated bipolar cells (dark, intermediate, and light), which have microvilli that extend through a taste pore into the oral environment. The microvilli contain the taste receptors. To reach the microvilli, tastants dissolve in saliva and a mucus layer for transport to taste receptors (individuals with diminished salivary production can show impaired taste perception). Taste receptors for sweet, bitter, and umami/savory stimuli occur via GPCRs, while sour and salty tastes occur via ion channels. In contrast to the GPCRs encoded by the OR genes, there far fewer taste receptor (*TAS*) genes: in humans, the TAS1 family has 3 members, while the TAS2 family has 25. The T1R proteins (receptors) encoded by the *TAS1* genes form heterodimers to transduce sweet (T1R2/T1R3) and savory (T1R1/T1R3) stimuli. The T2R proteins encoded by the *TAS2* genes provide the ability to detect a wide range of structurally diverse chemicals that humans describe as bitter (Behrens et al. 2018). Notably, the *TAS2R* receptor genes contain polymorphisms that alter receptor functioning and explain individual differences in bitter perception (e.g., Hayes et al. 2011). Genetic variation in bitter taste receptors translates into differences in ability to taste bitters in the diet, dietary behaviors toward food/beverages with these bitter compounds, and diet-related diseases associated with ingesting these foods/beverages (Tepper et al. 2014). Despite having a single heterodimeric protein, the sweet receptor appears to have multiple binding sites, which allows it to respond to diverse chemicals of varying size and shape (DuBois 2016; Reyes et al. 2019). The bitter taste receptors may also show similar complexity (Fierro et al. 2019). The ion channels responsible for sour and salty taste are less understood, although some candidates have been identified recently. For sourness, the OTOP1 proton-selective ion channel appears to be involved in sour taste transduction, at least in mice (Teng et al. 2019). Regarding saltiness, lower concentrations of salt are sensed in mice via amiloride-sensitive epithelial sodium channels (ENaCs) (Vandenbeuch et al. 2008); however, other amiloride-insensitive channels also play a role in salt perception (Roebber et al. 2019). Additional work is needed to determine if these mechanisms apply in humans.

Once a taste receptor is activated, the taste receptor cell needs to transmit this signal to a neuron to carry the signal to the central nervous system. The chorda tympani branch of cranial nerve VII (CN VII) innervates fungiform papilla on the tongue tip, while the glossopharyngeal nerve (cranial nerve IX; CN IX) innervates the circumvallate and foliate papillae on the posterior side of the tongue, respectively; the superior laryngeal branch of the vagus nerve (cranial nerve X; CN X) carries taste signals from the throat (Snyder and Bartoshuk 2016). Humans show large variation in both the number of fungiform papillae and the number of taste buds located within these papillae (Miller and Reedy 1990). These sources of variation may to relate to sensory abilities: some reports suggest greater numbers result in great taste intensity although other studies fail to find this effect. Notably, the peripheral taste system is highly redundant: unlike olfaction, damage to a single nerve does not result in total loss of function, emphasizing the evolutionary importance of taste function as a gatekeeper of ingestive behavior. All three of the cranial nerves mentioned above project to the nucleus of the solitary tract (NST). This region also receives information from the somatosensory and the olfactory systems. From the NST, signals travel to the ventrobasal thalamus and then to the taste cortex, orbitofrontal cortex, amygdala, and lateral hypothalamus.

The third chemosensory system that contributes to flavor perception is chemesthesis (i.e., chemical touch). Sometimes referred to as oral irritation or the trigeminal sense, the term chemesthesis was coined in 1990 to describe the panoply of sensations that arise from chemical stimuli that activate the somatosensory system (Green 2016). Chemesthesis includes thermal sensations like the burn from capsaicin in chilies or the cooling from menthol but also mechanical sensations like the buzzing from Sichuan buttons (hao jiao). For the mouth and nose, these signals are largely carried by the trigeminal nerve (cranial nerve V; CN V) but also the glossopharyngeal nerve (cranial nerve IX; CN IX). In the nasal cavity, trigeminal receptors occur throughout, with the highest density toward the posterior nasal region (Poletti et al. 2019). The practical distinction between true smell and nasal irritation is blurred somewhat as many putative odorants also stimulate trigeminal receptors (Filiou et al. 2015). Still, the careful distinction between chemesthesis and oral somatosensation depends not on the anatomy, as the same nerves are generally involved, but rather on the nature of the stimulus (i.e., chemical vs. physical/mechanical). Thus, activation of the polymodal TRPV1 (transient receptor potential vanilloid 1) receptor on trigeminal neurons gives rise to hot painful burning sensations, regardless of whether the stimulus is the capsaicin in a habanero-laced salsa or a scalding hot cup of tea. Indeed, one study suggests a 4.9 uM capsaicin solution generates the same burning sensations as 52C water (Kapaun and Dando 2017). Likewise, the buzzing sensation from Sichuan buttons matches a vibrational frequency of 50 hz (Hagura et al. 2013).

Oral touch also plays a key role in the perception of foods and drinks, as somatosensory mechanoreceptors mediate sensations like grittiness (i.e., particle size), mouthfeel, and creaminess. Fat moving across the tongue during eating or licking stimulates trigeminal nerve fibers within fungiform papillae to provide sensations that are perceived as creamy or oily (Prutkin et al. 2000). Tactile acuity on the tongue is at least as good, if not better, than on the fingertip (Miles et al. 2018), and this leads to the ability to detect exceedingly small differences in particle sizes within foods, on the order of a few microns (Breen et al. 2019). The structures in the oral cavity that detect mechanosensation are similar to those found in hairless skin; like the fingers, the oral cavity contains Merkel's disk receptors (edge and point detection) and Ruffini endings (stretch), as well as Meissner corpuscles (pressure and flutter). However, it is not clear if the mouth contains Pacinian corpuscles (pressure and vibration).

Astringency has classically been considered a chemically initiated tactile event (Breslin et al. 1993) – that is, it is assumed drying and roughing sensations are purely mechanical phenomena caused by increased friction following delubrication.

Saliva contains multiple proteins that lubricate the oral cavity, and when acids or polyphenols react with and precipitate these proteins, lubrication is lost, and the mouth feels dry and rough (see Bajec and Pickering 2008). Indeed, those who are less able to replenish their salivary proteins report more astringency from tannic acid (Fleming et al. 2016). However, recent data also suggest some astringent stimuli may also activate specifically tuned chemoreceptors (Schobel et al. 2014), which would explain how high-fat foods like chocolate can still trigger dry and rough sensations, despite lubricity from the fat (Fleming et al. 2016). If confirmed, these findings would suggest astringency may be, at least in part, chemesthetic in nature, and not merely a simple mechanical consequence of delubrication.

Integration of Olfaction, Gustation, Chemesthesis, and Oral Somatosensation

Separate anatomical systems carry smell, taste, chemesthesis, and oral somatosensation from the periphery to the brain for packing or sensory integration with visual sensory input into a composite flavor sensation in the insular cortex (Gogolla 2017) and the orbitofrontal cortex (Rolls 2015). Eating an ice cream cone exemplifies the integration of physiologically distinct peripheral messages (Green 1984). When licking a scoop of coffee Oreo ice cream, sugar binds to the TAS1R2/R3 dimer and depolarizes the cell. The chorda tympani nerve (CN VII) carries the sweet signal centrally, while the trigeminal nerve carries information on coolness, creaminess, and texture of the ice cream and added cookies. As the ice cream is moved back through the mouth, more taste receptors are stimulated with recruitment of branches of cranial nerves IX and X, and mechanical action releases and pumps volatile odorants to the olfactory epithelium, where they bind to olfactory receptors, activating a specific pattern of glomeruli that we perceive as coffee and Oreo percepts from our prior learned experience. The visual, taste, olfactory, and touch signals are carried to the brain on separate pathways that are integrated by the orbitofrontal cortex into a composite flavor message and, with the amygdala and in the anterior cingulate cortex, to produce a hedonic and reward signal, and then to areas in the cortex for decisions about eating the ice cream (I will have more) and hypothalamus for satiety and fullness signals (Rolls 2015).

Sensory integration occurs when we perceive foods and beverages that are complex mixtures of stimuli for taste, smell, and touch receptors, and this process is mostly seamless and unitary: when I sip my Coca-Cola, I think “Ah, a Coke” without specifically noting the sweetness of the sugars, the bite of the phosphoric acid, the tingle of the carbon dioxide, or the individual contributions of the vanilla, cinnamon, nutmeg, and citrus aromas. Perceptual interactions occur frequently, with different combinations of stimuli showing enhancement or suppression. For combinations of prototypical taste stimuli, mixture suppression in the norm (e.g., Keast and Breslin 2003) although super-additivity (synergy) is seen for some combinations of sweeteners (Reyes et al. 2019) or savory (umami) (Zhang et al. 2008) stimuli. For cross-modal interactions, enhancement is commonly observed, as taste and retronasal olfactory input work synergistically to enhance overall perceived intensity from the oral cavity. Enhanced taste intensity (typically sweetness) in conjunction with a congruent food odor has been repeatedly observed (Duffy et al. 2016). For example, Bartoshuk and colleagues have aimed to breed better fruits and vegetables by enhancing the sweet volatiles to enhance the overall sweetness without adding sugar or debittering to remove important nutrients (Bartoshuk and Klee 2013). A similar phenomenon also is seen when adding vanilla to milk (Wang et al. 2019) or adding sweet-smelling volatiles to highly phenolic juice from the aronia berry (Duffy et al. 2016). However, enhancing sweetness via cross modal interactions may not be sufficient to increase liking, if other attributes like astringency are not reduced (e.g., Duffy et al. 2016). Increasing viscosity typically decreases taste intensity, and this appears a perceptual, not physiochemical effect, as the volatile concentration does not change with alteration in viscosity (Cook et al. 2003; Hollowood et al. 2002). In summary, given all the complex interactions that can occur, attention must be paid to the overall percept of a food product to assure it is acceptable.

There are clinical and experimental examples of altered oral sensations that occur with changes to sensory information received from the taste-related cranial nerves. One sudden source of taste loss occurs with severing of the chorda tympani nerve (cranial nerve VII) during middle ear surgery, such as to remove an acoustic neuroma (Kveton and Bartoshuk 1994). Early clinical reports showed this damage could influence more than just taste perception. In 1965, Bull (1965) observed two individuals with chorda tympani damage from middle ear surgery (out of three) who complained of alterations in true taste, oral somatosensation, and retronasal olfaction, including inability to differentiate between coffee and tea, but also that foods, such as bread and chocolate, were “doughy” and “greasy,” respectively.

The interactions between multiple sensory systems in the mouth can be shown experimentally with injection of a small amount of anesthesia into the middle ear to temporarily remove taste inputs that occur via the chorda tympani nerve (CN VII). This anesthesia does not numb the mouth overall but only serves to remove taste input from the anterior tongue. Anesthesia to CN VII on one side abolishes taste on that side simultaneously increasing the intensity of taste on the other side from a separate cranial nerve (cranial nerve IX) (Lehman et al. 1995; Yanagisawa et al. 1997). This phenomenon is thought to indicate release of inhibition. CN VII normally dampens down input from CN IX, but when input from CN VII is lost, this inhibition disappears, resulting in greater intensity from regions of the mouth innervated by CN IX and phantom oral sensations. Sensory interactions between taste and flavor is seen after modifications of taste with certain plant extracts (i.e., *Gymnema sylvestre* (“gymnema”) or *Synsetalum dulcificum* (“miracle fruit”)) (Hudson et al. 2018).

The chemosensory system shows plasticity or the ability to generate new cells, maturation, and programmed death. Neuroplasticity in the olfactory system, or the ability to make new functional neurons (neurogenesis), can occur throughout life (Brann and Firestein 2014) and is key to maintaining olfactory function throughout life. Extrinsic (e.g., exposure to microorganisms) and intrinsic (e.g., growth factors, sex hormones) factors can stimulate neurogenesis in the olfactory system. Olfactory sensory neurons that express olfactory receptors can regenerate across the lifespan, in contrast to sensory systems like vision and audition, which can generally only form new synapses during critical developmental windows (Coppola and White 2019). The ability of olfactory sensory neurons to regenerate these connections has fueled the concept of olfactory training to stimulate plasticity in response to damage as a means to recover the sense of smell (Hummel et al. 2018).

For taste, early experiences with diet may influence peripheral and central development. Children born of mothers who experienced dehydration during pregnancy due to excessive vomiting (hyperemesis gravidarum) report greater preference for salt during infancy (Crystal and Bernstein 1998) that can persist into adulthood (Leshem 2009). Sex hormones also appear to influence taste function. Taste function varies across the menstrual cycle (Prutkin et al. 2000), rising to a peak at the first trimester of pregnancy to the lowest point by the third trimester (Duffy et al. 1998), and then declines across menopause. Hormones and neuropeptides (e.g., insulin, ghrelin, and cholecystokinin) that regulate metabolism also influence taste perception and have implication for food preferences, diet behaviors, and risk of chronic diseases (Loper et al. 2015).

Disorders of Smell, Taste, and Somatosensation

Chemosensory disorders impair quality of life and can make it difficult to maintain a healthy diet and overall health. The reverse is also true, as many chemosensory disorders can be prevented through healthy behaviors and improved overall health. Indeed, population-based studies indicate that physical activity is associated with lower risk of olfactory dysfunction (Hoffman et al. 2016; Schubert et al. 2013), and a healthy diet consistent with public guidance such as the US Dietary Guidelines (https://health.gov/dietaryguidelines/2015/) prevents chronic diseases and obesity that are associated with chemosensory disorders. Further, smoking (Duffy et al. 2019) and excessive alcohol intake (Hoffman et al. 2016) each associate with olfactory impairment. Healthy behaviors including physician-recommended vaccinations, maintaining oral health, and healthy living environments can prevent viral infections and exposures that are associated with chemosensory dysfunction.

Clinically, disorders of smell are far more common than taste or oral somatosensory disorders. Notably, patient complaints of “taste loss” are almost always olfactory in nature, as the colloquial usage “taste” (i.e., flavor) differs from its use as narrow technical jargon. As noted previously, most individuals do not separate and distinguish true taste from smell, chemesthesis, or oral somatosensation when a food or beverage is consumed. Because of this understandable semantic confusion, patients often complain of “taste loss” when the fundamental cause is a disruption of olfaction, as this dysfunction is most apparent during eating. Olfaction is more vulnerable than taste to loss with aging because of its anatomical structure and because aging associates with changes in peripheral and central components.

Olfactory information is carried only by a single nerve (cranial nerve I), while taste is transmitted by multiple branches of three separate nerves (cranial nerves VII, IX, X). Olfactory sensory neurons pass through fine holes in the cribriform plate at the top of the nasal cavity. These neurons are directly exposed to environmental insults such as toxins and infectious agents, and their connections to glomeruli in the olfactory bulb at the base of the brain may even be severed with head trauma. These axons may fail to regenerate, causing loss of smell, or worse yet, regrow incorrectly, connecting to the wrong glomerulus, resulting in stimuli taking on the wrong olfactory quality (i.e., a parosmia).

Infection or trauma can cause generalized anosmia (i.e., inability to smell). In population-based studies, the prevalence of measured olfactory dysfunction ranges from as low as 3.8% (Schubert et al. 2012, 2015) in the Beaver Dam Offspring Study to 12.4% in the NHANES (Hoffman et al. 2016) and up to 19.1% in the Skövde study (Bramerson et al. 2004). Increased rates of olfactory dysfunction are seen in older adults (Hoffman et al. 2016; Murphy et al. 2002; Pinto et al. 2015), males (Boesveldt et al. 2011; Doty et al. 2011; Menon et al. 2013; Pinto et al. 2015; Roberts et al. 2016; Schubert et al. 2013), certain ethnic/racial minorities (Hoffman et al. 2016; Pinto et al. 2015), and those with lower income/educational attainment (Hoffman et al. 2016; Schubert et al. 2012). However, it should also be noted that many individuals retain a good sense of smell well into their seventh or eighth decade; rather, the prevalence of olfactory dysfunction (i.e., the number of people in the population with some sort of dysfunction) increases with aging, due to increased opportunity for trauma or damage from infection. That is, increasing prevalence with aging should not be interpreted as an overall gradual decline within an individual with aging.

Total ageusia ("taste blindness") is rarely seen. Data from the University of Pennsylvania Smell and Taste Center serve as compelling evidence in support of this statement. In over 1,000 individuals presenting to this Center with "taste loss," less than 1% had measurable taste impairment, while 32% had severe olfactory dysfunction (Deems et al. 1991; Pribitkin et al. 2003). The inability to distinguish sour from salty and bitter is more common (Cruickshanks et al. 2009; Welge-Lussen et al. 2011), although this may be a semantic labeling issue rather than a biological deficit (McAuliffe and Meiselman 1974). Because common conditions can influence both smell and taste function (e.g., mucus quality, viral infection, head trauma, cognitive function), individuals can suffer from simultaneous smell, taste, and oral sensory disorders (Walliczek-Dworschak et al. 2017).

Clinicians must use measures of self-report with functional testing to understand and be able to treat the disorder.

Smell

Individuals suffer from diminished (hyposmia) or absent ability to perceive and identify a few (specific anosmia) or all tested (general anosmia) odorants (Murphy et al. 2003). Specific anosmias are largely due to genetic variation across individuals.

For example, 6% of adults are estimated to have a specific anosmia to the musky compounds galoxide and androstenone (Amoore 1977; Bremner et al. 2003), which is explained by polymorphisms in the OR7D4 gene (Keller et al. 2007). These genetic variations are widespread and involve multiple olfactory receptor genes (Trimmer et al. 2019). Altered olfactory perception or dysosmia also exists. Dysosmia can be the distortion of odor quality (parosmia, e.g., smelling burnt paper instead of baby powder) or a phantom olfactory sensation with no apparent olfactory stimulus (i.e., olfactory hallucinations, termed phantosmia) (Murphy et al. 2003). Based on nationally representative data (NHANES 2011–2014), the prevalence of phantosmia was estimated at 6.5% of the population (Bainbridge et al. 2018).

As noted above, odorants reach receptors on olfactory sensory neurons via two routes: orthonasally (via the nostrils) and retronasally (from the mouth via the nasopharynx). Either route can be disrupted, causing olfactory dysfunction. Prior to placing food in the mouth, we may perceive food odors through passive breathing (i.e., orthonasally) and sniffing, which can increase perceived intensity. Foods and beverages that are cold or contain odorants trapped in the food matrix may provide little olfactory stimulation until they are warmed and/or released in the mouth. Notably, odorants delivered retronasally are perceived (localized) as occurring in the mouth, rather than the nose. This perceptual localization is attributed to concurrent touch and taste sensations taste (Snyder and Bartoshuk 2016). Patients report retronasal olfactory impairment with loss of taste from the anterior tongue that is medically (Bull 1965; MacCarthy-Leventhal 1959) or experimentally (Fast et al. 2000) induced. Conversely, individuals who have heightened taste response report greater retronasal olfactory intensity from model foods and beverages (Pickering et al. 2006), as the taste cortex is needed to integrate retronasal smell into a flavor percept (Blankenship et al. 2019). Taste and touch sensations may help to maintain the ability to perceive food flavor (and thus quality of life) even if the sense of smell is impaired (Oleszkiewicz et al. 2019).

The olfactory epithelium has olfactory sensory neurons, supporting cells, and basal cells. The supporting cells secrete mucus to protect against foreign agents, and basal cells serve to generate new olfactory receptor cells. Odorants must dissolve in mucus for them to interact with the receptors expressed by olfactory sensory neurons; this mucus also contains odorant-binding proteins that carry and concentrate hydrophobic odors, as well as xenobiotic-metabolizing enzymes that transform odorants (Heydel et al. 2013). There is genetic variation in odor-binding proteins that is associated with variability in olfactory ability, differentiating normal ability from hyposmia in healthy participants (Sollai et al. 2019). The metabolizing enzymes also may clear odors from olfactory receptors to increase olfactory acuity (Heydel et al. 2013). The size of the olfactory epithelial area varies. Individuals with congenital anosmia (i.e., born without a sense of smell) have reduced or absent olfactory epithelium (Moran et al. 1992). The nasal microbiome may also be key to developing a normal olfactory epithelium. Variability in this microbiome is associated with differences in olfactory ability in otherwise healthy individuals (Koskinen et al. 2018).

Taste

Individuals can also show diminished (hypogeusia) or absent (ageusia) taste perception. As noted above, total ageusia is very rare. The ability to taste with whole-mouth stimulation is maintained despite regional loss of input from damage to individual nerves that innervate different regions of the oral cavity (i.e., taste has redundant wiring). Individuals can suffer from taste altered perception, which is termed dysgeusia. Chronic dysgeusia (a persistent taste sensation) can result from a true stimulus in the mouth (e.g., the taste of an oral infection) or when stimuli reach taste receptors from the blood stream (e.g., persistent bitterness from some medications). Dysgeusia can also describe phantom sensations generated by spontaneous neuronal activity in the absence of a stimulus (analogous to phantom limb sensations) (Snyder and Bartoshuk 2016). Such sensations are often described as being metallic. A human metallic taste receptor has not yet been identified, but other data suggest metallic sensations in the mouth may be oral (taste or chemesthetic) in nature and not merely due to retronasal olfaction (Lawless et al. 2004).

Oral and Nasal Somatosensation

Oral somatosensation also can be altered. Individuals experience diminished touch sensations (numbness) and response to chemical irritants (desensitization). Individuals also perceive pain or hypersensitivity to stimuli, such as chronic smokers reporting intense sensations from concentrated salt (Duffy et al. 2019) as well as and oral pain syndromes (e.g., burning mouth syndrome (Imamura et al. 2019)). Interestingly, there is a rare syndrome called empty nose syndrome where patients perceive obstruction in their nasal passages, yet upon examination, the passages are clear. Trigeminal impairments could be part of the cause of this syndrome (Gill et al. 2019).

Assessing Chemosensory Disorders

There are a variety of questions and psychophysical tools available to assess chemosensory complaints, as well as screen for and fully measure taste and olfactory functioning. If a chemosensory dysfunction is suspected, additional physical examinations, including otolaryngologic, neurological, and dental evaluations, can assess probable causes of the disorder.

Determining if the Complaint Is Sensory or Non-sensory in Origin

Because of the tight integration of multiple sensory systems in flavor perception as well as the role of prior experience in our affective responses, individuals may complain about the “taste” of foods for a number of reasons unrelated to chemosensory dysfunction. Loss of pleasure from eating and loss of appetite can occur separately from altered sensory signals from foods and beverages. Simple questions can help to distinguish dysfunction that is sensory in nature from other non-sensory problems.

Self-Report of Chemosensory Disorders

Table 1 lists interview questions for assessment of chemosensory disturbances. Self-reported health status can provide important insight to understand how an individual evaluates and acts on symptoms as well as provides a historical complement to a single measure of function. Some clinicians favor quantitative assessment over self-report; however, asking about perceived changes provides additional information about how individuals attend to their health and health-

Table 1 Questions for a patient interview on possible chemosensory complaints

What does food "taste" like to you? Can you taste salt on snack foods or from the salt shaker, the sweetness of table sugar or honey, sourness of vinegar or lemon, and bitterness from strong coffee? Answers to these questions help determine if the complaint is sensory and help rule out a taste problem
When did you notice the problem? Did the problem come on at once or do you think it was a gradual change? Answers to these questions help determine if the complaint is a chronic versus an acute problem
Do you associate the complaint with any other problem? Answers to this and the proceeding question may identify if the condition is associated with events or exposures that cause chemosensory disorders. The question could then be expanded to request a history of specific chemosensory-related conditions
Is the problem better on some days or times than others? Individuals with olfactory dysfunction associated with nasal/sinus disease can report smell fluctuations. They may benefit from an otolaryngology evaluation to rule out nasal/sinus disease, a treatable cause of olfactory disorders
Do odors smell as they should? Does, for example, peanut butter smell like peanut butter? Do you think you could tell what you were eating if your eyes were closed? These questions address the sense of smell, not only diminished orthonasal olfaction but also odor distortions and retronasal perception
Do you have a persistent salty, sweet, sour, or bitter taste? This question should help determine if the individual has a dysgeusia. The individual may not be able to describe the quality as salty, sweet, sour, or bitter and may instead describe the quality as something vague (e.g., "yuk" or foul). This may be an olfactory sensation related to the smell of an infection
Are you suffering from oral pain, burning, prickling, or numbness on your tongue or in your mouth? These questions are designed to reveal a somatosensory disturbance associated with the "taste complaint." Individuals who respond positively to this question may benefit from further dental or medical evaluation

related behaviors. Self-report also is the only way to collect information on phantom chemosensations or altered function such as dysgeusia, phantosmia, and parosmia. Among those seeking treatment for chemosensory disorders, greater nutritional risk (e.g., weight changes) is seen in those who reported the disorder changed their interest in eating or felt that eating exacerbated the disorder (Mattes et al. 1990).

Self-rating of sensory function requires an individual to evaluate their own sense of well-being, rate a perceptual experience, and, in relation to aging, compare current function to that of an earlier age. Young and older subjects are equally unable to assess their olfactory abilities correctly, but each age group makes a different type of error in self-assessment: young patients underestimate their abilities, while older patients seem unaware of the deficit (White and Kurtz 2003). Discordance between self-reported and measured olfactory function may stem from the fact that olfactory testing is rarely part of routine health assessments. Individuals may notice a sudden loss (as with an insult such as head trauma) or a problem temporarily related to the sense of smell more easily than a gradual loss of function. Still, with dramatic changes in function, an individual may notice the change even if it occurs gradually. Finally, some people may neither assign value to their sense of smell nor exhibit overall health-seeking tendencies. Therefore, they may just assume that their sense of smell is adequate without really giving it much thought.

Standardized Survey Questions with US Nationally Representative Data for Comparison

The National Health and Nutrition Examination Survey (NHANES) included a chemosensory component for the first time in its 2011–2014 waves. NHANES is a continual, cross-sectional evaluation of the nutrition and health of the USA in a nationally representative sample (Centers for Disease Control and Prevention 2013); the protocols and data are available for review and analysis. The NHANES chemosensory component had a home interview with a Chemosensory Questionnaire (CSQ) that included items regarding self-reported olfactory, flavor and taste ability, problems such as phantom smells and dysgeusia as well as symptoms, changes notice with aging, medical treatments, and presence of related risk factors for chemosensory dysfunction that is available online (CDC 2013). These questions were content-validated by experts in chemosensation and tested to ensure consistency in participant understanding, processing, and interpretation (Hoffman et al. 2016). Combining items into an alteration score can increase the ability to detect normal function and dysfunction (i.e., specificity and sensitivity, respectively) (Hoffman et al. 2016; Rawal et al. 2014), although many people do not notice milder dysfunction (e.g., hyposmia). For example, only about 1/3 of smokers self-reported olfactory alteration despite having evidence of hyposmia upon examination (Duffy et al. 2019). Poorer sensitivity is expected of conditions, such as olfactory dysfunction, which are rarely measured (Oksanen et al. 2010).

Assessing the Complaint of Dysgeusia

Individuals who experience dysgeusia find it highly disturbing, and it can be difficult to diagnosis correctly. Unfortunately, much of the medical literature confuses taste and flavor, particularly in the cancer literature (Boltong et al. 2011), without accurately reporting dysgeusia. In practice, clinicians can use a combination of questions and testing methods to diagnose the origins of dysgeusia, as described elsewhere (Bartoshuk et al. 2005). First, determine if the patient has a persistent taste (salty, sweet, sour, bitter, etc.). Does gently swishing the mouth with water and expectorating or eating diminish the dysgeusia? If so, the source may be a stimulus in the mouth (e.g., infection, medication). Alternatively, a physician or dentist can apply a topical anesthesia to test the effect on the dysgeusia. If a topical anesthetic abolishes the persistent taste, then it may be due to a stimulus in the mouth. Addressing the source of the taste or changing the medication may alleviate the dysgeusia. If the sensation is not changed by rinsing or with a topical anesthetic, it may be a centrally mediated phantom sensation. There is evidence that dysgeusias and phantom oral pains may respond to stimulating taste, with a mild irritant, lozenge, or eating (Bartoshuk et al. 2005) or pharmacologically with low doses of clonazepam (Heckmann et al. 2012). The rationale for this treatment is that the oral pain is centrally mediated and possibly controlled by the trigeminal nucleus of the medulla. Taste appears to inhibit oral pain through gamma-aminobutyric acid (GABA), an inhibitory neurotransmitter. Clonazepam, a GABA receptor agonist, intensifies the inhibition normally provided by GABA and thus can suppress the oral pain and taste phantoms. An individual who has intensification of a dysgeusia from a topical anesthetic should have further medical and dental evaluation.

Rapid Assessment of Screening for Taste and Olfactory Function

The sense of taste is the easiest to test with stimuli readily available food stimuli (table sugar, salt, white vinegar for sour, and instant coffee crystals or Angostura Bitters for bitter). Please see the NHANES chemosensory protocol manual for a standardized script (Centers for Disease Control and Prevention 2013). Patients who report a taste intensity below “weak” probably have taste damage.

Smell should be screened via both orthonasal and retronasal routes (i.e., via the nostrils and via the mouth, respectively). The simplest assessment is to use an identification task and add on an intensity measure as well. One odor identification test that uses common stimuli you can obtain at a typical grocery store is the Connecticut Chemosensory Clinical Research Center Test (Cain et al. 1988). This low-cost screening test uses baby powder, chocolate, cinnamon, coffee, mothballs, peanut butter, and Ivory® soap, as well as Vicks VapoSteam®, as a trigeminal probe. The stimuli should be visually concealed from participants: putting the stimulus in a jar and covering with cotton gauze or cotton rounds or cotton balls work well. The stimuli should be refreshed weekly. Unseal the jar right before testing and hold under the participant’s nose. Using a word bank, have the participant identify the odors; the word bank should include the 8 stimuli and 8 other distractor items, for a total of 16 choices (Cain et al. 1988). Because odor *identification* tasks measure both sensory function and cognitive ability (Lehrner et al. 1999), provide correct feedback, and present misidentified items a second time to minimize cognitive effects. If a participant misses four out of the seven non-trigeminal odors (even after giving correct feedback and presenting missed items a second time), they have probable hyposmia and should be referred for more in-depth evaluation by an otolaryngologist. If the stimuli for the olfactory testing are kept fresh, an intensity task can be added to the identification task with very minimal additional time. After the participant smells the odor, first ask an intensity judgment on the gLMS (Fig. 1), and then ask for the odor identification. Again, after excluding the trigeminal control (Vicks VapoSteam), participants who report more than half of the odor stimuli as less than moderate in intensity likely have depressed olfactory function. Commercially produced screening kits are also available, as a scratch-and-sniff (Brief Smell Identification Test) or capped markers (Sniffin' Sticks). The scratch-and-sniff version also comes in 2, 4-odor packets (Pocket Smell Test), and results can be compared with US nationally representative NHANES data (Centers for Disease Control and Prevention 2013).

To test retronasal olfaction, orally sampled jelly beans work well, and gourmet jelly beans work especially well, as their flavors can be highly distinctive. To distinguish taste from retronasal olfaction, have the participant pinch their nostrils, and then have them put the jelly bean into the mouth and chew fully. Then, have the participant unplug the nose. Plugging the nose allows only the taste and chemesthetic input (for jelly beans, this will be primarily sweetness and sourness unless cinnamon- or chili-flavored jelly beans are used). Opening the nostrils at the end of chewing should cause a rapid retronasal transport of odorants to the olfactory epithelium. Typically, this causes an "aha" moment. If the participant does not notice a stark difference between the plugged and unplugged nose, this suggests

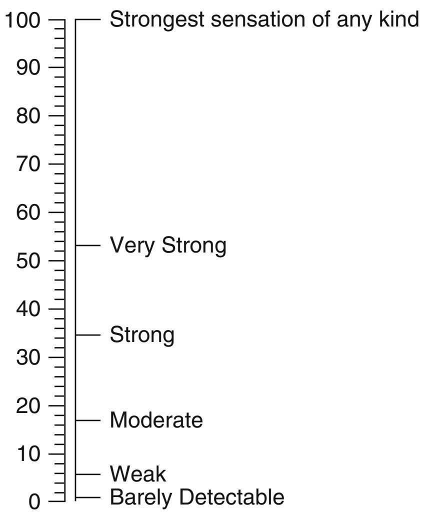

Fig. 1 The general labeled magnitude scale (Bartoshuk et al. 2004) for testing intensities

they have impaired retronasal olfaction. If more precision is required, have the participant judge the intensity of the sweetness of the jelly bean with the nose plugged on the gLMS (Fig. 1) and then the jelly bean sweetness and flavor with the nose unplugged. A rating below “moderate” that does not increase in perceived sweetness would suggest depressed retronasal olfaction. For screening, we have used chocolate, coffee, and cherry jelly bean flavors, as well as Tabasco®-flavored jelly beans, as a trigeminal probe (Hubert et al. 2019). Jelly beans also can be used in an identification task. Select the jelly bean flavors that might be most familiar to your participants, and set up a word bank that includes the correct labels and an equal number of distractors. Be sure to give feedback and retest missed items to maximize olfactory effects and minimize cognitive effects. Misidentification of more than half of the jelly beans probably would constitute olfactory impairment.

Measuring Taste and Olfactory Functioning

Thresholds provide a measure of sensitivity but critically may or may not reflect the ability to perceive stimuli at concentrations relevant to eating, at least for taste (Pangborn and Pecore 1982; Webb et al. 2015). The food and beverage world is one of suprathreshold sensation, rarely tapping sensations close to threshold (except perhaps when chemosensation is used to detect faint off flavors or spoilage). Conversely, suprathreshold tasks measure perception of ecologically relevant stimuli and include perceived intensity measures and identification tasks. For olfaction, threshold versus suprathreshold tests may help in the diagnosis of disorders that impair peripheral olfactory function (e.g., chronic rhinosinusitis) versus those that impair central odor processing and memory (e.g., Alzheimer’s disease) (Wu et al. 2018). Discrimination testing also may help track improvement in olfactory function related to peripheral olfactory disease (Wu et al. 2018). This is a nonverbal test where the participant smells a reference odor and then needs to match that reference odor out of four additional odor probes.

Measures of perceived intensity are preferred for the assessment of taste and can be useful in the assessment of olfaction if the testing stimuli are assured for quality and freshness. Identification tasks are not useful for the sense of taste as there is only four or five qualities and there is common confusion between sour and bitter (McAuliffe and Meiselman 1974). The perceived intensity method must (1) allow subjects to express the full range of their sensations (reducing ceiling effects); (2) avoid the use of a standard to assign a particular value or the limits of the scale; (3) use a scale that allows for ratio comparison of relative intensities within individuals; and (4) provide a valid way to compare perceived intensity across subjects (Bartoshuk et al. 2006; Hayes et al. 2013). The gLMS measure described above with standardized instructions and practice with non-taste or smell stimuli meets these four criteria. For identification tasks, the method must attempt to separate sensory influences from cognitive influences. Chemosensory tasks that utilize foods and beverages may have the most application in the exploration of the relationship between chemosensation and nutrition.

Comprehensive olfactory testing generally requires both threshold and identification tasks, including some measure of retronasal ability. Commercial odor identification tests are available, including The University of Pennsylvania Smell Identification Test (UPSIT) (Doty et al. 1984) and Sniffin' Sticks (Rumeau et al. 2016). Olfactometers also are available – these devices standardize the air flow, concentration, timing of when the odor is delivered and for how long, and when it is shut off. Research grade olfactometers have a high level of precision but are quite expensive; less expensive olfactometers that provide a reasonable level of stimulus control are also commercially available. Inclusion of an intensity judgment task extends the utility of the odor identification tests described above. The Sniffin' Sticks also comes with threshold modules of either n-butanol, which has a trigeminal component, or 2-phenylethanol, which is a floral odor and has no trigeminal component. The UPSIT is a commercially available test of olfactory functioning (www.sensonics.com). This test includes 40 "scratch-and-sniff" odors and a multiple-choice format; a brief 12-item test is also available. Normative data for these tests determine the level of olfactory functioning (i.e., anosmia, hyposmia) according to age range and sex. These tests are also available for different cultural groups. Individuals with evidence of olfactory dysfunction should be evaluated by an otolaryngologist based on medical history, the examination with nasal endoscopy, full olfactory testing, and imaging (CT scan, MRI, and EEG) (Boesveldt et al. 2017).

Taste tests are designed to assess dysfunction but also can test the wide range of normal ability, including those who experience "pastel" oral sensations (also referred to as nontasters) versus those who experience "neon" oral sensation (also referred to as supertasters). Thresholds for a particular compound may be useful to test a mechanism of taste receptor binding or in sensory analysis to assess for off-tastes. Taste thresholds are difficult to measure, requiring precise control of the stimulus and the non-stimulus for non-taste attributes (e.g., temperature), and are slow and labor-intensive. Perceived intensity measures, particularly that probe the cranial nerves that innervated taste, offer a useful measure of taste function as initially described by Bartoshuk et al. (1994) for full testing of cranial nerves VII, IX, and X and updated with improved intensity scaling in the National Institutes of Health Toolbox (Coldwell et al. 2013) and procedurally in the NHANES protocol. In the full spatial taste testing protocol, the researcher draws cotton swabs soaked in taste solutions (sweet (1 M sucrose), salty (1 M sodium chloride), sour (32 mM citric acid), and bitter (1 mM quinine hydrochloride)) unilaterally across different areas of taste nerve innervation before a measure of intensity with whole-mouth stimulation (Sipiora et al. 2000). The NHANES protocol is a briefer measure of taste function: it only includes the salt and bitter probes with bilateral stimulation of the tongue tip and the whole mouth. Participants report the intensity of the taste on the gLMS and the quality. Adding in a water probe may be able to provide additional information on dysgeusia if the participant reports a taste from the water applied to areas of taste nerve innervation. A brief test of the ability to taste the bitterness or propylthiouracil (PROP) can be added to the spatial taste test as a screening for the most common genetic variation in taste (Hubert et al. 2019) that has been associated with diet and health outcomes (Tepper et al. 2017). For further discussion of different functional measures of taste, see (Webb et al. 2015).

Biological Measures of Smell, Taste, and Somatosensation

These measures rely less on psychophysical testing and instead on the electrophysical measures of brain potentials, magnetic responses, and changes in blood flow in response to chemical stimuli. Olfactory event-related potentials (OERP) involve providing an odorant and asking the participant to respond to the stimulus while minimizing other visual, somatosensory, or auditory sensory inputs. The OERP provides information on the length of time it takes to show significant changes in neural electrical response to the odor (i.e., latency) and the magnitude of neural response (i.e., amplitude). However, interpreting the OERP is challenged by differentiating signals from noise via complex data analyses. Comparison of individuals with normal smell versus anosmia in an automated OERP correctly identified 75% of anosmics (Guducu et al. 2019), suggesting additional refinement would be required before clinical use is indicated.

Electrogustometry is frequently used in research and practice, but it only measures taste thresholds, which, as noted above, have limited utility in relation to eating behavior. The method usually involves localized testing by applying a mild electrical current to the surface of the tongue. However, the stimulation also captures multiple qualities of taste as well as irritation. Thus, electrogustometry may be somewhat misnamed in that it may not detect taste damage but can determine the integrity of cranial nerve VII (Snyder and Bartoshuk 2016). Electrophysical recording from the tongue also has been reported for assessing the ability to taste the bitter stimulus propylthiouracil (Sollai et al. 2017). This method involves placing silver electrodes on the dorsal and ventral surface of the tongue and analyzing bioelectrical potential variations for peripheral taste responses. Assessing fungiform papillae density on the tongue tip or taste buds within these papillae is difficult and requires magnification and a contrast agent. Even with an operating microscope, 10× magnification, blue food coloring, and the ability to video record the images for in-depth reviewing, it is challenging to identify fungiform papilla from filiform papilla (non-taste) because of their varying shapes and sizes (Miller and Reedy 1990). Assessing taste bud number requires 40× magnification of a few papillae and looking for shadows indicating taste pores on slow-motion replay. Confocal laser scanning microscopy is a newer technique that can examine singular papilla or area on the tongue over time with more accuracy (Saito et al. 2017).

Conclusion

Taste, smell, and oral somatosensation contribute to food enjoyment and nutritional health by receiving sensory input from foods and beverages. A significant amount of research has advanced our knowledge of the basic mechanisms of chemosensory perception from stimulus receptor binding, transduction, nerve transmission, and central nervous packaging into an integrated perceptual experience. Directed questioning, psychophysical testing, and biological assessment identify normal variation in chemosensory function and alterations associated with genetic differences, development, and exposures as well as diseases across the lifespan. Most common is alteration of olfactory perception and changes to olfactory component of food flavor. Poorly oral health may further increase the risk of olfactory dysfunction by reducing retronasal processing of olfactory food flavor. Loss of true taste as perceived with the whole mouth is rare because of the tremendous redundancy in cranial nerves that carry taste sensations from the periphery to the brain. However, recent evidence shows that localized loss of taste from individual areas innervated by cranial nerves can alter oral sensations from foods and beverages and change food preferences and patterns of food intake. Localized losses of taste, if extreme enough, can result in dysgeusia and oral pain syndromes that impair the quality of life and the ability to obtain oral nourishment. Individuals who complain of olfactory loss and oral sensory disturbances or complain that eating is not enjoyable deserve a thorough assessment. Chemosensory disorders can improve if the underlying cause is treatable, such as through the modification of medications or alleviation of the underlying condition (see ► Chap. 61, "Causes of Smell, Taste, and Oral Somatosensory Disorders Affecting Eating and Drinking" by Duffy in this handbook). Cross-disciplinary opportunities exist across the food, nutrition, and health spheres to personalize eating recommendations matched with chemosensory variation to support healthy eating and the quality of the eating experiences.

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Part IV

The Social Sciences

The Psychology of Food Choice: Anticipation and Mental Simulation

9

Betina Piqueras-Fiszman

Contents

Abstract

Throughout our lives we develop a system that helps us navigate in a food environment. In a routine where we are constantly thinking about food and making choices, ranging from whether we actually want to eat, through selection of food category and portion size, to eventual consumption, it is worth highlighting that many of those microdecisions are made without full awareness. Focusing on the situations of having to make a choice among foods, we would mainly rely on two sources of information: that of the product's intrinsic properties, and the additional information we get about it simultaneously (e.g., recommendations, or packaging information). However, most probably we have already consumed a similar product previously. Therefore, our brain will simulate the likely impact (hedonic and utilitarian) the product will have on us and, after experiencing it

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(moment of truth), will determine whether it is congruent with the image or schema we had about it, and if not, to some extent, it will accommodate, and that image will be adjusted. Now, certain products inherently trigger predominantly certain types of simulations (e.g., a cake triggers simulations related more to short-term effects and fruit more longer-term effects), which depending on our own goals will result in certain behavior. This chapter will discuss the process of mentally simulating and anticipating different stages of food consumption and will provide novel evidence on the effect this has when used as a strategy to steer food choices in a desirable way.

Introduction

As one can imagine, the psychology of food choice is not straightforward, and entire volumes could be written on each of the multiple aspects that intervene on the decisions that people make about food. One of the reasons why there are nearly endless intervening factors is precisely that we are almost constantly making decisions about food throughout our day. Of course upon entering in a food outlet (e.g., a supermarket, a shop at the train station), consumers have a predefined idea of what they are going to take home (or consume on their way). But realistically speaking, going in and out is quite utopic; in many cases we inevitably spend additional time comparing certain options within a food category, "oh now it also comes in this flavor," "this one will give me the energy I need," or "this looks *just* too good." Naturally these quotes stay in the back of our mind, most likely while we are placing already some products in our shopping bag. These "go" decisions are based on the assumption that the product will fulfill the expectations raised by the packaging or by its exteroceptive cues, or, if it is a product that we are already used to, that it will still meet our utilitarian and hedonic standards (that we have stored in memory). In this sense, we will anticipate the effect that the product will have on us by quickly creating mental simulations about the product. There will be a moment of truth in which we will actually consume the product, and we will adopt it (or continue adopting it) if the expectations regarding the experiential attributes are satisfied. Particularly, this chapter will discuss the triggers of mental simulations about the sensory/consummatory but also of the outcome/consequential characteristics of the product and how these two types of characteristics influence subsequent food choice.

Anticipation and Mental Simulation

When faced with a choice of food products, either for immediate or later consumption, our brain anticipates the likely impact that the products will have on us. We will automatically mentally simulate the sensory pleasure we will obtain from the product but also the consequences of having consumed it. These mental representations will be based on the verbal or pictorial information available or the appearance of the product itself, and of course depending on the product, on olfactory and tactile input as well. Needless to say, the more familiar we are with the products, the clearer those representations will be because we will already have that sensory information stored in our memory from past experiences. Then our choices will be largely determined by those memories.

Most of the literature on anticipation is based on the anticipated pleasure (so, on the consummatory dimension). The reason is that it is assumed that pleasure, or liking, is the primary reason why people make a particular food (and portion) choice. That is, they would buy a product, sometimes in a large amount to be able to consume it in several days, with the idea that they will like it until the end of consumption. Note, however, that it has been demonstrated that people are quite bad at estimating predicted liking over time (Kahneman and Snell 1992; Rozin et al. 2006). Another major influence of food choice relates to the post-consumption consequences, which one may imagine once that, or a related product, has been consumed before. One can imagine the short-term post-ingestional effects of a food and/or the longer-term effects (what in other terms is referred to as "health" effect).

Food products have specific characteristics that make them appealing or desirable to consumers. Some products are more appealing for their long-term benefits, whereas others are commonly known to deliver direct gratification or a short-term benefit. Consumers can infer these based on the intrinsic properties of foods and/or on how the product is being promoted (e.g., the labelling provided). We could therefore say that products are usually more dominant in one aspect or the other and that the dominant aspect would trigger either stronger sensory-hedonic or more consequential-utilitarian mental representations. Apart from the product's properties, what is salient also depends on the eye of the consumer and the focus they have in mind. However, before delving into these aspects, let's define first what mental simulation is.

Mental representations can be characterized as images or can be embodied as a complete experience, including body sensations, feelings, and images. From a grounded cognition perspective, this imagination process is referred to as mental simulation, which allows us to recreate previous experiences that deepen our innermost self through perceptual, motor, and introspective states (Barsalou 2008). Additionally, mental simulation is multimodal and creates the experience of "being there" (Barsalou 2005; Kappes and Morewedge 2016); it can even activate the gustatory and olfactory cortices in the brain (Spence 2016). Moreover, imagining a favorite food (memory of food) may be more crucial in activating reward-seeking behavior than actual food. In the next sections, I will elaborate on these two types of anticipation regarding these food-specific benefits. Next, I will discuss novel strategies to possibly shift the mindset of consumers toward hedonic/short-term benefits or more utilitarian/longer-term benefits of foods to influence food choice.

Hedonic Anticipation

In a given context, what determines pleasure or the hedonic aspects of food is mainly its sensory properties (surely there are other factors, like environmental and social ones, but these are covered in other chapters of this volume). Surely before consuming something, we can already fantasize about the likely taste, aroma, texture, and sounds (overall flavor perception). Some product categories are inherently highly effective in evoking sensory imagery (bakery products, chocolate, etc.) in general and are commonly known to deliver direct gratification or a short-term benefit even before consumption. In fact, fantasizing about, or mentally simulating, appetizing food may activate the reward areas of the brain and provoke a strong motivational response such as increased desire for that food (Pelchat et al. 2004).

The Effect of Hedonic Mental Simulation on Food Choice and Portion Size Selection

Research has been consistent on the effects of mental simulations. However, at the outset it is worth highlighting that the strategies used by researchers to evoke mental simulations greatly vary among the studies. In some studies participants have to visualize appetizing food (well, considered appetizing for most people) directly or as part of a cover task, and in others the instructions are more explicit and ask participants to imagine the consumption thereof. Across studies, it has been shown that the appetizing foods induce salivation (Keesman et al. 2016) and trigger food cravings (Kemps and Tiggemann 2013; Schumacher et al. 2017). These findings are supported by the Elaborated Intrusion Theory of Human Motivation (EI Theory) which posits that thinking about a food increases desire for that food, as measured by means of motivation-related questions or tasks (May et al. 2015).

Some findings also point at mental simulation being an effective strategy to control food intake, potentially helping people make healthier choices. For example, Larson et al. (2014) conducted two experiments showing that repeated evaluations of food pictures led to lower consumption enjoyment on other foods sharing a sensory aspect (which is related to sensory-specific satiety). In Experiment 1, participants found eating peanuts less enjoyable after rating the attractiveness of pictures of salty foods versus rating pictures of sweet foods. In a second experiment, they replicated this finding when once again participants had to rate attractiveness or had to choose between two foods, but not when the task was unrelated to the taste characteristics of the food (e.g., rating the brightness of the images). The authors argue that simply exposing one to pictures of food is not enough to decrease enjoyment, presumably because it does not trigger the sensory simulations. It could also be that when people evaluated food pictures based on something completely unrelated to consumption in general, then goals related to consumption were also not activated. Perhaps judging them based on healthiness, for instance, would also trigger consumption-related thoughts and also impact a consumption-related variable, like enjoyment in this case.

Regarding amount consumed, the number of times people engage in imagining consuming a food is also important. Morewedge et al. (2010), for instance, asked participants to repeat the imagination of consumption of M&Ms 30 or three times and showed that imagining eating M&Ms 30 times resulted in a smaller amount of subsequently eaten M&Ms than in the latter case. Engaging in such a large number of repetitions requires time and a very high level of motivation and self-control, and it is conceivable that the difficulty of the task might cause reduced compliance and thus be a threat to the intervention's objective. Indeed, previous research showed that the availability of self-regulatory resources is necessary for the reduction in food intake induced by repeated imagined consumption to occur (see also Missbach et al. 2014, Study 2). Haasova et al. (2016) asked participants to imagine eating chocolate pudding 15 or 3 consecutive times. Results showed that participants who imagined eating the chocolate pudding 15 times ate more of the pudding than those who imagined consuming it 3 times. Taken together, the results of these studies suggest that there is an inverted U shape relationship between repetitions of imagined consumption of a particular food and the amount subsequently consumed. Other researchers have been working on reducing the "portion size effect" (Petit et al. 2017) and the portion size choice (Cornil and Chandon 2016; Petit et al. 2016). In a series of studies, Cornil and Chandon (2016) investigated the effect of multisensory imagery on portion size choice. Participants in their study were asked to imagine vividly the taste, smell, and texture of three hedonic foods before choosing a portion size of another hedonic food. The sensory imagery made non-dieters opt for smaller portions due to an increased expected enjoyment for a food (chocolate cake) but backfired dieters, who felt tempted to choose larger portions. In the case of health imagery, people saw the same three hedonic food pictures, but they were asked to imagine the negative impact of these foods on their health and body. No effects were found in expected eating enjoyment nor in actual enjoyment, but all participants chose smaller portions, and the effect was marginally stronger among non-dieters.

Although research in the food domain refers to an imagined food consumption experience as multisensory imagery (Cornil and Chandon 2016; Lacey and Lawson 2013), consumption imagery (Petrova and Cialdini 2005), sensory simulation (Larson et al. 2014), or eating simulations (Papies 2013), these seem to capture only one of two distinct types of mental simulation, known as "process" simulation (Taylor et al. 1998). Process simulation evokes the act of using or consuming the product, and for foods, this includes, for instance, the flavor of food, the sensations while eating, and also an affective component, which can vary from positive to negative. It should also be noticed that most of these cited studies have used high calorie, hence indulgent, food as stimuli (e.g., cakes, sweets, fries). Therefore the effects of imagining the consummatory aspects of eating a less indulgent product are not well known, but I will describe some recent findings on this in the following sections.

Utilitarian Anticipation

As mentioned above, individuals can also mentally simulate the functional and emotional consequences (e.g., recreating the satiation feeling and also the guilt or satisfaction) of having consumed a product, before even choosing it. In this case this mental simulation is called "outcome" simulation, and one could argue that it happens spontaneously more often (and in a more dominant way) in products that are categorised as being "healthy." Compared to the process simulation described above, it has received relatively little attention in the literature (though see Zhao et al. 2011). Yet there is plenty of research, albeit not referring explicitly to mental simulations, which touch upon this topic when discussing the effect of, for instance, calorie-related labels or visual volume of a product on satiation and satiety. For example, Yeomans et al. (2014) manipulated the "actual" and "perceived" amount of soup that the participants consumed. Before lunch, half the participants were shown 300 ml of soup, and half were shown 500 ml. During lunch, half of each group consumed 300 ml and the other half 500 ml, inversely. Immediately after lunch, self-reported hunger decreased as expected, and the differences observed were related to the portion of soup actually eaten. However, 2 and 3 h after the meal, the participants' hunger was determined by the portion of soup they had been shown before lunch. After 24 h, the expected satiation delivered by a 400 ml bowl of soup was significantly higher for those who had previously seen 500 ml of soup, regardless of the amount actually consumed. This seems to confirm that the memory of recent eating can influence subsequent expected satiation assessments through the participants mentally simulating the effects of the visually displayed amount of soup (see also Higgs 2002, 2008, for additional evidence on the effect of memory on subsequent intake). That said, and emphasizing the point above, in most of these studies, there are no explicit instructions to imagine the consequences of consuming the products.

Process and Outcome Mental of Simulation and Food Choice

Most studies described so far on the impact of (mainly) process simulation have focused on enjoyment of consuming a given portion or on consumption amount (portion), or selection thereof, as dependent variables. However, as mentioned in the introduction, we normally also make decisions on what to select, for instance, in a restaurant for dessert or at a train station as a snack. Many people, mostly us who have a "sweet tooth" (or salty or fatty, for that matter!), would give in to temptation and go for the most indulgent (vice) option. This is because we naturally tend to prioritize short-term goals, which provide immediate gratification (i.e., eating the mouth-watering snack) and delay long-term goals (i.e., dieting to achieve a fit body and health). Since long-term goals are further in the future, consumers are often faced with the dilemma of whether to eat or not to eat the mouth-watering snack or to choose a healthier (virtue) option. The dilemma in consumers' mind can be seen as the conflict between a long-term goal and a short-term goal.

Process and outcome simulation types may be associated with temporal patterns of activation (Trope and Liberman 2003), that is, activation of short-term and concrete (process simulation) versus long-term and abstract goals (outcome simulation). The activation of these two constructs in a food consumption event could shift the balance from more concrete and short-term goals toward an activation of abstract and long-term goals and vice versa.

One way to possibly shift the balance between short-term goals and long-term goals is to use people's imagination. In a recent study, imagining the eating consumption itself and imagining the benefits/consequences of consuming the food were differentiated (Muñoz-Vilches et al. 2019). The interest lied in investigating the effect of instructed process versus outcome mental simulation on food choice and how such effects differ between vice ("high-calorie") and virtue ("low-calorie") products. Moreover, we also looked at the moderating effect of the chronic orientation of people toward short or long-term consequences (i.e., level of health orientation).

For this purpose, the study followed a 3 (simulation type: control, process, and outcome) $\times$ 2 (product type – vice, virtue) within-subjects experimental design. The two products (crisps and a green smoothie, which were similarly liked) were presented to the participants as unbranded pictures. During the first session, all participants engaged in the control condition (i.e., no mental simulation) to provide baseline measures for both the vice and the virtue products. After they attended the first session, participants were randomly assigned to the process simulation or the outcome simulation condition. Once they had finished the second session, they were contacted again and scheduled for the third and last session. All the participants completed it within one week and had to complete the task roughly at the same time for all sessions.

To manipulate the type of mental simulation, specific instructions for process and outcome simulation were created ensuring that everyone thought of cognitive and affective aspects during both simulation sessions. In the context of food, Xie et al. (2016) proposed, based on the theory of grounded cognition (Barsalou 2008), that process simulation/outcome simulation of the food consumption experience includes sensory perceptions such as taste/aftertaste, motor states of chewing/feeling full, and introspection as enjoyment/satisfactory and energy levels. After the simulation, participants had to indicate how much they would want to eat the product they imagined at that moment, and finally they were given the choice between a green smoothie, a packet of crisps, or none.

The results of this first study showed that imagining the consumption of the vice product and the post-consumption of the virtue product increased the rate of wanting for that corresponding product; the same pattern was found for the choice but only for outcome simulation. In other words, when people had to image consuming the crisps or having had consumed the green smoothie, their wanting for these products increased, and in outcome simulation, it led to an increased choice for the virtue product. However, when the products and the mental simulations were less "matching," these effects were diminished. A possible explanation is that the perceived likelihood of the consumption event increased due to simulation heuristic, which is the ease in which people generated a mental script of the consumption event (Kahneman and Tversky 1982; Tversky and Kahneman 1973). When people were asked to simulate the consumption experience for a vice product, the accessibility of features related with the experience (such as sensory attributes, enjoyment of eating) would have been more salient and easier to imagine; the same outcome would be expected when imagining the consequences of having consumed a virtue food, resulting in a positive motivational reaction.

Impact of Health Orientation

The extent to which people are more or less health-oriented could also have a moderating role on wanting and choice. It would be plausible that people with a stronger goal, or more determined, to keep a healthier diet would be more resistant to change their wanting level and choice for a product. In Muñoz-Vilches et al. 2019, this hypothesis was only partially confirmed since health orientation (as measured with the Food Choice Questionnaire; Steptoe et al. 1995) moderated only when simulation and product type did not share the same dimensions (so when they had to imagine the consequence of a vice product and the consumption of the virtue product). Those less health-oriented people decreased their desire for the vice product possibly because the imagined consequences reminded them of a health goal. In a teleological system, behavior adjusts according to the revaluation of the goal that is triggered, either by an alteration in the state of motivation or because new knowledge is acquired (Dickinson 1985). It is likely that outcome simulation made the health goal more salient, permitted a revaluation of goals, and led this low health segment of people toward a behavior more compatible with their new goal, which led them to choose the virtue product. In other words, mental simulation could have activated and changed the initial goal of people. Research in goal prime showed that, indeed, goal primes increase attention for goal-congruent items and the likelihood of choosing them (van der Laan et al. 2017). Therefore, outcome simulation could have primed low health-oriented people with a healthier goal, which increased attention for the goal-congruent features (utilitarian) and led people to opt for the virtue and healthier product.

On the other hand, we hypothesized that high health-oriented people would be less likely to change wanting and choice, regardless of the product and the simulation they performed. However, although this group remained quite constant in their preferences (the virtue over the vice product) in both simulations, the wanting for the vice product was not constant, and indeed, they increased desire for that food equally in outcome and process simulations compared to the control condition. This result suggests that higher health-oriented people have a high self-control resource, since they get tempted with the vice product but they do not choose it over the virtue option. The relative importance of hedonic versus utilitarian product attributes changes across consumers, and, as one would expect, the importance of healthfulness is much higher among the health-conscious segments than other segments (Maehle et al. 2015). In the case of the virtue product, even though the results mirrored the ones of the vice product, they were not as pronounced. In this product, health orientation did not moderate when process and outcome simulations were compared to the control.

Role of the Valence of the Mental Simulation (Imagined Experience)

So far, in this chapter I have discussed variables like wanting or desire and choice, but the experience of the consequences of past eating can significantly impact subsequent intake or enjoyment of foods since the integration of internal and external signals that influence food intake relies on memory systems (Booth 1992). More specifically, it seems that the valence of the remembered experience is what determines subsequent behavior and/or enjoyment. For example, Robinson and colleagues showed that how we recall food enjoyment can influence subsequent enjoyment of foods (Robinson et al. 2011, 2012). Two studies examined whether remembered enjoyment of eating a food can be increased and whether this makes individuals more likely to eat that food in the future (Robinson et al. 2012). A simple manipulation of instructing participants to revisit what they found enjoyable about a food right after eating it was used to increase remembered enjoyment (relative to controls). This experimental manipulation successfully increased remembered enjoyment for the food. In the second study, they explored whether this very manipulation resulted in participants choosing to eat more of a food from a buffet lunch the following day, the results suggesting that it is the case. Taken together these findings suggest that remembered enjoyment can be modified by simply recalling a past occasion and that this act can increase or decrease the amount of food chosen and eaten later. Moreover, additional evidence suggests that memory of food, or thoughts of future meals, suppresses subsequent food intake (Vartanian et al. 2016).

Together with Sara Jaeger, the impact that food-related memories have on people's emotional state and how this state is projected in a subsequent evaluation of images pertaining to food and food-related behaviors was investigated (Piqueras-Fiszman and Jaeger 2016). Through an online survey, three memories were investigated (a positive meal, a routine evening meal, and an overeating occasion) among UK respondents. Participants had to recall one of these three memories and write it down. Following this, they evaluated images of food and food-related behaviors in terms of emotions conveyed (provided to them). Participants who recalled an overeating memory evaluated images related to junk food as conveying more feelings of guilt and shame than did participants primed with the memory of a positive meal. Moreover, this effect was moderated by participants' dietary restraint status. Participants classified as having a high dietary restraint had stronger associations with the emotions guilt and shame than participants classified as low in dietary restraint. In contrast, a memory of a positive meal did not lead to positive valuations of any of the food-related images shown. Overall, the findings from this study illustrate the partial impact that personal food memories have on people's emotional response toward food-related issues, which in turn has the potential to affect future behavior.

Now, in the context of the instructed mental simulations, one could argue that both process and outcome simulations would increase the desire for an imagined ambivalent product (which could be both vice and virtue) in a similar way since no negative imagination was imposed. People assign a positive value to things that are conducive for goal achievement and negative value to things that are detrimental for goals achievement (Förster et al. 2007). We further explored whether the valence of the imagined experience could modulate the desire for the imagined product (Muñoz-Vilches et al. submitted). Thus, we expected that in our case, the imagined experience would lead to a positive feeling, and it would increase wanting. Yet, having a negative feeling about the imagined experience (i.e., for a person the product might have negative sensory attributes or lead to post-consumption feelings such as guilt) would decrease wanting. Therefore, the valence of the imagined experience would mediate the effect of mental simulation on the wanting for the imagined product. Imagining a food experience evaluated as positive (negative) would increase (decrease) the motivation to eat the product they have imagined. Finally, we also hypothesized that upon a real choice of foods (a healthy and an unhealthier snack), performing process simulation with an ambivalent product would increase the likelihood of choice for the unhealthy product and that outcome simulation would increase the likelihood of choice for the healthier one.

The procedure was the same as with the other study described (Muñoz-Vilches et al. 2019). After the mental simulation phase, with a cereal bar (in this case as an exemplar of an ambivalent product), they evaluated the valence of the thoughts evoked by the imagined experience. At the end of the session, participants were presented with two transparent containers, one with 65 g of a healthy product (grapes) and another with 65 g of an unhealthier product (chocolate covered raisins). Participants were asked to evaluate the liking of both products before tasting them and had to choose one from the two products to do a "taste test" as part of a cover story. Only the choice was recorded, but participants did not notice any connection between the mental simulation phase and this "other" tasting test.

Participants under process simulation, that is, imagining the process of eating, had a higher desire for the imagined product compared to a control condition, but when having to choose between a healthy and an unhealthier product, more people chose the unhealthier product over the healthier one. On the other hand, outcome simulation, that is, imagining the outcome of eating, also generated a higher desire for the imagined product, but in this case, people chose the healthier option. The results also showed that the type of mental simulation indirectly influenced wanting for the imagined product through its effect on the valence of people's imagined experience. So, in other words, the more positive the imagined experience was, the more desire the participants had for the food.

The results highlighted the impact that mentally simulating the process of eating something versus its consequences has on the choices people make regarding snacks. Making people focus more on the consequences of the consumption, even if it is not a vice nor a virtue product what is being imagined and not being part of a choice, could lead to healthier choices, as our study suggested. This strategy, one could argue, makes people direct their attention toward different aspects of the product. Most importantly and in alignment with previous literature, if the imagined (post)consumption experience elicits positive feelings, we will be more inclined to eat that or a similar product, but if the experience elicits more negative feelings, then we will tend to not prefer that food (or perhaps even reject it).

Taken together, these findings highlight how important the memories we have of our eating experiences are. In fact, according to the cognitive psychological tradition that became known as "analysis-by-synthesis" (e.g., Gregorey 1980), our brain does not build its current model of how the world is simply by accumulating information from the bottom up (i.e., from low-level cues). Rather, it tries to predict the current incoming cues from its best models of the possible causes (see Hohwy 2007). Over the last decade, more and more neuroscientists have subscribed to this perspective using a Bayesian framework to suggest that our brain uses hierarchical or empirical Bayes to infer the causes of the sensations invading it (e.g., see Friston 2005; and Piqueras-Fiszman and Spence 2015 for a more elaborated discussion on this). Considering this we could say that we make decisions without much processing of incoming information and in a pretty automatic way by trying to predict whether the products we are choosing from will satisfy our hedonic and utilitarian needs, based on the priors stored in memory from previous experience. As part of this process, mental simulations contribute to us anticipating the likely (post) experience we will have with the product.

Conclusions and Implications

As mentioned at the beginning of this chapter, mental simulations occur naturally and automatically as soon as we encounter a product; however the behavioral outcome is then also mindless and greatly relies on our recall of similar experiences (hedonic and functional) we have had in the past. This highlights the importance that past experiences and our memory thereof have in our behavior.

This chapter also provided an overview of recent evidence highlighting the potential effects of instructing people to remember or imagine different aspects of the (post)consumption experience, mainly on wanting of food in general and in subsequent choice of different categories of foods (vice or virtue). Findings so far seem to suggest that making people focus on the consummatory/sensory experience of eating leads to choices related to a more hedonic experience, whereas focusing on the consequences would drive healthier choices. This is not to say that the first type of simulation is always linked to pleasure and the latter to more negative feelings, but there seems to be a congruity in terms of psychological distance or goal activation, which warrants further attention. Clearly, also the valence of what we reminisce plays a role, as has been demonstrated in enjoyment of subsequent eating episodes and in the emotions that food-related images convey.

The biggest potential of instructed mental simulation would be to aid people with a less salient health goal, to decrease their temptation and preference toward unhealthier and highly hedonic products, and to “persuade” them to make healthier choices. Moreover, industry could benefit by evoking more outcome-related thoughts when a virtue product is in question. Mental simulation could be used to shift attentional focus, at convenience, toward more hedonic or utilitarian features. Thereby, greater understanding of the impact of mental simulation on anticipated consumption may prove fruitful in individual strategies to regulate temptation, as well as in the creation of more effective communication strategies of healthier food.

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Development of Food Preferences

10

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Abstract

Understanding food and beverage preferences is important given the role that likes and dislikes play in our choices and, ultimately, in our health. While both genetic and environmental influences are important determinants of preferences, in this chapter, emphasis is given to the different processes that encourage and maintain preferences, commencing prior to birth and into adulthood. In particular, various forms of learning, including exposure, evaluative, and nutrient conditioning, are crucial, while culture provides the necessary specifics in terms of the actual foods that we learn to like. In turn, the learning processes and cultural influences are modified by our individual characteristics, including genetics and dimensions of our personality.

Introduction

Food and beverage preferences, like many complex human behaviors, result from the interaction of genetics and environmental influences. In turn, the environmental effects are mediated by learning processes that have evolved to deliver hedonic states that motivate us to select and consume some foods over others (Prescott 2012). While acknowledging that culture is overwhelmingly important in determining which foods are consumed, and therefore preferred, an account of cultural differences is not the aim of this chapter. Rather, the discussion will focus on the mechanisms that underlie the development of food preferences generally, irrespective of culture or demographic factors. For the same reason, short-term influences on food likes and dislikes, including such phenomena as sensory-specific satiety, alliesthesia, and the effects of actual or anticipated satiation or satiety, will also not be considered.

Innate Influences

Genetics

While exposure and learning are probably most influential in determining food preference, there is, nonetheless, good evidence for strong genetic influences on the foods we choose. Studies of monozygotic and dizygotic twins have shown heritability for specific foods, with the degree of heritability differing according to the category of foods (Falciglia and Norton 1994). Heritability appears to be strongest for proteins and smallest for desserts, and for fruit and vegetables, moderate–strong degrees of heritability are seen. In a series of studies of Finnish twin populations (see, for example, (Keskitalo et al. 2008; Tornwall et al. 2012) heritable components have been observed for preferences for a variety of the sensory qualities of foods, including astringency, sourness, oral pungency, and for “healthy” foods, high-fat foods, sweet foods, and meats.

What actually is being inherited? Some genetic influences on food preferences may arise from variations in perception. The most studied genetic variation in taste perception has been that underlying the bitterness of two thiourea compounds, phenylthiocarbamide (PTC) and 6-n-propylthiouracil (PROP), the taste of which is linked to polymorphisms in the bitter receptor gene, *TAS2R38* (Bufe et al. 2005). This gene and its associated phenotypic variations are of interest because of the fact that PROP/PTC sensitivity has been used as an index of sensitivity to other food qualities including tastes, oral pungency and tactile qualities (Prescott et al. 2004), as well as to specific food preferences and intake (Duffy et al. 2010). Therefore, some of the variations in heritability found in twin studies may reflect genetic variations such as these, and in particular for those foods that are bitter. Genetic variations in taste sensitivity may not only explain person-to-person differences in food likes, but they could also be responsible for some observed sex differences in food preferences, since being highly sensitive to PROP bitterness is more common among women than men.

Although PROP sensitivity has been extensively studied, it is not unique, in that other physiological/anatomical variations may have an impact on food preferences. We vary, for example, in the density of structures that contain taste buds, fungiform papillae (FP), on the tongue. Groups varying in FP density show differences in the sensory properties of, and preference for black coffee and in their addition of sugar to coffee (Masi et al. 2015). Vegetable preferences, too, have been linked to higher FP density, particularly in those individuals who were less sensitive to the bitterness of PROP (Duffy et al. 2010). Furthermore, nontasters with more papillae reported greater vegetable consumption than nontasters with fewer papillae, suggesting that when bitterness does not predominate, more papillae enhance vegetable liking.

Personality

The role of personality variables in determining the perception and preference of foods and their sensory qualities has received increased scrutiny in recent years. In particular, the trait of food neophobia (FN) is an important contributor to food preferences (Jaeger et al. 2017) and shows substantial heritability (Cooke et al. 2007), and thus may contribute to genetic influences on food preferences. Although FN was initially conceptualized only as a reluctance to consume unfamiliar foods, it has global impacts on food preferences, with higher FN being associated with reduced dietary variety, specifically in higher numbers of foods that have never been tried and the lower of number of foods liked overall. Highly neophobic children show reduced preferences for, and lower intakes of, vegetables and fruits in terms of both variety and amounts and reduced consumption of protein foods. FN persists into adulthood in a substantial proportion of the population, and increasing neophobia in adults, as with children, is associated with reduced acceptability and intake of vegetables, fruits and protein foods, as well as in higher numbers of disliked foods overall, even extending to reduced preferences for, and consumption of, familiar foods. The inherited factor in FN is uncertain but may be a tendency to experience high arousal in response to both unfamiliar foods and intense food flavors (Laureati et al. 2018). A number of other personality factors with strong heritability, including *disgust sensitivity* and *sensation-seeking*, are also linked to food choices, but it is probably premature to conclude just how important many of these are as independent determinants of food *preferences*.

Taste Preferences

The most ubiquitous preferences present at birth are those of the so-called basic tastes, in that we are born with established hedonic responses to sweetness, bitterness, sourness and umami (glutamate taste), while a preference for saltiness develops in the first few postnatal months. These fixed preferences are in contrast to our preferences for odors/flavors, which are molded by exposure and learning from an early age (see below). Taste preferences are reflected in distinct, and unambiguous, facial expressions to sweetness and bitterness that are present at birth in humans, monkeys, and rats and are essentially the same responses that we have as adults. Both in terms of willingness to ingest, and also in the quality of these characteristic facial expressions, sweetness is highly liked and bitterness rejected in human neonates (Desor et al. 1975). Sourness is also disliked, especially at high levels. Preference for glutamate (*umami* taste) is highly dependent on its context – in essence, it becomes highly liked when part of an overall flavor.

These stereotyped responses present at birth suggests that innate taste preferences are likely to have important roles in regulating the intake of nutrients and avoidance of toxins. Thus, the palatability of sweetness is thought to signal the presence of energy in the form of calories provided by sugars and other plant carbohydrates, which are crucial to survival. Saltiness signals the presence of the sodium ion (Na^+), crucial for maintaining the body's fluid balance. The strong dislike that we naturally have to bitterness is thought to be a protective mechanism: Many plants manufacture toxins as a defense against predators, and very many of these toxins are bitter. The significance of our dislike for high levels of sourness is not as clear-cut. It may be a signal for unripeness/spoilage in foods, or the fact that concentrated, and thus extremely sour, acids can cause tissue damage. The origins of umami preferences (like those of some other amino acids) are less clear, but may act to promote protein intake.

Sweetness remains preferred and is an important determinant of food preferences into adulthood, even though there is a general decline in the levels of sweetness preferred (Desor and Beauchamp 1987), and there is considerable person-to-person variation. A substantial proportion of adults still exhibit a "sweet tooth," but there are also large minorities who increasingly dislike sweetness as it becomes more and more intense, even if weaker levels remain liked. Studies of sweet liking have identified three to five groups that varying in their optimal sweetness level, at least in solutions and beverages (Kim et al. 2014). Indeed, in the case of both sweet solutions and foods, sweet liking, as distinct from our perception of sweetness, has been found to be partly heritable and may be linked to other genetic variations in bitterness sensitivity.

Exposure

It is clear that innate taste preferences undergo modification during the transition to adulthood and it may be the impact of differential exposure to taste qualities within the context of foods that produces subgroups based on taste preferences. In regard to other taste qualities, the aversion for bitterness present at birth remains, although adult bitter likers and dislikers, based on food preferences, have been identified. However, the initially aversive response to sour tastes is increasingly converted to a sour preference for some infants, over an initial timeframe of approximately the first 18 months, but increasing during infancy and into childhood. This is reflected in increasing acceptance and intake of sour-tasting foods.

Foods and Food Flavors

Flavor and food preferences vary as a function of many factors, including genetic status. However, the overwhelmingly largest influence on food preferences is exposure. At birth, each of us has already experienced some months of in utero exposure to food flavors through the common bloodstream of the mother and fetus. In the second trimester, swallowing and sucking by the fetus can be detected, and immediately prior to birth the fetus is actively swallowing considerable amounts of amniotic fluid. This fluid contains not only minerals but also compounds that stimulate both taste and olfactory receptors. Moreover, the results of this exposure have been demonstrated in the flavor preferences of the infant at up to 2 years of age (Mennella et al. 2001).

The maturity of the olfactory and taste systems at birth allows feeding experiences to have an immediate impact in development of later preferences. The fact that breast milk is both sweet and high in glutamate (and hence presumably in umami taste) means that it is immediately preferred. At the same time, the infant is being exposed to a variety of flavors from the mother's diet that are expressed in her breast milk. The impact of this is evident through studies in which flavors (e.g., garlic; vanilla) introduced into the mother's diet increase the duration of breast-feeding by the infant. An important distinction between bottle-fed and breast-fed infants is the degree of exposure to flavors. The fact that bottle-fed infants experience a relatively uniform taste and flavor environment is likely to be important in the extent to which these infants will later accept novel foods into their diet. In other words, early experience of flavor variety is associated with later acceptance of variety in food experiences.

Studies on both young infants and children (typically, 4–8 years of age), using both ratings of liking and amount consumed, have seen increases in acceptance with repeated exposure to novel vegetables, fruits and cheeses (Wardle et al. 2003). In most cases, it seems that amount of change in liking is a positive function of the number of exposures. The impact of early exposure can be seen into childhood and adolescence, with significant links between preferences for foods at 2–3 years old and those following puberty (Nicklaus et al. 2004).

Cultural Transmission of Flavor Preferences

Exposure both in utero and postnatally via breast and bottle feeding provides the infant with a set of preferred flavors, and these preferences can be seen to persist into the child's consumption of solid foods. We would expect, therefore, that initially at least the child's flavor preferences would match those of their mother. But there are broader implications of this transmission of flavor preferences. When seen in a cultural context, what is transmitted from mother to child is a set of preferences that define the flavor principles of the culture in which they live.

The idea of flavor principles was introduced as a means of characterizing how cuisines differ from one another (Rozin and Rozin 1981). The principles consist of particular ingredients – meats, vegetables, herbs, spices – as well as food preparation and cooking methods that will distinguish the cuisine of one culture from that of another. The flavor principle of a cuisine also performs a utilitarian function in that it allows a cuisine to be flexible in its ingredients (for example, swapping one staple protein for another in the face of changing availability) without eliciting neophobic responses.

The potential variations to which infants may be exposed is vast, but it can be expected that these will reflect to a great extent the adult diet. Thus, a preponderance of sour or fermented or spicy flavors within a culture will be reproduced in the preferences of infants. Likewise, the absence of certain foods or flavors with a culture will mean that the infant fails to develop preferences for those qualities. The relatively passive process of flavor exposure is also augmented by more active interventions – for example, the gradual access to chilli provided to young infants in Mexico by their parents (Rozin 1990). Much of this latter type of social learning – essentially modeling on the behavior of parents and other significant adults – takes place at the later stage of development.

Establishing Preferred Sensory Qualities

As noted above, saltiness is hedonically neutral at birth, but a clear preference for salty water over plain water develops by about the sixth month postnatally. More generally, infants begin to learn the appropriate levels of tastants and the qualities of flavors for different foods and beverages. This same process can be shown to operate in determining or modifying adult food preferences as well. Reducing sugar in tea to coffee, or salt in foods, for health reasons is an example of the impact of exposure to initially disliked levels of tastant on the development of a liking for that reduced level. Such effects have been shown experimentally with exposure to salt-reduced versions of foods (Methven et al. 2012). Similar effects can be seen with long term reductions in overall dietary sodium, which have been shown to reduce the optimal level of saltiness for multiple foods (Bertino et al. 1986).

Repeated exposure provides a context for a wide range of the sensory properties of foods, and can explain why there are variations in preferences across cultures even when the foods themselves are very similar. Expectations that a beverage will be served at a particular temperature, for example, reflects only one's prior experience with that beverage, and can be altered by repeated exposure to a new version served at a different temperature (Zellner et al. 1988). Similarly, a product's color will be seen as appropriate or not depending on prior experience. We also learn that a particular texture belongs with a particular food: There is nothing intrinsically likeable about *crunchy*, *mushy* or *flaky* as food qualities. Food textures are highly dependent on preparation techniques and meal context. In turn, these vary by food, a fact that is specified within each culture's cuisine.

Violating these expectations can be a potent source of food rejections. A study of a savory, smoked-salmon-flavored "ice cream/mousse" showed that its acceptance or rejection largely depended on the researchers' manipulation of the context. Telling participants in the study that they were consuming smoked salmon "ice cream" provoked considerable dislike for the dish, whereas it was much more acceptable when labeled as cold smoked salmon mousse (Yeomans et al. 2008a). The crucial difference here is that the information provides a way of interpreting what is being eaten as either consistent with what we expect (that a mousse can be savory) or not (that ice cream does not come in fish flavors) – based on prior exposure to multiple examples of both mousse and ice-cream.

Mechanisms of Exposure

Sections "Associative Learning" and "Post-Ingestive Learning" (below) discuss various mechanisms for producing changes in liking that occur through pairing with valenced (liked/disliked) stimuli or with the metabolic consequences of food ingestion (see also Fig. 1). In these cases, simple, repeated exposure to a food or flavor is a necessary precondition to facilitate learning. But, as in cases outlined above, it is sometimes sufficient to increase liking without additional processes. In fact, the idea that exposure to a stimulus alone can increases liking for that stimulus seems to be a general phenomenon, observed with a broad range of visual and other sensory stimuli (Bornstein 1989). Foods and food flavors are special stimuli because of their biological significance and their potential to be toxic. As such, exposure, may have unique effects. As noted earlier in the discussion of food neophobia, food novelty may be a source of unpleasant high arousal because it implies unpredictability in terms of its suitability as food. Conversely, repeated exposure (without negative consequences) is known to reduce arousal and is consequently rewarding. The impact of exposure on arousal in the context of foods is not primarily about conversion of disliked to liked stimuli. Rather, it can be seen as a means of dealing with novelty as a signal of unpredictability of flavor. If the flavor of a food might be unusual, and thus not previously tried, it can therefore be potentially dangerous, and it is this unpredictability that is the source of the arousal.

External signals of safety also encourage food trial, even among those that are highly neophobic. These signals include "models," for example, peers or an adult modeling consumption of novel food or information about the food's flavor, or linking the unfamiliar food with a familiar and liked food or ingredient such as a

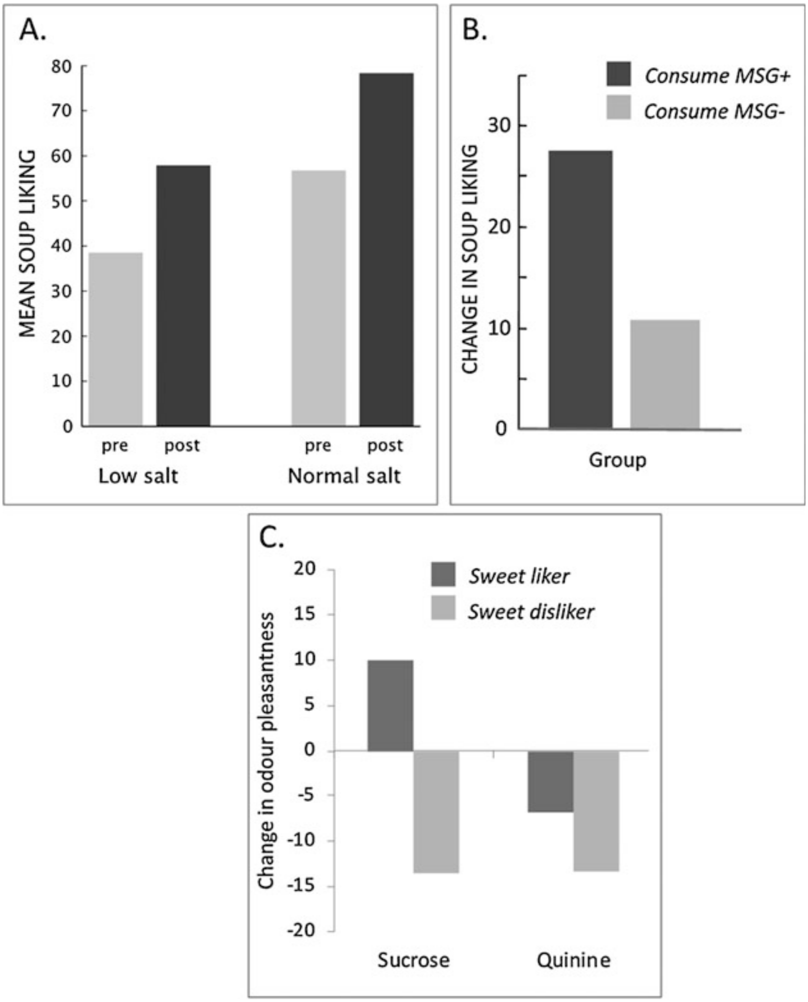

Fig. 1 Examples of changes in liking for flavors and odors via different learning processes. (**a**) Effects of **exposure** shown in changes in mean liking ratings prior to (pre) and following (post) repeated exposure to the taste (no consumption) of a soup flavor at either low or regular salt levels. (Data adapted from Methven et al. (2012)). (**b**) Effects of **post-ingestive (flavor–nutrient) learning** shown by changes (pre- to post-exposure) in liking for the flavor of a novel soup consumed while hungry either with (MSG+) or without (MSG-) added monosodium glutamate (MSG). (Data adapted from Prescott, J. (2004) Effects of added glutamate on liking for novel food flavors. *Appetite*, 42 (2), 143–150). (**c**) Effects of **evaluative (flavor–flavor) learning** showing through changes (pre- to post-exposure) in liking for novel odors that have been repeatedly tasted with either sucrose or quinine in solution. Data are shown for both sweet likers and sweet dislikers, illustrating the importance of the individual differences in the hedonic value of the taste to changes in liking. (Data adapted from Yeomans, M.R. and Prescott, J. (2016) Smelling the goodness: sniffing as a behavioral measure of learned odor hedonics. *Journal of Experimental Psychology: Animal Learning and Cognition,* 42(4), 391–400)

condiment or a sauce. In the latter case, the familiar item will be strongly influenced by culture. In fact, we can see this process as one in which consumption of a novel food is encouraged by the use of a “flavor principle” (see section “Cultural Transmission of Flavor Preferences”).

Associative Learning

Bitterness as a quality per se remains largely unpalatable into adulthood. Yet, at the same time, we willingly consume bitterness, at least in the context of other flavors such as coffee and beer. However, the fact that we typically experience bitterness in the context of other more liked qualities such as sweetness raises the question of how much this pairing is responsible for the development of liking for bitter foods and beverages.

Evaluative Conditioning

It is thought that repeated pairing of something that has valence – that is, is liked or disliked – with something that is novel (or disliked) will typically produce a change in the hedonic qualities of the latter. This type of learning, generally known as evaluative conditioning, is similar in procedure to classical (Pavlovian) conditioning, except that we are learning likes and dislikes rather than that one stimulus (a bell, for example) predicts the occurrence of another (the presentation of food). Evaluative conditioning has been shown with stimuli from a variety of sensory modalities, including visual, auditory and olfactory stimuli (De Houwer et al. 2001).

These same processes are at work during the development of food preferences, and evaluative conditioning commonly begins prior to consumption via a product’s image or through awareness generated by advertising. Advertisers typically embed the images of product presentation and/or consumption in a variety of what they judge are positive contexts that are being paired with the product. Marketers rise to the challenge of dealing with products that have aversive characteristics such as bitterness in beer through advertising that links preference for the taste for this bitter brew with the idea that it marks the drinker as having sophisticated tastes.

As well, brands and labels have an important role in that they can signal prestige or group membership or an important value for the consumer. Hence, foods with an organic label or labeled as “natural” or “healthy” can be evaluated as better tasting and promote increased consumption (Cavanagh and Forestell 2013). Many of these effects depend, though, on the consumer’s attitudes and values regarding that nutritional information. Those interested in health or nutrition may find added value in labels that signal such properties, but the same labels can also convey simultaneously a negative taste message since, for many consumers, “healthy” and “tasty” are perceived as incompatible.

The exposure to the product itself by eating or drinking is experienced in contexts, which can be social (dining with family or friends) or occur in pleasant environments, and in each case, the context can provide positive associations for food and drink flavors that encourage the development of preferences. In some cases, while a pleasurable context might produce liking for a food, the food becomes strongly linked only to that context. Hence, a familiar food or meal will be enjoyed more if it is eaten in an environment that is highly regarded, such as a restaurant, than if the same meal is consumed in a student cafeteria (Edwards et al. 2003). This is probably the reason why restaurant evaluations often emphasize the "atmosphere" – which might include location, noise level, lighting, other diners, image, and so on.

Individual foods can also become part of the overall enjoyment of special occasions, as in popcorn at the cinema, and various, otherwise inedible, items at sporting events; while on vacation, a local wine or *aperitivo* becomes paired with a bustling taverna or trattoria on a warm summer evening. The key to forming such strong links between the event or context and the food or drink is the positive emotion that is experienced at the time. Indeed, evoking positive emotions and pairing these with foods can increase liking for those foods (Kuenzel et al. 2010). We can understand the almost universal liking – particularly at times of stress – for comfort food, food that is not only familiar but part of our childhood and culture and that reminds us of "home."

The sources of positive associations for foods can include role models. For example, children who repeatedly watch their peers at school consume a food that they do not particularly like become more likely to select that food if given an opportunity (Birch 1980). It is possible in such cases both that the child is learning that a food is safe to consume (and hence can be regarded as an exposure effect) and that the liking that they have for their friends is being "transferred" to the food and thus an example of evaluative conditioning. Certainly, in some studies of observational learning, others' facial expressions – acting as cues to the acceptability of the flavor – have been shown to influence liking for a novel drink, suggesting that signals for safely are being assessed. Models showing dislike appears to be particularly effective, probably because such negative facial expressions are less ambiguous (Baeyens et al. 1996).

Flavor–Flavor Conditioning

The presence of innate responses to taste – both acceptance and rejection – provides a means by which we can develop hedonic responses to the vast range of foods that are available to us as omnivores. Food flavors are unique primarily because of their odor volatiles, and while exposure alone will generate preferences for odors, in the context of foods, these odors are always paired with tastes that are already pleasant or unpleasant. The impact of such pairing was first demonstrated in humans in a study in which novel tea flavors were mixed with sweetened or unsweetened water (Zellner et al. 1983). Following repeated pairing, the participants revealed a clear preference for the flavors previously paired with sugar – an effect that was over and above any increase attributable to simple exposure to the flavors. Flavor dislikes can be formed using exactly the same mechanism, by pairing a flavor with a disliked taste, typically bitterness. In practice, though, the impact of bitterness in foods on preferences is likely to be offset by other mechanisms such as post-ingestive effects (see section "Post-Ingestive Learning").

The natural history of the development of preferences for initially aversive flavors provide indications that we tend to instinctively employ such "flavor–flavor" conditioning to establish liking. Thus, sweeter beers such as lager are often drunk prior to developing a taste for ales and more bitter beers. Similarly, novice wine drinkers tend to favor sweeter wines, probably because initially unpleasant qualities like sourness and astringency are less prominent, and the subsequent development of a preference for wine flavors is supported by this pairing with sweetness. Paradoxically, this leads to the development of a liking for the flavor of wines that are dryer, less sweet and less fruity as the wine flavor itself, and not just its sweetness, becomes preferred. Coffee, in contrast, is commonly adulterated. Adding cream or milk, plus sugar, a common combination for novice drinkers, not only reduces the bitterness, but also provides the necessary positive tastes to produce liking for coffee flavor itself. This is why, even if you drink your coffee white and sweetened, the smell of black coffee brewing is so appealing. This also explains why the transition in coffee drinking is overwhelmingly from sweetened coffee to unsweetened coffee, rather than vice versa. There are indications, too, that evaluative conditioning processes are also sometimes understood and consciously applied to influence the preference of others. Favored methods for promoting food likes in children included demonstrating that target foods are liked by the parents, as well as involving the child in the (presumably) enjoyable activity of food preparation. Some part of this may reflect the fact that adult attention is generally positive for children, and has been shown, in itself, to promote liking for unfamiliar foods with which it is paired.

Evaluative Conditioning Processes

How exactly does the increased like or dislike become attached to the novel/neutral stimulus? The mechanism behind evaluative conditioning is still a matter of debate (De Houwer et al. 2001). Perhaps the most widely accepted model suggests that in pairing the already-valenced stimulus with one that is neither especially liked nor disliked, we are in fact encoding a compound stimulus of both stimuli in memory; in a food, this would be equivalent to the taste + odor/flavor. What is important in such a model is that each odor occurs together with a specific pleasant/unpleasant taste (strawberry + sweet) very frequently and with other tastes (strawberry + bitter) very infrequently. Subsequent to the pairings, it is this compound – which contains a liked or disliked element – that is liked or disliked.

Evaluative conditioning may explain how many of our food preferences develop without any apparent effort or conscious awareness, and indeed why they are long-lasting. It is thought that evaluative conditioning does not require an individual to be conscious of the pairing between the two stimuli – which explains how it is possible for an infant's early experience of vanilla in milk to manifest as a preference as adults for tomato sauce containing trace amounts of this same flavor (Haller et al. 1999).

A key to the effectiveness of evaluative conditioning in foods is that the taste with which the flavor is paired is perceived as positive or negative. However, as discussed in sections "Genetics" and "Taste Preferences" above, there are differences between individuals both in the intensity of tastes, particularly bitterness, and also in the extent to which sweetness is liked. Hence, whether or not a change in liking for a flavor occurs will depend upon an individual's characteristics. It can therefore mean that liking for an odor paired with sweetness, for example, will not occur (or occur to a lesser extent) in those who are "sweet-dislikers." For the same reasons, insensitivity to bitterness will undermine any conditioning that might occur in pairing a bitter taste and a flavor (Yeomans et al. 2009).

Reinforcement

It is easy to view the pairing a pleasant stimulus with a neutral stimulus, in order to change preference for the latter, in terms of the pleasant stimulus acting as some sort of reinforcement or reward that promotes liking for the neutral stimulus. However, in theoretical terms, associative learning and reinforcement learning are quite distinct. More specifically, reinforcement is used to increase (or decrease) the likelihood of a behavior. Its relevance to food preferences lies in its use to encourage consumption of (and, ultimately, preference for) particular foods, thereby allowing simple exposure to increase liking.

The general consensus of the use of rewards (positive reinforcement) to encourage food consumption is that it is relatively ineffective, or at least not as effective as other approaches such as simple repeated exposure (Wardle et al. 2003). In fact, studies have concluded that positive reinforcement using praise, access to preferred activities, rewards such as movie tickets, or negative reinforcement using parental pressure may actually be counterproductive, reducing preference for the food or beverage with which they are paired. One implication of this conclusion is that using one food as a reward (e.g., ice cream) to increase consumption of another – a green vegetable that the adult wants the child to eat, for example – is also likely to fail, mainly because the relative value of the foods soon becomes apparent. This may be due, too, to the *overjustification effect*, in which an activity undertaken because of the promise of a reward is actually valued less than if it were undertaken for its own sake – that is, where the reward comes from enjoyment of the activity itself.

In other specific cases, reinforcement may influence food preferences. Thus, negative reinforcement – the failure to experience something unpleasant – has been invoked to explain the preference for chilli, despite its often painful burn, as an exemplar of "benign masochism" (Rozin and Schiller 1980). One theoretical view of positive reinforcers is that they are valued precisely because access to them is restricted. This *response deprivation hypothesis* appears to be borne out in studies of children's food preferences, in which restricting access to a food increases preferences for it when compared to other initially equally liked foods that were more easily available (Fisher and Birch 1999). The implications of such findings for preferences for high sugar, high fat foods that the parent may wish to restrict are obvious.

Post-Ingestive Learning

The innate preferences for basic taste qualities – in particular, sweetness and bitterness – and the early emergence of sodium preference are typically interpreted in terms of the nutritional significance of these taste qualities. During development, however, we come into contact with a substantial repertoire of foods that, irrespective of the taste qualities present, will vary in terms of their nutritional consequences. In addition, metabolic needs vary considerable over the short and long term, and survival requires responsiveness to such changing needs. To achieve this, largely automatic processes link food flavors with their metabolic consequences, a process known as post-ingestive conditioning or, alternatively, flavor–nutrient learning.

Signals for Energy and Other Metabolically Useful Nutrients

In a very general sense, our body's needs can regulate the development of food preferences by pairing flavors with the consequences of eating, most obviously relief from hunger (satiation) or from thirst. In addition, though, there are specific nutrients that are effective in promoting flavor preferences. The ability of a sweet taste to produce liking for an odor with which it is paired in a flavor relies on the fact that sweetness is very commonly a signal for the energy value of a carbohydrate. However, this learning is considerably enhanced when our experience of the flavor is followed immediately by the *actual* energy – that is, once the food is consumed. Such flavor-nutrient learning appears to be a universal mechanism of food preference development since few, if any, foods contain no nutrients of potential value to the body. But, from a survival perspective, the body values nutrients that supply such energy and the mechanism for promoting consumption if energy is the development of preference for associated flavors.

In animal studies, where more direct demonstrations are possible, carbohydrates, fats, starches, and proteins introduced directly into the stomach increase liking for flavors that the animal had just experienced (Sclafani 1997). In studies with humans, these same nutrients all promote flavor liking. The effects of energy consumption of carbohydrates can be shown to be an additional influence on flavor preference beyond pairing with the liked sweet taste. This is achieved by comparing changes in liking for a novel food/flavor that contains an energy-containing sweetener such as sucrose, with the food/flavor when it is tasted but not consumed, or when it is consumed but contains a sweetener such as aspartame, which is sweet but provides no calories. Such studies do indicate that consuming a valued nutrient provides a stronger or quicker increase in liking than pairing with a liked taste alone (Yeomans et al. 2008c). The difference is essentially between a taste that is *usually* a reliable signal for calories to come versus the presence of the calories themselves. Importantly, too, flavor–nutrient learning is only really effective when the body values the calories, such as when we are hungry (Mobini et al. 2007).

Fat is an even more dense form of energy than sugar, and it is therefore unsurprising that, at least in Western countries, some of our strongest preferences are for foods – chocolate, desserts, cakes – that are high in both fat and sugar. These foods are extremely palatable precisely for the reason that the body places such a high value on concentrated energy sources. Any flavor paired with fat becomes an important signal for calories to come, and this is reflected in increased liking for that flavor (Johnson et al. 1991). In the same way, we can explain why pairing with a number of other sources of energy (the alcohol in beer and wine) and other positive benefits (alertness due to caffeine in coffee) can result in liked flavors (Mobini et al. 2005). The worldwide affection for these beverages reflects not only the processes of evaluative conditioning through pairing with liked sweet tastes, but learning about their physiological consequences following consumption as well, and it is probably this last effect which allows us to develop liking despite the presence of significant bitterness in many popular beverages.

Novel flavors repeatedly combined with glutamate (the prototypical *umami* taste) also become similarly liked, although the metabolic benefits are less obvious than with sugars or fats. Unlike the taste of sweet carbohydrates, glutamate by itself is not an inherently pleasant taste. But adding glutamate to suitable meat- or vegetable-based savory foods – soups, stews, pasta, and other sauces – makes them richer and *fuller* tasting, and much more liked than those without added glutamate. Unlike salt or the energy that is signaled by sweet or fat tastes, we do not need to take in glutamate in the diet to survive, so it is unclear why glutamate promotes flavor preferences. It has been suggested that because glutamic acid is an amino acid present in animal and vegetable protein, umami taste may act as a signal for the presence of protein, with its effects on palatability therefore promoting consumption. Hence, people with very low protein intakes prefer higher concentrations of glutamate than those whose protein intake is adequate (Vazquez et al. 1982), although glutamate can also increase food palatability irrespective of the taster's nutritional state.

Wanting

An important distinction that is gaining traction in efforts to understand food choices is between *liking* and *wanting* (Havermans 2011). Although it is clear that foods that we want to consume are most often liked, and vice versa, there are times when wanting might be influential independently of whether or not a food is liked. In particular, the idea of wanting involves the central idea of motivation. One obvious example would be that, if we were exceptionally hungry, we might be strongly motivated to eat foods that were unpalatable. Conversely, chocolate is typically consumed in relatively small amounts even though it is consistently rated as many people's most liked food.

Typically, wanting can be shown to be modulated by degree of hunger, and it can be distinguished most easily from liking by determining desire to consume or actual amounts consumed. Recent studies have supported the importance of post-ingestive conditioning in the development of wanting. Thus, repeatedly pairing food flavors with MSG within a soup was shown to increase subsequent ad libitum soup intake, while the taste of a soup previously MSG-paired also increased ratings of hunger, suggesting increased motivation to consume the soup (Yeomans et al. 2008b). Another conditioning study has demonstrated changes in wanting in hungry elderly participants, as reflected in increased intake, in the absence of changes in liking, for novel flavored soups repeatedly paired with added MSG (Dermiki et al. 2015) possibly because the MSG added soups were unpalatably salty.

Preferences Based on Correcting Nutrient Deficiencies

The fact that nutrient conditioning using calories is effective primarily during hunger suggests that specific nutrient deficiencies may also provide opportunities for flavor conditioning to occur. However, the evidence for this comes primarily from animal studies. There is one exception, namely, the human appetite for salt, which far exceeds what is physiologically necessary, suggesting that salt intake in driven by taste. Sodium depletion can be an immediate threat to health and there is ample evidence from humans and other animals that saltiness is both highly palatable and highly sought after in such circumstances (Beauchamp et al. 1990). This effect has also been seen in humans following sodium depletion due to perspiration following vigorous exercise (Wald and Leshem 2003), with greater flavor conditioning for a novel drink being evident in those showing the greatest sodium loss, as reflected in higher levels of perspiration.

Learned Aversions to Flavors

The most dramatic example of post-ingestive learning involving odors or flavors is the development of "taste" aversions that follow pairing of a flavor and subsequent nausea (Garcia et al. 1985), a pairing that can result from incidentally occurring illness, and chemotherapy-induced or motion-induced nausea. Studies on population samples in the USA have suggested that at least 40% of the population will develop a learned aversion to one or more flavors during their life. Such aversions are not merely dislikes but rather a viscerally unpleasant reaction to a food that may have been liked previously. Meats and fish, particularly in a main course meal context, are particularly vulnerable to aversions, while intermediate rates are found for vegetables, desserts, and alcohol, with potatoes, bread, and rice all showing low rates.

This classic form of taste aversion learning seems to be an automatic process that typically occurs following a single nausea plus flavor pairing, and it also tends to be very long-lasting. Being aware that the nausea/illness was produced by, say, a bout of influenza rather than by the consequences of the food associated with that flavor, has no impact on the development of this type of aversion. But humans also experience taste aversions that are essentially cognitive in nature, that is, involving associations between foods and either feelings of disgust or negative information about the food (Batsell and Brown 1998). For some, reactions to certain foods are clearly sufficiently potent to produce an aversion without the food having been consumed or even without direct contact with those foods. In such cases, modeling others' reactions to foods or being emotionally upset by some aspect of a food are involved. Estimated at around 20% of all human aversions, cognitive aversions are thought to be even longer-lasting than traditional, nausea-based aversions. Another major difference between cognitive and nausea-based aversions is that, for most of us, nausea will reliably induce an aversion to a recently experienced flavor. In contrast, a characteristic of cognitively mediated aversions is that the same experience of a food can be disgusting to one person and not to another. For example, aversions have been linked to instances of "moral vegetarianism," in which the idea of killing animals is so unpleasant that the flavor or even odor of meat can become highly unpleasant.

Relative to the numbers of different foods that we eat, taste aversions are rare. The vast majority of foods or meals are not followed by illness, and those with aversions typically have them for a single food. One group that is severely affected by taste aversions is patients undergoing treatment for cancer. Severe nausea is often a consequence of chemotherapy treatments and, as a result, aversions to foods eaten prior to treatment sessions are common, particularly in children. Even in adults, it has been estimated that as many as 50% of those receiving chemotherapy will develop an aversion to one or more foods.

Other sources of learned dislikes have also been reported, and they reflect flavors acting as signals for bodily needs. Regular caffeine consumers repeatedly exposed to a novel non-caffeinated drink when caffeine-deprived develop a dislike for that flavor, although this is not evident when these individuals are not caffeine-deprived (Yeomans et al. 2002). Flavors that have been paired with exercise also become disliked relative a control flavors, an effect that appears unrelated to any discomfort produced by the exercise (Havermans et al. 2009). Instead, this appears to be due, not to gastrointestinal upset, but rather to the net loss of energy (calories) that physical activity produces. It is thought that the body may be seeking to protect itself by avoiding any signals – in this case, flavors – that might predict such energy loss. It is not clear, in either of these cases, whether such effects are commonplace or a major influence on food preferences.

Conclusion: Do Learned Likes and Dislikes Last?

Food preferences can, of course, change, but research on learned likes and dislikes suggests that, once acquired, preferences typically persist in the absence of active intervention. Data for the impact of exposure over time are scarce, but the demonstration that the effects of the addition of a vanilla flavor to infant formula can influence responses to vanilla in foods decades later (Haller et al. 1999) suggests the potential for exposure effects to be effectively permanent. Unlike classically conditioned responses, preferences formed by evaluative conditioning do not appear to extinguish. That is, they does not decrease once the pairing is no longer in place (Baeyens et al. 1988). For example, an odor paired with a sweet taste will become liked, but once this has occurred, further links to the sweetness seem to be unnecessary for the odor preference to be maintained. With coffee, for example, the initial pairing of the flavor with a sweet taste has the effect of producing a permanent liking for the flavor, with or without added sweetness. So, while foods may fall out of favor for various reasons, foods that we have learned to like tend to stay that way, as do those we have learned to dislike, unless there is some strong additional association operating in the other direction. The important caveat is that data for estimating the impact of evaluative conditioning exist only for the short to medium (months) term.

Dislikes formed by taste aversions are notable for their longevity, but there is at least anecdotal evidence that they can be overcome with sufficient motivation and effort. It can be assumed that the effects of post-ingestive conditioning of preferences are also persistent, although one study does suggest that liking can be adversely affected with repeated exposure to a familiar and liked food whose energy content has been reduced (O'Sullivan et al. 2010). Whether this reflects a reversal of post-ingestive conditioning (that is, extinction) or an acquired dislike based on an energy reduction is unclear, and may be of little practical importance, given its implications for the impact of foods formulated for energy reduction diets.

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Normal Eating

11

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Contents

Abstract

We present a theory of normal eating, based on three fundamental elements: hunger, palatability, and norms of appropriateness. These three elements can account for food intake and choice, although not all three elements are equally important and they vary in terms of their importance in different situations. We suggest that various factors that are regarded as influential in food intake and choice (e.g., dieting, emotional arousal) may be understood in terms of our three basic elements.

In this chapter, we present a theory of normal eating. There has been surprisingly little formal or theoretical attention paid to normal eating, perhaps because researchers (and people in general) assume that everyone already knows what normal eating is and how it works. A "negative" approach to the understanding of normal eating is evident in discussions of eating disorders, which are often seen as pathologies of normal eating but without specifying what normal eating

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is other than the default condition from which the pathologies deviate (Herman and Polivy 1996). Researchers and people in general – when asked to explain why people (and they themselves) eat the way they do, why they choose (or reject) particular foods to eat, and why they eat as much (or as little) as they do on a given occasion – tend to fall back on two explanations, hunger and palatability (Vartanian et al. 2008). These explanations are taken for granted and rarely explored, because they are assumed to be self-evident. When given a choice of foods to eat, people (believe that they) choose the foods that they find most palatable. If given a choice among equally palatable foods, people may explain their choice in terms of hunger: a hungry person will often select the food that is higher in calories or at least perceived to be more satiating. In the absence of choice of food, people will typically explain why they ate a lot of the available food by claiming that they were particularly hungry or that the food was particularly palatable. Reduced intake is conversely attributed to low palatability or an absence of hunger (Vartanian et al. 2017).

We have recently outlined a theory of normal eating (Herman 2013; Herman et al. in press) in an attempt to provide a positive and comprehensive analysis of why people eat the way they do. This theory is not derived from the absence of disordered eating. It likewise does not assume that "everyone" already knows what normal eating is. Rather, it starts with the basic elements of normal eating and describes how they are related to each other and how they operate in particular eating situations. This theory is not self-evident. We hope to draw attention to aspects of eating that are generally taken for granted or overlooked altogether.

Normal Eating

We propose that there are three principal factors that govern normal eating: hunger, palatability, and norms of appropriateness. These three factors all have an impact on normal eating, but they are not equally powerful. Once we have described these three factors, we shall elaborate on them by postulating how they operate conjointly. For the record, we define normal eating as how people in modern societies eat when there is sufficient, culturally acceptable, and at least minimally palatable food. We acknowledge that many people in the world do not have the luxury of engaging in normal eating.

Hunger

Hunger is experienced subjectively as a desire to eat, sometimes with accompanying symptoms such as stomach pangs or light-headedness. This desire presumably reflects an underlying biological need for food. The intimate connection between the need for food and the desire, pursuit, and consumption of food is thought to reflect the "wisdom of the body," (Cannon 1932) which has evolved to detect an energy deficit and to remedy that deficit. Historically, most research on hunger and eating has been conducted on animals who cannot report on their internal states – not that humans are particularly adept at reporting on their internal states. In the case of rats, for instance, researchers have tended to beg the question of the connection between hunger and eating: if the rat eats, it is assumed to be hungry. Correspondingly, if it doesn't eat, or stops eating, the rat is assumed to be not hungry, or sated. This tautological connection between hunger and eating quickly falls apart upon inspection. First, we can all think of times when we were hungry and nevertheless did not eat. This disconnect between hunger and eating may arise because, even though the individual feels hungry, the available food is unpalatable or perhaps the individual is on a diet or perhaps no one else in the group is eating and so the individual feels awkward giving in to her hunger or perhaps the individual is so focused on some event or activity that she doesn't attend to her hunger sensations. By the same token, there are situations in which people continue to eat despite feeling sated – perhaps because the food is simply irresistible or because of social pressure to eat.

Hunger as perceived or reported at the beginning of an eating episode is often not a good predictor of how much food will be consumed (see ▶ Chap. 6, "Food Intake and Physiological Regulation: The Means and the End" by Bellisle in this volume). If hunger or food deprivation is the only variable involved, then there is a reasonable correspondence between hunger/deprivation and intake (Kissileff and Thornton 1982), although Le Magnen (1971) suggests that hunger may be more evident in terms of latency to eat than in terms of amount eaten. Moreover, hunger/deprivation is rarely the only factor involved, and the effect of hunger on food intake is often overridden by other factors (in particular, palatability and norms of appropriateness), with the result that more often than not hunger/deprivation is ultimately only weakly reflected in the actual amount of food consumed.

Weingarten (1985) distinguishes between depletion-based hunger, which is how we normally think about hunger, and externally controlled hunger. He has demonstrated that rats will act as if they are hungry, eating additional food, if they encounter a stimulus (e.g., a visual or auditory cue) that has previously been paired with eating. Thus, you can make a sated rat start to eat even more if you provide an "eating cue." This situation certainly forces us to reconsider whether hunger as traditionally understood – arising from a true nutritional deficit – is always present when people (or rats) eat. Another example of eating that does not reflect hunger as we traditionally understand it is temporally conditioned hunger. We tend to become hungry as mealtime approaches. Of course, this could simply be equivalent to saying that we tend to become hungry as more time goes by since we last ate; in that case, the traditional depletion/repletion view of hunger would apply. But if for some reason – something comes up – you fail to eat at your normal mealtime, you may well find that your hunger, instead of continuing to grow, abates. Note also that "hunger is not at its daily peak upon awakening" (Mattes 2010, p. 24), even though the interval since the last meal is generally longer than just before lunch or dinner. And despite the lengthy interval since the last meal, breakfast is typically not the largest meal of the day. This phenomenon certainly defies the depletion view of hunger; it suggests instead that mealtime itself acts as an "eating cue," much like Weingarten's visual or auditory stimuli, and that once the cue is no longer there, cue-based hunger subsides.

There is some debate about whether most of us ever experience "true" hunger. Rogers and Brunstrom (2016) argue that whatever caloric deficits we experience over the course of hours or even days are insignificant compared to our basic energy stores. "Energy requirements meal-to-meal are trivial compared with total body energy stores, and energy supply to the body's tissues is maintained if a meal or even several meals are missed" (p. 465). It may be that only when we are truly deprived of food for days on end will we experience genuine hunger of the sort that drives the frantic food intake of starving people, food intake that proceeds irrespective of the palatability of the food and the behavior of other people. (Needless to say, it is virtually impossible to study such extreme food deprivation in the laboratory.) In any case, it is evident that hunger is not a simple matter and that we may need to develop a vocabulary that distinguishes between "true" hunger and the sort of everyday hunger that we experience most of the time. How everyday hunger drives eating remains a matter of debate. For now, suffice it to say that it may not be as unambiguously important a driver of eating as is usually assumed.

Palatability

Like hunger, palatability is generally acknowledged as a principal factor governing eating. Palatability refers to the extent to which the eater enjoys the sensory properties of the food. Palatability is often considered to be equivalent to taste, but it is a broader construct and also includes aspects of food enjoyment such as texture, temperature, and appearance. As with hunger, researchers often beg the question of how palatability affects food intake, especially when studying animals who cannot provide us with independent measures of those two constructs. If a rat eats a lot of a particular food, it is assumed that the rat finds it palatable. If it rejects the food, we may be tempted to infer that the food is unpalatable. Of course, in making these inferences, we often forget that we are prepared to make parallel inferences about hunger; so if a rat rejects a particular food, is it because the food is unpalatable or because the rat simply isn't hungry? It is possible to devise studies that separate these two influences on eating, but we are often careless about distinguishing them in real life. Thus, when we ask people why they ate so much, they are likely to cite hunger and/or palatability, more or less indiscriminately.

Palatability is more obviously in play when we present a rat or a human with two different foods and assess which one is chosen. In such a study, hunger (or at least food deprivation) can be held constant, allowing us to ascribe higher palatability to the more frequently chosen food. There are two qualifications here, however. First, we all acknowledge that one man's meat is another man's poison, so judgments of palatability are to a large extent idiosyncratic. Even though we can combine judgments over several raters to document that chocolate is generally more palatable than is broccoli, their relative palatability may be reversed for a handful of individuals, particularly if we are talking about humans. Also, we must acknowledge that the choice of chocolate versus broccoli may be driven by considerations other than palatability. Some people will select the broccoli, even though they prefer the taste and other properties of the chocolate; considerations of health or social appropriateness will sometimes lead people to select the less palatable option. For example, Sullivan et al. (2019) found that when presented with a choice between a food item that was tasty but not healthful versus an item that was healthful but not tasty, 78% of their sample chose the tasty-but-not-healthful item, but 22% chose the healthful-but-not-tasty item. The same considerations may lead people to behave "perversely" in terms of amount eaten, with health or appropriateness considerations leading them to eat less of their preferred food and more of their non-preferred food.

Just as hunger declines over the course of a meal, so does palatability. Rolls (2000) has studied "sensory-specific satiety," the phenomenon whereby an initially palatable food becomes less palatable over the course of the meal. This decline in palatability arises from repeated exposure to the same taste (and to some extent other sensory properties such as texture). This reduction in palatability acts as a brake on eating, whence it is referred to as "satiety," although it is acknowledged that the satiety here is largely metaphorical. The fact that true satiety has not developed is evident when the individual is offered food that differs dramatically in its sensory properties from the original food (Pliner et al. 1980). This "variety" induces a resumption of eating, which presumably would not occur if true satiety had been achieved.

We refer to the decline in the palatability of a particular food over the course of a meal as sensory-specific satiety. There is a similar decline in palatability when the same food is served repeatedly, meal after meal. This effect is referred to as monotony and can be reversed by providing distinctly different foods (see Remick et al. 2009 for a review).

People often cite palatability when explaining why they ate as much or as little as they did (Vartanian et al. 2017). We concur that palatability is an important driver of food intake and food choice. In the research literature, however, palatability is often neglected as a principal factor governing food intake for the simple reason that research participants are usually offered palatable food to eat. The role of palatability in food intake becomes evident only when it is manipulated over a large range of values; we can then observe that people eat more palatable food than unpalatable food. If palatability is held constant at a high level, as it often is in research studies, its importance in controlling eating will be masked (Pliner et al. 1990).

Norms of Appropriateness

The last – but by no means the least – driver of food intake and choice is norms of appropriateness. Norms of appropriateness are rarely cited by researchers or eaters themselves as important in the regulation of eating, but we maintain that they are very important, at least in humans. "Norms of appropriateness" refer to people's concerns about eating in a manner that is socially approved. People are social creatures, and they are sensitive to the judgments of others. They want to be seen as – and see themselves as – eating appropriately. When it comes to food choice, there are widely shared cultural norms about which foods are suitable for consumption, and people tend to feel some pressure to eat suitable foods. This pressure is strongest when the individual is eating in a group and everyone else has chosen to eat the "appropriate" food and to reject the "inappropriate" food. It takes a strong individual – someone who doesn't care what others think – to order a rich dessert for himself when everyone else at the table is ordering something "healthy" or not ordering dessert at all.

Insofar as culture affects eating, then, we suggest that it does so through the inculcation of norms of appropriateness. Cultural variations in eating – the particular foods that are eaten, how food is eaten, how much is eaten, and so on – are evident in the variations in norms of appropriateness from one culture (or subculture) to another.

Norms of appropriateness apply to food intake as well as to food choice. For instance, one powerful norm in our culture involves people's fear of being seen as having eaten excessively. People who eat excessively are judged negatively; they are viewed as less attractive, less intelligent, less moral, and generally less worthy as individuals (see Vartanian et al. 2007, for a review). Women who eat excessively are seen as less feminine (Chaiken and Pliner 1987). The only positive trait associated with excessive eating is "fun-loving."

Avoiding the imputation of eating excessively is thus an important consideration affecting how much people eat. The problem for the eater, however, is to figure out how much she can eat without eating excessively. Unless she is on a diet that specifies food intake for each eating occasion – and most people aren't on such a diet – it's not intuitively obvious how much one can "safely" eat. What happens is that people eating with co-eaters learn to observe the co-eaters' intake; and they use that intake as a measure of what is "allowed." If you eat no more than your co-eaters do, then you may avoid the imputation of eating excessively (Herman and Polivy 2008). Note the opportunity here for collusion by the group eaters, who may explicitly or tacitly agree to eat more food than they would normally eat. If they all go along, "permissible" food intake increases, with everyone enjoying the splurge. There are some complications in the group scenario, as when your co-eaters eat varying amounts, muddying the line beyond which eating becomes excessive; but these complications can generally be handled by our theory of normal eating – or at least studied.

It is worth noting that social norms are typically internalized, which means that the individual may be governed by these norms even when eating alone (Feeney et al. 2017). Thus, people judge themselves and are concerned to avoid eating excessively even when they are eating alone. In one research paradigm – what we call the "remote confederate" paradigm – the research participant eats alone but is provided with information about how much others have previously eaten in the same situation. This information is concocted by the researcher; there are no other “prior participants.” Participants are powerfully affected by this information (e.g., Feeney et al. 2011; Roth et al. 2001), even though there is no chance that these other people will be judging them. Of course, in this situation, as in most studies of food intake, research participants are led to believe that the researchers are not judging – or even measuring – their food intake.

The concern to avoid eating excessively represents only one social norm, albeit a norm that pervades the domain of food intake. Other norms that we might mention include:

- Politeness/consideration, as when we feel compelled to eat *more* than we might otherwise be inclined to and to eat foods that we might otherwise avoid, when we find ourselves in a situation in which our host enjoins us to “have another helping” or serves us something that we do not like. A variation on this normative pressure was documented by Exline et al. (2012), who found that at least some people eat more than they otherwise would simply in order to make their large-intake eating companions feel more comfortable.
- Regulatory balance, as when we believe that we ought to eat less if we have recently eaten a lot. Thus, if we mislead research participants into believing that what they recently ate was highly caloric, they will eat less in a subsequent eating situation (Wooley 1972). A variation on this theme is provided by Higgs (2008), who has demonstrated that if people are asked to recall their lunch today, they will eat less in a mid-afternoon snack than if they are not asked to recall their lunch today or are asked to recall their lunch yesterday.
- Portion size (see ▶ Chap. 34, “The Influence of Portion Size on Eating and Drinking” by Rolls, this Handbook). People eat more when served larger portions, and there is accumulating evidence that this effect is driven by the fact that people who are served larger portions consider larger portions to be “appropriate” (Herman et al. 2015; Robinson and Kersbergen 2018). This conclusion is reinforced by recent evidence that rats do not eat more when portion size is increased, suggesting that the effect in humans is mediated by higher cognitive processes (Naneix et al. 2019).
- Segmentation effects. People eat more when presented with one large item of food than when the same item is subdivided into segments. Kerameas et al. (2015) demonstrated that this effect is mediated by changes in the perceived appropriateness of eating a single larger (unsegmented) item versus several small (segmented) items.

Drivers and Inhibitors

We have identified hunger, palatability, and norms of appropriateness as elements governing food intake and choice. It should go without saying that these factors do not operate unopposed. Indeed, our description of norms of appropriateness has already included several examples of norms that inhibit eating: concern about eating excessively is basically an inhibitory factor, setting an upper limit on how much one may eat without making a negative impression on observers and even on oneself. Some norms of appropriateness may increase the likelihood of selecting a particular food (see ▶ Chap. 14, "Social Influences on Eating" by Higgs and Ruddock's in this volume) or the likelihood of eating more than one normally would (e.g., the politeness norm mentioned above), but norms of appropriateness more often act as inhibitors of eating; they allow a certain intake but no more. Hunger, of course, normally drives eating and has an "opposite," satiety, which terminates eating. Technically, satiety is not quite the opposite of hunger, either in terms of its basic nature or its parameters. For instance, hunger arises much more slowly as a function of time spent continuously not eating than satiety does as a function of time spent continuously eating. Still, for our purposes, we may say that whereas hunger promotes eating, satiety inhibits eating. Palatability, likewise, has its opposite. Unpalatable food suppresses eating. In research studies, the food is typically palatable, but occasionally researchers will explore the effects of unpalatable food (see Pliner et al. 1990, for a review). Of course, there is a continuum of palatability, ranging from highly palatable to highly unpalatable, and we all acknowledge that the palatability of a particular food may vary from individual to individual.

Relative Weight of the Three Factors

Of the three main drivers of eating, hunger is the weakest. This assertion is based not on people's reports – recall that people tend to identify hunger and palatability as the principal reasons for eating as much as they do – but on a more careful examination of the research literature. We ourselves, making the same assumptions that most people (and researchers) do, were relatively slow in coming to the realization that hunger is a weak influence. Several years ago, for instance, we outlined a "boundary model for the regulation of eating" (Herman and Polivy 1984). This model proposed that eaters, at any given moment, were either hungry, sated, or in a "zone of biological indifference," neither hungry nor sated. When in this zone of indifference, we argued, people's food intake is affected by all sorts of factors, including palatability and what we would now call norms of appropriateness. Moreover, we argued that most of us spend most of our time within that zone of indifference, so that our eating is affected by factors other than hunger/satiety. If, however, we allow ourselves to drift into a state of hunger (by eating too little or too late) or satiety (by eating too much or too soon), then these powerful biological conditions would take over and either (in the case of hunger) drive eating regardless of palatability or norms of appropriateness or (in the case of satiety) suppress further eating regardless of palatability or norms of appropriateness.

We conducted (and replicated) a study designed to demonstrate that sufficiently hungry people would eat even if the food is unpalatable (Kauffman et al. 1995). That prediction followed from our commonsense boundary model and had been articulated earlier by Jacobs and Sharma (1969). In the Kauffman et al. study, participants were deprived of food for up to 24 h and then given access to either a good-tasting milkshake or to a bad-tasting milkshake (the same milkshake but adulterated with bitter quinine). Across two versions of the study, hungry participants ate more of the good-tasting milkshake than did non-hungry participants, as expected; but contrary to common sense and contrary to our boundary model, hungry participants ate *less* of the bad-tasting milkshakes than did non-hungry participants. Jacobs and Sharma, who found the same thing in dogs, suggested that this "paradoxical" effect of hunger on intake of bad-tasting food may stem from bad-tasting food being potentially toxic and thus being particularly dangerous to those eating on an empty stomach. (Note that this effect does not require conscious awareness; people and dogs have evolved to reject bad-tasting food when they are hungry.) In any case, it is evident that when we examine the effect of hunger conjointly with the effect of palatability, the effect of palatability on intake dramatically overrides the effect of hunger. It is worth noting that in our study, people were food-deprived for 24 h, which is considerable but by no means comparable to what some people have endured under conditions of extreme starvation. We concede that truly starving people might be more enthusiastic about eating bad-tasting food, but 24 h worth of hunger is apparently not enough to increase intake of bad-tasting food in people who are otherwise not undernourished. In other words, hunger is not as powerful as is palatability in normal people.

Another set of two studies (Goldman et al. 1991) examined food intake in hungry and non-hungry people. In these studies, we did not manipulate the taste of the food; rather, we manipulated the food intake of an experimental confederate who ate alongside the naïve participant. The boundary model and common sense both predicted that the (large versus small) intake of the confederate would have an effect on the intake of the naïve participant, but if the naïve participant was hungry – again, up to 24 h without eating – then she ought to eat enthusiastically even if the confederate ate sparingly. What we found, however, was that the confederate's intake strongly influenced the naïve participant's intake, irrespective of the naïve participant's hunger level. A very hungry person eating with someone who eats sparingly will herself eat sparingly. Indeed, the impact of the confederate's intake was so strong that hunger/deprivation had virtually no impact whatsoever on intake. These studies demonstrate that norms of appropriateness – in this case, the example set by a confederate eating a lot or a little – powerfully influenced food intake, whereas up to 24 h of food deprivation had virtually no impact on eating. Again, hunger is not as powerful as are norms appropriateness in normal people.

These studies provide convincing evidence that hunger is not a powerful driver of normal eating, certainly not when compared directly to the influence of palatability or norms of appropriateness. We concur with Mattes (2010, p. 30), who concludes that "hunger and thirst are only weak predictors of energy and fluid intake, respectively." (See also Mattes 1990, who found at best very weak associations between hunger reports and intake occurrences and amounts in free-living humans.)

If palatability and norms of appropriateness are both more powerful than is hunger in the acute control of eating, we might now ask which of these two powerful factors is *more* powerful. At this point, we are reluctant to pursue this question, because it is probably unanswerable. Palatability drives eating in a direct fashion – the more palatable food, the greater the intake – but norms of appropriateness do not drive eating in the same way. Occasionally a norm of appropriateness requires that we eat more than we otherwise might; the politeness/consideration norm cited above would be an example. Most of the time, however, norms of appropriateness do not drive intake so much as *permit* it. An experimental confederate's intake indicates an upper limit of intake beyond which one may not proceed; but there is no requirement that the limit be reached. Indeed, in most experiments involving large-eating confederates, the intake of the naïve participants increases above control levels but does not come close to matching the inflated intake of the confederates. In other words, whereas highly palatable food directly promotes increased intake, high-intake norms only *allow* increased intake; they do not drive it in the same way. Thus, palatability and norms of appropriateness are incommensurate. They both override hunger, but we cannot regard one as more powerful than the other. Highly unpalatable food will suppress eating even if confederates eat a lot of it (Pliner and Mann 2004), and confederates who eat minimally will suppress intake even if the food is highly palatable, as we saw in the Goldman et al. (1991) study.

A Dynamic Theory of Normal Eating

Having provided a rough weighting of the three factors driving eating (with hunger relatively weak compared to palatability and norms of appropriateness), we may now turn our attention to how these factors combine dynamically to control eating. In our review of the effects of social factors on eating (Herman et al. 2003), we postulated that "in the presence of palatable food, and in the absence of inhibitory forces. . ., people continue to eat indefinitely." This deceptively simple formulation includes just about everything required to account for food choice and food intake.

Food choice is the simpler case, with palatability accounting for most decisions. Some inhibitory factors – say, a concern about how observers (or you yourself) might judge your choice of a highly palatable but unhealthy food – may interfere with food choices based entirely on palatability; but by and large, people tend to select the food that has sensory appeal for them. (Of course, in the real world, factors such as cost and convenience may affect food choice, but these factors are rarely studied in the lab.) Pliner and Mann (2004) found that people tend to disregard the example of others when those others select a disliked food. We may imagine an obverse case, in which the individual is confronted with a relatively unpalatable food (which she normally would not be eager to eat) but experiences pressures to eat it nevertheless. Considerations of politeness or health may drive food selection. For example, Girz et al. (2012) found that in the absence of caloric information about menu items, people concerned about their weight chose the "healthy" salad option rather than the (more palatable) pasta option. When they were told – correctly, as it happens – that the salad and the pasta were equally caloric, however, people shifted their choice to the pasta. So here we have an instance of "the presence of norms of appropriateness that promote the choice of an unpalatable food," which may then be overcome by information suggesting that the less palatable food is not actually more calorically appropriate.

When it comes to food intake, palatability is again crucial, in the sense that it is a precondition for further eating. If the food tastes bad, people won't eat (much of) it. Most of the time, however, both in the lab and in the real world, people have at least reasonably palatable food available to them. What is crucial to note here is that our formulation requires the presence of (reasonably) palatable food, but it does not require the presence of hunger. We thus acknowledge what has become increasingly evident recently – namely, that many of us eat in the absence of hunger. The mere presence of attractive food appears to be enough to drive eating. As Fay et al. (2015, p. 156) put it, "increased frequency of eating in the absence of homeostatic need, notably through snacking, is an important contributor to overconsumption and may be facilitated by increased availability of palatable food in the obesogenic environment."

Our dynamic theory suggests that palatability alone will drive intake and drive it indefinitely. People do not eat indefinitely, though, so we must now turn our attention to the "inhibitory factors" that terminate eating, sooner or later. The most obvious terminator of eating is satiety. Even though satiety often lags intake – it can take 20 min or more for inhibitory feedback from ingestion to trigger feelings of satiety (Booth et al. 1970), and so people often eat more than they wish they had – eventually satiety registers, and the eater will stop. (Our theory, then, weighs satiety as a "stop" signal more heavily than hunger as a "start" signal.)

Although satiety is the ultimate backstop, intake often ceases well before satiety occurs. Other inhibitory forces often come into play earlier. We have already discussed sensory-specific satiety, the metaphorical satiety that we experience when our meal is dominated by a single food or flavor. We may think of sensory-specific satiety as a preemptive form of satiety or, alternatively, as a decline in palatability; in either case, it stops food intake before true satiety occurs. This is one instance of an inhibitory force.

One prevalent reason for stopping eating is when we run out of food, as happens, for instance, when we have cleaned our plate. In the lab, researchers usually try to ensure that there is more food available that can be eaten. In any case, if all the food is gone, then the eater is no longer "in the presence of palatable food," and so the basic precondition for eating is no longer satisfied.

Other forces that inhibit eating may be found among the many norms of appropriateness that govern eating, many of which reflect the appropriateness of eating moderately or even sparingly, usually with the goal of making a positive impression on our co-eaters, on observers who are not eating alongside us, or even just on ourselves.

Elements of the situation that convey norms of appropriateness almost always establish an upper limit of food intake beyond which we dare not go. Even when the situation appears at first glance to encourage eating, it nevertheless entails a maximum permissible amount. Thus, large portions encourage more eating than do small portions, but even the large portion must not be exceeded. Research participants eat more when they eat with experimental confederates who eat a lot than when they eat with confederates who eat only a little; but even when the research participants eat a lot, they do not eat more than the large-eating confederates (Vartanian et al. 2015).

We are aware of only one study in which the amount eaten by large-eating confederates did not establish an upper limit for naïve research participants (Leone et al. 2007); and in that case, we argued, the ambiguity in the conflicting amounts eaten by the various confederates prevented the naïve eaters from perceiving a clear upper limit on intake. In our previous list of norms of appropriateness, we included politeness/consideration as a norm that could lead people to eat more than they might otherwise be inclined to. Obviously, we cannot argue that eating more as a way of complimenting the host or making a large-eating companion feel better is an inhibitory factor, but we do suggest that these examples of eating more than one really wants to are exceptional. Moreover, concern-about-excessive-eating norms of appropriateness ensure that our politeness and consideration for others do not lead to any more eating than is absolutely necessary to discharge these social obligations and may even dictate eating less than we would prefer, so as to leave enough for others to eat.

Extensions and Distortions of Normal Eating

Now that we have established the basic drivers (and inhibitors) of eating, we are in a position to enquire about problematic eating.

Obesity: Normal eating is not necessarily optimal eating. Consider the obesity epidemic. While we cannot say with certainty what is responsible for the epidemic (see Herman 2018; Keith et al. 2006; and McAllister et al. 2009), it is easy to see how normal eating processes might lead to overeating.

Consider palatability. Nisbett (1968) served ice cream varying in palatability – using the same quinine adulteration that Kauffman et al. (1995) later employed – to normal-weight, overweight, and underweight people. As palatability increased, people ate more of the ice cream, but the precise pattern for the different groups showed an interesting anomaly. Whereas normal-weight and underweight people ate more ice cream as a continuous function of increasing palatability, the overweight people showed what Nisbett called a "step function": once the palatability level rose above neutral, the overweight people ate a lot of it; and further increases in palatability made no difference. This finding suggests that obese people do not discriminate between decent-tasting food and highly palatable food; alternatively, it suggests that people who do not discriminate between decent-tasting food and highly palatable food are prone to becoming obese. This is a simple example of how an anomaly in the domain of palatability might produce overeating and weight gain.

Overeating may arise from "inappropriate settings" in norms of appropriateness. We have already discussed how the intake of your eating companions can influence your own eating; so if you regularly eat with people who eat a lot, odds are that you will end up eating a lot as well. In fact, simply eating with other people seems to lead to greater eating. There is a sizable literature documenting the social facilitation of eating (Herman 2015): people eat more when they eat with others than when they eat alone. One interesting explanation for this effect is that, when people eat in groups, they arrange for more food (per capita) to be available; in effect, groups arrange for larger portions. More generally, if we are constantly served (or serve ourselves) large portions, it stands to reason that we will end up overeating. These examples of “inappropriate norms of appropriateness” have not yet been shown conclusively to lead to overeating (Herman 2018; Herman et al. 2016), but the notion is tantalizing.

Dieting or restrained eating: Restrained eaters (dieters; ▶ Chap. 59, “Dieting and Overeating” by van Strien in this volume) are committed to suppressing their food intake, owing to their conviction that it is desirable and appropriate to eat less than hunger and palatability considerations would otherwise demand. Indeed, restrained eaters struggle to overcome the hunger produced by whatever success they have in suppressing their intake; and they struggle to overcome the pervasive lure of palatable food, which is often high in calories and which may become even more alluring as one’s weight decreases and/or as one expends more energy avoiding such desirable foods (i.e., psychological deprivation).

Polivy and Herman (1987) note that restrained eaters comprise a large proportion of some populations, including females in Western societies. Indeed, one could argue that in many subpopulations, restrained eaters are in the majority, and so we might consider dieters to be normal eaters, at least statistically. Polivy and Herman invoke our boundary model (Herman and Polivy 1984) to explain how dieters differ from nondieters. Specifically, dieters have a “diet boundary” that sets an upper limit on their permissible intake and that is reached well before satiety. Thus, dieters will often eat less than will nondieters; and yet, they often eat more. This breakdown of dietary restraint may be explained in terms of the elimination of the diet boundary. This may happen in situations in which the dieter breaks her diet by eating more than the diet allows; once the diet boundary has been breached, there is nothing to stop additional eating until the satiety boundary is reached. (Herman and Polivy argue that the satiety boundary is displaced for dieters, so that dieters experience satiety later – after more food is consumed – than do nondieters.) Another scenario in which the diet boundary becomes inoperative is when it is temporarily abandoned altogether in favor of more urgent priorities; for instance, when the dieter becomes emotionally agitated, she may abandon her diet, at least temporarily. This analysis allows us to interpret the behavior of dieters as “normal,” both in the sense that it is statistically prevalent and also in the sense that it is responsive to the sort of controls or boundary pressures that regulate eating in (almost) everyone, the only difference being the presence of a “diet boundary” that reflects the dieter’s commitment to eating less, a commitment that is vulnerable to being overridden.

Thus, problematic eating may arise both when the normal controls on eating are “broken” and when the normal controls are intact but set at levels that conduce to overeating and/or choosing unhealthy foods. Normal controls may also be set at levels that conduce to undereating. Most analyses of the classic eating disorders (i.e., anorexia nervosa, bulimia nervosa, binge eating disorder) depict these disorders as stemming from true pathologies of hunger, satiety, emotion, and body image. Our theory of normal eating does not specifically pertain to these eating disorders, but it is interesting to speculate as to how these recognized eating disorders might arise not because of pathology but through extensions of normal eating mechanisms. Crandall (1988), for instance, discusses how binge eating can spread through a sorority through the enforcement of social norms. Websites promoting certain eating disorders may serve to normalize these pathologies (Norris et al. 2006). In short, certain forms of abnormal eating may just be extensions of normal eating, making it all the more important for us to understand normal eating and how it operates.

Emotional eating: It is a common belief that eating is driven by emotions; and indeed, emotional arousal can both promote and suppress food intake and certain food choices (e.g., Macht 2008). Bruch (1973) speculated about the possibility that some people confuse other internal or emotional states with hunger, with resultant overeating. At the same time, clinical depression has been associated with both weight loss and weight gain (Polivy and Herman 1976). We concur that emotional arousal affects food intake and choice. We propose, however, that the effect of emotional states on eating is not direct but rather is mediated by the effects of emotional states on the basic factors that control eating. Thus, insofar as emotional arousal suppresses food intake, it may do so by inducing satiety, as Schachter et al. (1968) argued, citing Cannon (1915). Insofar as emotional arousal increases food intake, it may do so by altering (or removing) inhibitory norms that typically keep food intake in check (Polivy and Herman 1999). In short, we do not deny that emotional eating can have a strong effect, but we suggest that this effect is best understood in terms of our basic theory of normal eating. Indeed, we suggest that virtually every aspect of eating can be best understood in terms of our theory of normal eating, whose relative simplicity offers a concise approach to what has heretofore been an unduly complicated analytic enterprise.

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Measuring Liking for Food and Drink

12

Gastón Ares and Leticia Vidal

Contents

Abstract

The hedonic component of food reward is the result of an integrative process where the sensory and perceptual information about the food or drink is combined with a range of factors unrelated to the product itself, such as the individual's physiological status, personal experiences, culture and context. This perceptual and evaluative component of reward has been regarded as a key predictor of food consumption. Hedonic measures obtained in response to food and drink products have great importance in sensory and consumer science and are used to inform decision making in the food industry. In this context, the aim of the present chapter is to review methodological approaches to measure liking for food and drink. The most popular direct and indirect (i.e., implicit) methods are presented.

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Advantages and disadvantages of the methods are discussed from a critical perspective and recommendations for practitioners are provided.

Introduction

The reward system of the human brain has been hypothesized to evolve to promote engagement in behaviors that can be beneficial and to discourage potentially dangerous behaviors (Blaukopf and DiGirolamo 2007). Considering that eating sufficient and varied food is essential for our survival, it is not unexpected that food intake is regulated by both the homeostatic and the reward systems (Lutter and Nestler 2009). The rewarding nature of food consumption has been associated with eating foods that may be beneficial for survival and avoidance of potentially dangerous foods (Saper et al. 2002). Although the reward system was highly important for survival in an environment characterized by food scarcity, in the context of a food environment characterized by the wide availability of calorie-dense food, it is being increasingly recognized as a key determinant of the growing prevalence of overweight and obesity (Berthoud 2011). In this sense, recent research has shown that the brain's reward system can lead to excessive food intake, even in the presence of satiety signals (Berthoud and Morrison 2008).

Reward has three interrelated psychological components: (i) learning, (ii) liking, and (iii) wanting (Berridge and Robinson 2003). Learning refers to knowledge about the relationships between stimuli and actions, which is necessary for making anticipatory responses and for goal-directed action (Dayan and Balleine 2002). Liking is basically the hedonic component of reward, i.e., the degree of pleasure or displeasure associated with a stimulus or a behavior. In the context of food and drink, liking has been conceptualized as the pleasantness of eating, the immediate qualitative, affective evaluation of food and drink, or the pleasantness of the food or drink in the mouth (Mela 2006). Finally, wanting is the motivation to perform a behavior or the conscious desire to translate affect into action (Berridge 2009). According to Berridge and Robinson (2003), wanting may be a separate psychological component from "liking" to facilitate comparison and choice among competing rewards.

The hedonic component of food reward is the result of an integrative process where the sensory and perceptual information about the food or drink is combined with a range of factors unrelated to the product itself, such as the individual's physiological status, personal experiences, culture and context (Cardello 1996). This perceptual and evaluative component of reward has been regarded as a key predictor of food consumption (Tuorila 2007). Hedonic measures obtained in response to food and drink products have great importance in different fields related to food and eating behavior and are used to inform decision making in the food industry (Cardello and Jaeger 2007).

The aim of the present chapter is to review methodological approaches to measure liking for food and drink and to discuss their advantages and disadvantages from a critical perspective.

Methodological Approaches to Measure Liking

Liking for food and drink is a psychological process with neural mechanisms that has objective markers in the brain as well as accompanying cognitive experiences (Berridge 2009). This affective process can be represented on multiple conscious and unconscious levels (Winkielman and Berridge 2003). The processes underlying liking can produce conscious pleasure but can also occur without it (Berridge and Robinson 1998).

Liking measurements have mainly focused on the conscious or cognitive aspect of the hedonic experience (Cardello 1996). For this reason, self-reports are the most popular methodological approach for measuring liking for food and drink (Tuorila 2007). They basically require respondents to indicate their personal impression of how much they like a target food or drink. However, this cognitive representation of pleasure may not be a faithful reproduction of the underlying affective processes (Berridge 1996). Thus, methods that do not require people to report their conscious experience have been developed and are being increasingly used (Pool et al. 2016).

Hedonic Scaling

Most methodological approaches to measure liking for food and drink derive from the developments of psychophysics to assess the intensity of sensory experiences (Berlyne 1973). The most common approaches rely on the evaluation of the magnitude of liking and/or disliking using hedonic scales (Lim 2011). In the following sections, the most popular scales for measuring liking are described and their theoretical and practical differences discussed.

9-Point Hedonic Scales and Its Variants

The 9-point hedonic scale is the most popular methodological approach to measure food liking. This scale was developed between the late 1940s and the 1950s at the Quartermaster Food and Container Institute for the Armed Forces, in the United States (Peryam and Girardot 1952; Peryam and Pilgrim 1957), motivated by the need for a tool to measure the hedonic response of soldiers to various food items. Early research compared different scale lengths, wording, and presentation formats, leading to the present form of the scale, which is shown in Fig. 1a (Lawless and Heymann 2010; Lim 2011).

The 9-point hedonic scale is a labeled category scale, composed of nine phrases which are intended to cover a continuum of likes and dislikes. It is arranged as a balanced bipolar scale, with four positive (like) and four negative (dislike) categories around the neutral "neither like nor dislike." The use of the scale is simple as participants are only asked to select one of the nine categories according to their degree of liking of the focal sample. In most applications, samples are served one at a time, and a response is required after the evaluation of each sample (Lawless and Heymann 2010).

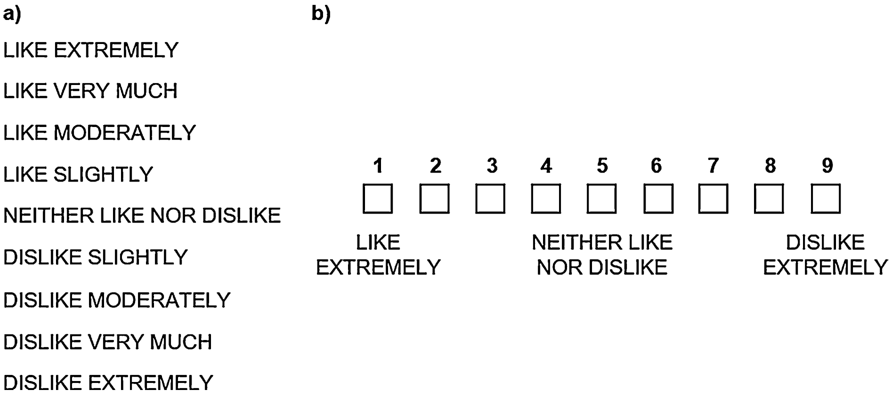

Fig. 1 Example of 9-point hedonic scales: (**a**) original version developed by Peryam and Girardot (1952), (**b**) alternative format

Although in theory data collected using the 9-point hedonic scale (as well as with any category scale) are ordinal, it is common practice to assign the numbers 1 to 9 to the categories, with 1 being "dislike extremely" and 9 being "like extremely," and to treat the responses as points in a continuum (Lim 2011). Thus, mean ratings are usually calculated, and parametrical statistics, such as t-test or analysis of variance (ANOVA), are used to evaluate product differences in liking. This practice is usually justified by the robustness of techniques such as ANOVA, and the fact that affective consumer tests involve large sample sizes, which allow to obtain meaningful results even though discrete data are being analyzed as if it were continuous (Schutz and Cardello 2001; Lawless and Heymann 2010).

After its development, the 9-point hedonic scale was rapidly accepted internationally by both industry and academia. Alternative presentations to the original format of the scale have been used, with the categories arranged either vertically or horizontally, using simple check-boxes with anchors in the extremes and sometimes in the neutral point, and with or without integer numbers in each category (Fig. 1b; Lawless and Heymann 2010; Yao et al. 2003; Wichchukit and O'Mahony 2014). The 9-point scale and its variants is by far the most popular tool to measure liking and it has been extensively used to assess the hedonic response to food and beverages, as well as many nonfood products (Lawless and Heymann 2010; Stone et al. 2012).

The main reason for the great popularity of this scale is probably its simplicity, both for participants and researchers. With only minimal instructions, naïve consumers can easily understand the task, and it is also simple for researchers to record and analyze the resulting data (Lim 2011). Besides, results obtained with the 9-point hedonic scale have been reported to be stable and reproducible (Lawless and Heymann 2010; Stone et al. 2012), while comparisons with other scales have shown that it is as sensitive for product discrimination as other methods (Lim 2011).

In spite of being a simple and effective measuring instrument for liking of food and beverages, the 9-point hedonic scale has some disadvantages that should be acknowledged. First of all, the intervals between the scale labels are not equal, as was recognized by its developers (Jones et al. 1955; Jones and Thurstone 1955) and later confirmed by other authors (Moskowitz and Sidel 1971). From a mathematical point of view, this means that the obtained data are ordinal, and consequently nonparametric approaches (such as Friedman's test) should be used for their analysis. Besides, conclusions on the ratios of degree of liking of different samples cannot be drawn with this type of scale, as well as meaningful comparisons between individuals and groups (Lim 2011).

Another shortcoming of this scale, which is common to all category scales, is the existence of the "central tendency" bias (Hollingworth 1910), meaning that assessors tend to avoid using the end, i.e., extreme, categories. The underuse of the extremes reduces the effective number of categories of the scale and limits its ability to differentiate products which are highly liked or disliked (Schutz and Cardello 2001). Moreover, the small number of available categories limits the expression of a full range of hedonic responses, as two products under the same category are not necessarily equally liked (Lim 2011; Wichchukit and O'Mahony 2014). Besides, most commercial food products receive hedonic scores that range between 6 and 8, which makes it a small scale for product discrimination. Furthermore, the presence of the neutral category "neither like nor dislike" has been show to decrease the efficiency of the scale (Jones et al. 1955), probably by encouraging certain degree of complacency among assessors (Schutz and Cardello 2001).

Lastly, it should be noted that although the scale has been translated into many languages (Curia et al. 2001; Yao et al. 2003; Yeh et al. 1998), this has not been done without issues related both with translation of the labels as well as cultural differences in the use of the scale. For example, research has pointed out that Japanese, Korean, Chinese, and Thai consumers tend to use a smaller range of the 9-point scale compared to American consumers (Yao et al. 2003; Yeh et al. 1998), which has been attributed to Asian cultures presenting acquiescence and polite response styles as well as a tendency to avoid extreme responses. The translation of the nine category labels to other languages is also problematic in some cases. For example, in Korean, the translation of "extreme" has a stronger semantic weight compared to English (Yao et al. 2003; Wichchukit and O'Mahony 2014). Similarly, Curia et al. (2001) evaluated different versions of the translation of the 9-poinit scale labels to Spanish, asking people of different ages from two towns in Argentina to rank the phrases from "like least" to "like most." The authors found that a large percentage of participants inverted the order of two or more phrases and called for caution when using the scale in languages other than English, suggesting that number or unstructured (without labels) versions of the scale might be more appropriate in such cases.

Labeled Affective Magnitude Scale

The known drawbacks of the 9-point hedonic scale have motivated the search for alternative tools which could overcome issues such as the limited response options, the central tendency bias, and the unequal spacing of categories with the consequent inability to use parametric statistics. Among the proposed alternatives, the Labeled Affective Magnitude (LAM) scale (Schutz and Cardello 2001) has gained its place in the sensory and consumer science toolbox (Cardello and Jaeger 2010; Lawless and Heymann 2010; Stone et al. 2012).

The LAM scale was developed by Schutz and Cardello (2001), who extended the idea of category-ratio scales, which had been proposed for the measurement of perceived exertion (Borg 1982) and oral sensations (Green et al. 1993, 1996), to the hedonic domain. The LAM scale is a bipolar continuous scale with 11 labels describing the magnitude of (dis)liking, which are located at specific positions. The position of the labels was derived from a study in which the affective meaning of 44 positive, negative, and neutral semantic labels were rated using magnitude estimation. Subsequent studies on the reliability and sensitivity of different alternatives led to the selection of the labels from the 9-point hedonic scale, plus the two extreme anchors: "greatest imaginable (dis)like" (Fig. 2; Schutz and Cardello 2001). As the location of the labels on the line scale was based on the ratios obtained by magnitude estimation, the scale is assumed to have ratio properties, which enables the use of parametric statistics for data analysis (Lawless and Heymann 2010; Lim 2011).

Hedonic tests involving LAM scales are conducted in a similar fashion to those in which the 9-point hedonic scale is used, with the difference that, instead of selecting the category that best describes their degree of liking for a sample, assessors are

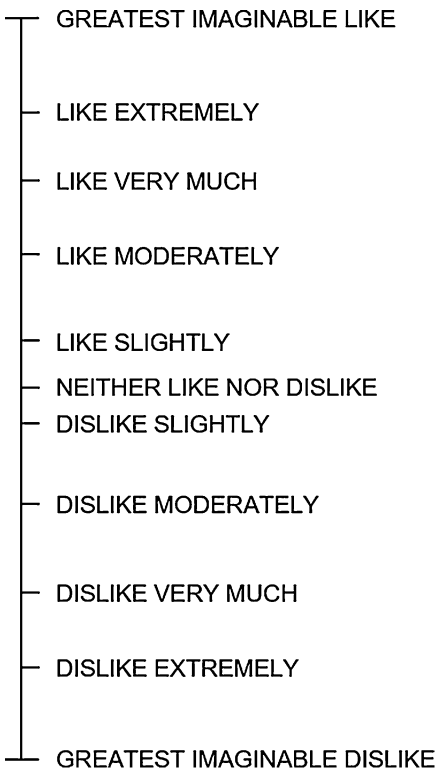

Fig. 2 Labeled Affected Magnitude (LAM) scale, developed by Schutz and Cardello (2001)

instructed to make a mark on the line scale to indicate how much they (dis)liked the sample. Thus, the problem of limited response possibilities associated with the 9-point hedonic scale is overcome. Besides, the inclusion of an extreme label ("greatest imaginable (dis)like") enables assessors to rate products higher (or lower) than "(dis)like extremely," which reduces the "ceiling" or avoidance of end use effect that the 9-point scale poses on responses (Cardello and Jaeger 2010). These facts might explain why Schutz and Cardello (2001) found that the LAM scale performed slightly better than the 9-point scale in the discrimination of highly liked products. Moreover, the LAM scale has been reported to be as easy to use as the 9-point scale for consumers (Schutz and Cardello 2001; Hein et al. 2008). Another point raised as an advantage of the LAM scale is that it reduces the percentage of ratings that fall near the neutral point, thereby minimizing the complacency bias (Schutz and Cardello 2001).

The wording of the most extreme categories of labeled magnitude scales has been a matter of discussion. Bartoshuk et al. (2002), when working on category-ratio scales to measure sensory intensities, argued that the end anchor should be the "strongest imaginable sensation of any kind," in order to extend the frame of reference out of the specific sensation being measured. Although this anchor is supposed to enable the scale to provide valid comparisons across individuals and groups with different sensitivities, it may be difficult to conceptualize for participants. In the case of hedonic scales, more extreme anchors to those of the LAM scale, such as "greatest imaginable (dis)liking of any kind" and "most (dis)liked imaginable sensation" have been proposed (Cardello 2017). However, research on the effect of different frames of references for the extreme anchors of the LAM scale, varying from "greatest imaginable (dis)like" for experiences of any kind, for foods or beverages in general, or for foods or beverages from a specific category, showed that a compression effect of the hedonic rating may occur with more extreme anchors (Cardello et al. 2008; Lawless et al. 2010a). This may result in lower product discrimination compared to the use of less extreme anchors.

Another criticism that the LAM scale has received is the potential misuse of the scale by consumers, who might use it as a category scale (only marking on the points where there are labels) instead of a continuous one. Thus, it is extremely important to give clear instructions to participants involved in test with the LAM scale and to ensure they understood the task (Cardello and Jaeger 2010; Lim 2011). Finally, from a practical point of view, the LAM scale has the disadvantage of requiring more time to process the results if data are collected on paper ballots, as the exact position of the marks on the scale needs to be measured. The construction of the scale with the exact label positions may also be difficult in some cases (Cardello and Jaeger 2010).

It should be noted that although the LAM scale and other similar category-ratio scales have been used by several authors (Cardello and Jaeger 2010), its use is not as widespread as the 9-point scale. This is probably because, from a practical point of view, the advantages of the LAM scale have not proven to be sufficient to justify the substitution of the 9-point scale. The slight advantage of the LAM scale over the 9-point scale for product discrimination found by some authors (Schutz and Cardello 2001; Greene et al. 2006; El Dine and Olabi 2009) has not been found by others

(Hein et al. 2008; Lawless et al. 2010b). In addition, the conclusions on the rankings of sample liking have shown to be equal for both scales (Hein et al. 2008; Cardello and Jaeger 2010; Lawless et al. 2010b). Thus, the advantages of the LAM scale do not seem to be enough to compensate the increased complexity of the scale and potential misunderstandings by consumers.

Bi-dimensional Measures of Liking

Concerns over the unidimensional nature of the underlying mechanisms of liking have been raised (Diener and Emmons 1984). Pleasure and displeasure have been argued to be not mutually exclusive and it has been suggested that hedonic and aversive reactions may vary according to two orthogonal processes (Berridge 1996). For this reason, the use of two unipolar scales (one for liking and the other for disliking) or bivariate grids composed of liking and disliking dimensions has been proposed (Kwak et al. 2013a, b; Kwak and Lee 2016). The authors reported that unipolar and bipolar scales showed similar ability to discriminate among products and low correlations between liking and disliking. However, the results reported in that work have raised concerns due to some methodological decisions involved in the experimental design (Cardello 2017). From a practical point of view, the use of bidimensional measures of liking increases the burden for both consumers and researchers, as they increase the time and effort needed to complete the task. In addition, it is not clear if consumers can simultaneously evaluate liking and disliking for a focal stimuli without the use of satisficing response strategies.

Best-Worst Scaling

Best-worst scaling is an indirect form of scaling in which scale values are derived from a choice-based task instead of a direct measurement of degree of liking (Lim 2011). The method, also called maximum difference of max-diff, was formally introduced by Finn and Louviere (1992) and started to be used in the context of food and drink liking about a decade ago (Hein et al. 2008; Jaeger and Cardello 2009; Jaeger et al. 2008).

Basically best-worst scaling is an extension of the paired preference test. Assessors are presented with a series of sets of three or more samples and are asked to choose among them the most and the least liked (Cardello and Jaeger 2010). A proper experimental design needs to be selected to establish the sets of samples to be presented, taking into account that each sample must be evaluated an equal number of times. A simple example is the case of 4 samples (A, B, C, D), which can be presented in four triads (A, B, C; A, B, D; A, C, D; C, B, D) where each individual sample will be tasted three times (Jaeger and Cardello 2009). Each consumer should evaluate the four sample sets in random order.

Data from best-worst scaling can be analyzed using two different approaches. One of them is to calculate the difference between the number of times each sample has been selected as "best" and "worst" for each assessor, which leads to individual-level scales. These scales can be easily compared across participants and may be aggregated to provide overall scores for each sample (Jaeger et al. 2008). These best-worst scores are assumed to have interval properties, and thus can be subject to ANOVA or other parametric statistical tests (Marley and Louviere 2005). The other approach is to apply a multinomial logistic regression to the pairs of "best" and "worst" choice frequency data, which in theory leads to data with ratio properties (Finn and Louviere 1992; Marley and Louviere 2005).

It has been argued that it is easier for people to identify stimuli at the extremes of a continuum than in the middle, and consequently, the best-worst method would require assessors to perform a more natural task from a cognitive point of view (Jaeger et al. 2008; Lawless and Heymann 2010). In fact, Hein et al. (2008) reported that consumers found best-worst scaling easier to use than direct scaling methods such as the 9-point scale and the LAM scale and were more confident they had provided accurate information during the test. Another advantage of best-worst scaling over direct ratio scales is that the method provides true, and not assumed, interval or ratio data (depending on how data are analyzed). Compared to other preference methods, such as paired comparison, best-worst scaling is more efficient in the sense more information is provided with fewer responses (Jaeger and Cardello 2009). Also, compared to the direct measurement of liking using hedonic scales, some authors have provided evidence of a slightly better discrimination power (Hein et al. 2008; Jaeger et al. 2008), especially in studies involving stimuli that do not require testing (food names; Jaeger and Cardello 2009), although other authors found different results (Mueller et al. 2010). Moreover, one of the most salient advantages of best-worst scaling is its potential for use in cross-cultural research. Issues that are common to most hedonic scales, such as the translation of anchors and intermediate labels, and cultural differences in scale use, do not affect the best-worst scaling method (Cardello and Jaeger 2010).

On the other side, a limitation of best-worst scaling is that no liking score is produced, so an absolute degree of liking of each sample cannot be inferred. Due to the indirect nature of the method, only the relative degree of preference among the samples considered in the study is obtained, which makes comparison across studies less intuitive, though possible (Cardello and Jaeger 2010). Also, the method requires assessors to evaluate each sample many times, unlike direct scaling methods in which each stimulus is presented only once. This increases the time and effort needed to set up and conduct a test and may pose additional challenges when dealing with samples that require strict control of serving temperatures or volumes (Jaeger and Cardello 2009; Lim 2011). This also represents a great disadvantage when samples need to be tasted, especially when working with fatiguing products such as wine (Mueller et al. 2010).

Regarding the comparison of best-worst scaling with direct scaling methods, such as the 9-point and the LAM scales, research has shown that the main conclusions on sample preferences are comparable (Hein et al. 2008; Jaeger and Cardello 2009).

Indirect Methods

Direct methods only focus on the conscious component of liking and do not capture unconscious hedonic processes (Berridge and Robinson 1998). In addition, self-reported measures of liking can be affected by several biases, including social desirability (i.e., tendency to give socially desirable answers, regardless of their true perception, feelings or attitudes; Crowne and Marlowe 1964), demand characteristics (i.e., tendency to give responses that please the researcher; Orne 1962), and consistency motif (tendency to appear consistent and rational in the responses to a questionnaire; Podsakoff et al. 2003). Implicit methods that do not require consumers to provide answers to questions can be used to overcome rationalization and response biases that diminish the validity and reliability of liking measures. These methods measure constructs using automatic processes, i.e., unintentional, uncontrollable, effortless, and fast processes (De Houwer and Moors 2007). Different implicit methods have been used to measure consumers' liking of food and drink, including implicit association tests, facial expressions, pupil dilation, and functional magnetic resonance imaging. Although the popularity of these methods has increased in the last decade, applications are still limited and mainly related to the academic context.

Implicit Association Test

The implicit association test (IAT) was developed to identify unconscious associations that are usually not accessible through introspection (Greenwald and Banaji 1995). This test involves two binary computer-based categorization tasks. In each task, participants have to classify a series of stimuli into one of two response categories, defined as combinations of an attribute dimension (e.g., pleasant and unpleasant) and a target dimension (e.g., water and soda) (Kraus and Piqueras-Fiszman 2018). The two tasks correspond to the two possible groupings of the attribute and target dimensions (e.g., pleasant/water vs. unpleasant/soda and pleasant/soda and unpleasant/water) (Fig. 3). The response categories are displayed on the right and left side of the screen and are assigned to specific response keys. Participants have to look at the stimuli (which can be words or pictures) and complete the task as fast and accurately as possible. The classification of each stimulus and the time needed by participants to complete the task are registered. The underlying assumption of the IAT is that participants would complete the categorization faster and more accurately when the response categories are composed of congruent concepts compared to when they are composed of incongruent concepts (Greenwald et al. 1998). An in-depth discussion of IAT and its variations, as well as applications in the food domain, can be found in Kraus and Piqueras-Fiszman (2018).

IAT has been used to evaluate consumers' liking of food and drink concepts, although comparisons with explicit scales are not frequent yet. For example, it has been recently used by Connell et al. (2018) to evaluate consumers' liking of fresh and frozen vegetables using fresh/frozen as the target dimension and pleasant/unpleasant as the attribute dimension. Participants were asked to classify a series of pictures of fresh and frozen pre-packaged vegetables as well as positively/negatively valenced

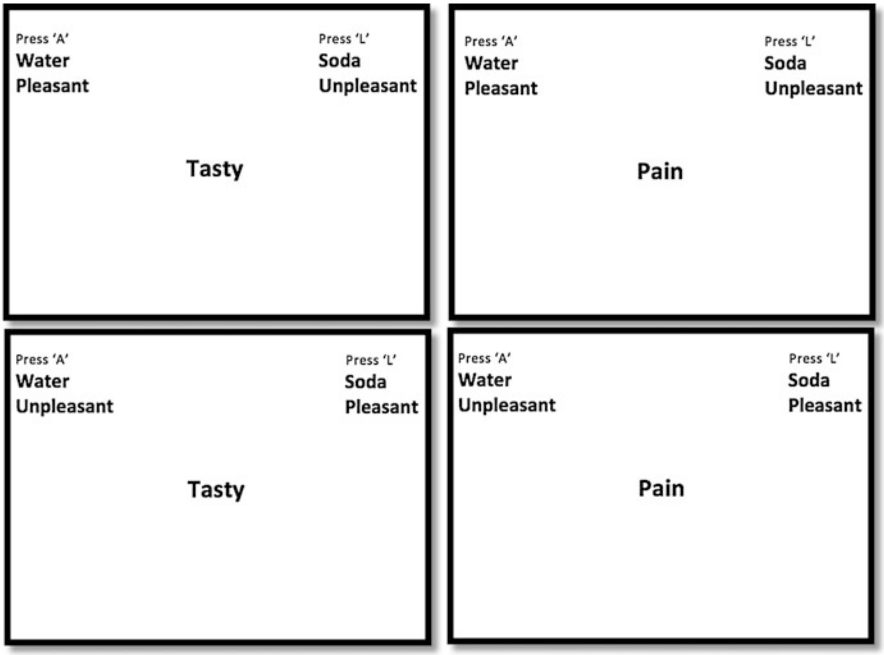

Fig. 3 Example of four classification tasks in an Implicit Association Test with pleasant/unpleasant as attribute dimension and water/soda as target dimension

words. Results showed that response times were shorter when participants completed the task using the categories fresh and pleasant versus frozen and unpleasant, compared to when the categories fresh and unpleasant versus frozen and pleasant were considered. This suggests an implicit negative hedonic attitude towards frozen vegetables compared to fresh vegetables.

Facial Expressions

Facial expressions have been regarded as the richest channel for non-verbal communication (Burgoon and Hoobler 2002). In the context of food consumption, they have been associated with the communication of warning signs related to the consumption of potentially harmful substances or facilitation of consumption of nutritious liquids (Oster 2004). For this reason, facial expressions are usually interpreted as expressions of liking (e.g., lip corner puller, smiling, lip smack) or disliking (e.g., nose wrinkle, outer eyebrows raised, brows pulled together and lowered) (Steiner 1973; Danner and Duerrschmid 2018). Facial expressions have been used to study innate liking for basic tastes in human infants: sweet taste has been associated with facial expressions related to liking (e.g., tongue propulsions), whereas bitter taste has been associated with facial expressions denoting disliking (gapes) (Berridge and Robinson 2003). Research with both children and adults has confirmed the potential of negative facial expressions to disliked foods, whereas positive facial expressions have not been found to accurately discriminate among liked foods (Danner and Duerrschmid 2018; Zeinstra et al. 2009). This reduces the applicability of facial expression for commercial product testing as product development is focused on liked products.

The analysis of facial expressions involves three basic steps: face acquisition in high-quality pictures or video recordings, identification of facial expressions (facial movements and facial feature deformations), and classification of the facial expressions (Tian et al. 2005). Although this analysis can be done manually, several commercially solutions are available for consumer research (Danner and Duerrschmid 2018). It should be noted that measurement of facial expressions face several challenges when evaluating liking for tasted food and drink as participants should be instructed to limit their movements while eating and drinking.

Pupil Dilation

The pupil, the circular opening in the center of the iris of the eye, regulates the amount of light that enters the retina by changing its size (Andreassi 2000). Constriction and dilation of the pupil is controlled by the sympathetic and parasympathetic nervous system in response to three stimuli: luminosity, emotions, and cognitive activity (Seeber and Kerzel 2011). Early research by Hess and Polt (1964) showed that the pupil dilated when people looked at pleasant pictures. More recently, Steinhauer et al. (1983) and Bradley et al. (2008) reported that pupil dilated when viewing affective pictures, regardless of whether they were pleasant or unpleasant.

Pupil dilation has not been frequently used to evaluate liking for food and drink. An exception is reported by Graham et al. (2011). These authors compared pupil dilation when viewing high-calorie savory foods (e.g., bacon cheese burger) and high-calorie sweet foods (e.g., chocolate cake) across women with different body mass index (BMI). The authors reported an interaction effect between BMI group and food type. Low BMI women did not show differences in their pupil diameter when viewing high-calorie sweet and savory foods. On the contrary, high BMI women showed larger pupil size when viewing high-calorie sweet foods compared to high-calorie savory foods, which indicates differences in implicit liking for these two types of foods.

Functional Magnetic Resonance Imaging

The pleasure associated with food consumption activates specific regions of the brain related to reward networks, which include anatomical regions of prefrontal cortex, such as portions of orbitofrontal, insula and anterior cingulate cortices, subcortical limbic structures, and amygdala (Berridge and Kringelbach 2015). Therefore, brain imaging techniques can be used to study the brain processes underlying hedonic reactions towards food and drink.

Functional magnetic resonance imaging (fMRI) is used to investigate where information is processed in the brain, how different brain areas are connected and how these connections are influenced by characteristics of the product or the individual (Dalenberg et al. 2018). This technique allows the identification of brain areas that are activated for processing information about a specific stimulus through changes in oxygen consumption (Huettel et al. 2014). During the experiment, which usually last 1–2 h, participants lie in a supine position on a bed inside the scanner and engage in a computerized task (Dalenberg et al. 2018). This limits the application of fMRI to visual stimuli, olfactory stimulation, or liquid foods that do not require chewing. In addition, despite the potential of fMRI to improve our understanding of food liking, its application is limited to basic research due to its cost, limited availability, and complex data analyses (Dalenberg et al. 2018).

An example of the application of fMRI to evaluate liking can be found in Jiang et al. (2015). Participants completed a liking task of 28 odorants while their brains were scanned using fMRI. Results showed that brain activation in the bilateral posterior OFC was correlated with subjective liking ratings. In addition, these authors provided evidence of the partial dissociation of liking and wanting within the cortico-striatopallidal circuit.

Liking for Sensory Characteristics

The sensory characteristics of food and drink are one of the main determinants of liking (Cardello 1996). For this reason, consumer studies usually include questions about liking for specific sensory characteristics to obtain insights on how these characteristics can be changed to increase liking (Lawless and Heymann 2010). One of the simplest approaches is to use hedonic scales to evaluate liking for sensory modalities (e.g., appearance, flavor, texture) or liking for specific characteristics (e.g., color, sweetness, creaminess). Despite the popularity of this approach, research has shown that a halo effect may exist and that consumers may not be able to evaluate liking for different sensory characteristics independently from each other. Ares et al. (2009) asked consumers to evaluate overall liking and liking for flavor and texture of a series of vanilla milk desserts formulated following a Taguchi experimental design with 5 2-level variables (starch, vanilla, sugar, carrageenan, and fat). Results showed texture, flavor, and overall liking scores were highly correlated to each other (R higher than 0.91), providing the same information.

Just-about-right (JAR) scales are another popular approach to evaluate liking for specific sensory characteristics. They can be regarded as a combination of intensity and hedonic scales as they involve the evaluation of intensity of sensory characteristic relative to consumers' ideal level (Lawless and Heymann 2010). JAR scales are bipolar: they are anchored in "just-about-right" and each side indicates that the intensity of the sensory characteristic is weaker or stronger than the ideal (Fig. 4). Although these scales are popular in the food industry to obtain insights for product formulation and reformulation, concerns have been raised over the fact that they could bias consumer perception (Popper et al. 2004).

According to Prescott et al. (2011), asking consumers to focus their attention on specific sensory characteristics can induce an analytical mind-set that reduces their ability to engage in the synthetic attentional processes that underlie hedonic responses. They argued that concurrently eliciting overall hedonic scores and

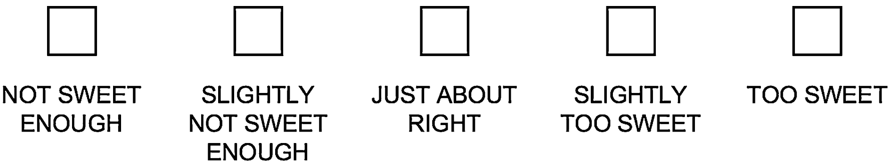

Fig. 4 Example of a Just-About-Right (JAR) scale to evaluate the adequacy of sweetness

attribute information can undermine the ability of hedonic scores to provide useful insights for decision making.

Contextual Effects on Liking for Food and Drink

Liking for food and drink is not absolute. Context, defined as the physical, social, and situational conditions under which products are consumed, has a strong effect on how consumers perceive food and drink (Cardello and Meiselman 2018). In this section, two types of contextual effects are discussed: contextual effects of the test and consumption contexts.

Effect of Contextual Effects of the Test on Liking Measurements

Several contextual effects influence liking scores, including the number of samples, stimulus range, contrast and frequency effects, end effects, centering biases, and stimulus-spacing biases (Lim 2011). Many of these effects involve the external frames created by other stimuli that are evaluated concurrently with a target stimulus in a consumer test (Cardello 2017). For example, contrast effects imply that a target stimulus is expected to show lower liking scores when evaluated after a better-liked stimuli and to show higher liking scores when evaluated after a less-liked stimuli (Zellner et al. 2006). This contrast effect has been demonstrated to be affected by the frame of reference. According to Zellner et al. (2002, 2003), contrast effects can be modified by adjusting the frame of reference. Contrast effects are expected to be higher if all samples are regarded as representatives of the same product category (e.g., fruit juices) or of different categories (e.g., fruit juice and fruit drinks).

Range and frequency effects imply that a target sample may be evaluated differently depending upon the range of samples included in the set that is evaluated (Lim 2011). Range effects imply that participants tend to subdivide the available stimulus range into equal segments and assign them to subranges of the hedonic scale, whereas frequency effects imply that the different subranges of the scale tend to be used equally often. These effects are expected to increase with the number of stimuli (Parducci and Wedell 1986).

The instructions of the test also influence consumers' liking scores. If consumers are not given a specific frame of reference for the evaluation, they may assume different consideration sets, which may increase the noise in the data. Research has shown that instructing consumers to rate their liking within the frame of reference of any food gives lower scores compared to when they perform the rating task considering foods like this as frame of reference (Cardello and Schutz 2007).

Effect of Consumption Context on Liking Measurements

Most research on consumer liking for food and drink is carried out in laboratory settings (Meiselman 2013). Although this approach allows to control for extraneous and confounding sources of variation, it lacks external validity as consumers do not usually eat in individual sensory booths (Cardello and Meiselman 2018). According to Lyman (1989), removing products from their habitual consumption context can change the meaning consumers attach to them. For this reason, the absence of a context can hinder consumers' ability to give valid responses about how they perceive products (Köster 2003). In addition, the food that is served in the laboratory usually differs from food served in natural settings in terms of several variables, including portion size, food combinations, presentation, and the length of exposure to the target product (Cardello and Meiselman 2018). In this sense, research has shown that liking for food and drink can differ with context (Stelick and Dando 2018).

The need to increase the ecological validity of liking measurements has been highlighted as a priority of the development of sensory and consumer science (Jaeger et al. 2017). This has prompted the use of natural or pseudo-natural settings in consumer studies, as well as the development of novel approaches to mimic specific consumption contexts within the sensory booths (Jaeger and Porcherot 2017). Considering the challenges associated with consumer testing under controlled conditions in natural settings, the use of evoked, immersive, and virtual contexts has become popular (Stelick and Dando 2018).

Consumption contexts can be evoked using written descriptions of situations consumers are asked to image when testing a product in laboratory settings (Hersleth 2018). This can include specific situations (e.g., when wanting something refreshing or while watching a movie) or each consumer description of their usual consumption context or the last time they consumed the product. This approach is expected to help consumers to mentally create a frame of reference for the evaluation, reducing the artificiality of central location tests (Jaeger and Porcherot 2017). Research has shown that evoked contexts can lead to differences in liking scores and discrimination (e.g., Hein et al. 2010, 2012; Hersleth et al. 2015). However, the modulation effect of evoked contexts on liking is still unpredictable and not consistently demonstrated (Stelick and Dando 2018).

Considering that consumers may not invest the cognitive effort required to vividly imagine a consumption context (Köster 2003), visual, auditory, tactile, and/or olfactory stimuli have been used to create immersive contexts for product testing. These contexts have been generated using video projections of natural consumption situations in laboratory settings or virtual reality (Porcherot et al. 2018). These approaches can increase consumers' motivation and interest in the study, increasing their ability to discriminate among samples (Bangcuyo et al. 2015). However, immersive or virtual context can also diminish consumers' attention on the products, which can be detrimental for product discrimination (Sinesio et al. 2018).

Individual Differences in Liking

Liking for food and drink strongly differs between individuals due to perceptual and socio-psychological differences (Tuorila 2007). For this reason, aggregated liking measures may mask consumer heterogeneity and reduce the accuracy of the results and, therefore, segmentation is strongly recommended to improve understanding of consumer perception.

An example of the benefits of segmentation for gaining a deeper understanding of consumer perception can be found in Oliveira et al. (2018), who studied consumer perception of sugar-reduced fruit nectars. These authors reported no significant differences between fruit nectars when liking data were analyzed at the aggregated level. However, segmentation demonstrated the existence of two consumer groups with opposite behavior: one of the segments increased their liking scores with sugar reduction, whereas the other showed the exact opposite behavior.

A priori and a posteriori segmentation methods can be used (Næs et al. 2010). A priori segmentation is based on the identification of consumer segments based on consumer personal characteristics, such as gender, age, habits, attitudes, or psychological traits. Consumers with similar characteristics are grouped and their data are analyzed separately. On the contrary, in a posteriori segmentation consumer segments are identified based on their liking data using cluster analysis. In this approach, consumer characteristics are used to interpret the differences between the groups. An in-depth discussion of clustering approaches for consumer liking can be found in Berget (2018).

Conclusions and Recommendations

Liking for food and drink is highly relevant in both industrial and academic settings and has been one of the central topic of sensory and consumer science for more than 80 years. The present chapter provides an overview of the most popular methodological approaches that are being used for measuring liking. All methods have advantages and disadvantages and practitioners should select the most appropriate method for answering the specific objectives of the study, taking into consideration the characteristics of the samples and consumers.

Direct or explicit methods provide actionable information about the most/least liked samples in a set, being particularly useful for most applications in the food industry. Following the psychophysics tradition, measurement of liking has been traditionally based on scaling. Hedonic scales are recommended when the degree of liking of individual samples is of interest. However, practitioners should be aware that hedonic ratings are not absolute and depend on contextual effects created by both the test instructions and the other samples included in the set. Although different hedonic scales have been developed, research has shown that they all provide similar results in terms of sample ranking. However, small differences among scales have been reported in terms of sample discrimination. The LAM scale may offer advantages over the 9-point hedonic scale in terms of ability to discriminate among well-liked samples. Best-worst scaling is an alternative approach for direct measurement of consumer liking. This method is useful when only information about the relative preference among a group of samples is sought, and has great potential particularly in cross-cultural research. However, its application is not advisable for large sets of tasted samples, particularly if they are fatiguing.

Indirect methods are being increasingly used to obtain a deeper understanding of liking. These methods open the possibility to evaluate unconscious aspects of liking and are particularly useful for projects in which self-report bias needs to be avoided. Although the popularity of these methods is expected to continue growing, it should be acknowledged that the information they provide is less actionable, more difficult to analyze and interpret, particularly in industrial settings, than that from direct methods.

Liking measurements collected under laboratory settings are still the most frequent methodological approach. Therefore, a strong need to increase the ecological validity of these measurements exists and several approaches have been proposed for this purpose. Evoked and immersive contexts are increasingly used to take into account the consumption context in central location tests. Despite the potential of these approaches, their effect on liking data does not seem to be consistent and an in-depth understanding of the mechanisms underlying their effect on consumer responses is still lacking to develop recommendations for best practice. In addition, the reaction after the first impression of a product may differ from the hedonic reaction after a long exposure to the product in normal consumption situations. In this sense, the development of methodological approaches that measure hedonic reactions to products under natural consumption conditions and after long exposures is still necessary. Purchase decisions are usually made based on recalled liking for products and not on the basis of immediate hedonic reactions to tasted products.

In closing this section, it is important to acknowledge that liking is only one of the components of reward. Although it is usually correlated with wanting, the motivational component of reward, it is not necessarily the case. Wanting has been generally overlooked in sensory and consumer science and further research on this component is needed. A deeper understanding of the distinction between liking and wanting is particularly relevant in the wake of the increasing prevalence of overweight and obesity worldwide. In addition, there is also a need to broaden our understanding of consumers' perception of products and to include to a larger extent other measures, such as emotional associations, perceived benefits, and perceived wellbeing.

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Atmospheric Effects on Eating and Drinking: A Review

13

Charles Spence

Contents

Abstract

Whenever, wherever, and whatever we choose to eat and drink, one thing is for sure, we will do so in an environment that has a certain atmosphere. And while most consumers tend to feel that they are in charge of their own food and beverage choices, a growing body of empirical evidence now supports the view that the multisensory environments/atmospheres in which we consume influence our eating and drinking behaviors to a greater extent than any of us probably realize. In this chapter, key findings illustrating just how profoundly the auditory, visual, olfactory, tactile, and multisensory attributes of the environment affect human behavior are summarized and a number of the putative underlying mechanisms outlined. Atmospheric effects on choice behavior, product perception, and

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patterns of consumption are discussed. Furthermore, attention is drawn to the palpable tension that exists currently between the sensory marketing approach to atmospherics (that may be encouraging us all to consume more than perhaps we should) and the emerging sensory nudging approach to modifying the environment (in order to try and help bias us toward slightly less unhealthy food behaviors).

Keywords

Atmospherics · Eating · Drinking · Consumer behavior · Multisensory · Sensory marketing · Sensory nudging

Introduction

There has long been a fascination with the impact of the atmosphere on consumer perception and behavior, with much of the contemporary interest in this area being stimulated by Kotler's (1974) seminal early paper on "atmospherics." In the years since its publication, researchers have studied the impact of the visual, auditory, olfactory, and even tactile aspects of the environment on various aspects of consumer behavior around food and drink. Much of this research has tended to focus on the effects of the atmosphere in diverse retail environments that include supermarkets, smaller stores, bars, and restaurants (see Spence 2017a; Spence et al. 2014b, for reviews). Ultimately, and perhaps worryingly, the suggestion is that atmospheric cues may be influencing our consumption behavior (and not, it has to be said, in a good way, at least as far as our waistlines are concerned). Understandably, the practitioners (e.g., restaurateurs) have also been interested in how the atmosphere in the spaces they manage can be used to influence sales (e.g., Anon 1965). On the flip side, however, there is now growing interest in the question of whether (sensory) nudges can also be used to help consumers eat and drink a little less and/or make healthier food choices (e.g., Guthrie et al. 2015; Kroese et al. 2016; McKie 2017; Campbell-Arvai et al. in press).

The majority of the empirical research that has been published to date on the topic of atmospherics (what is sometimes referred to as "context" effects; Sester et al. 2013; Meiselman in preparation) has tended to focus on trying to demonstrate, and thereafter to understand, the effects of varying just one sense at a time (perhaps changing the color or brightness of the lighting, or else varying the ethnicity, or type, of music playing in the background). More recently, however, researchers have also started to investigate whether multisensory modifications of the environment may exert a bigger effect than unisensory changes (Sester et al. 2013; Spence et al. 2014a; Wansink and Van Ittersum 2012). The limited evidence that has been published to date suggests that such combined multisensory atmospheric cues, at least when congruent (Helmefalk and Hultén 2017), may indeed be even more effective in biasing people's behavior (than are unisensory manipulations). And while any attempt to consider more than one atmospheric cue at a time undoubtedly constitutes a more complex undertaking, ultimately there can be no doubting the fact that the consumer responds to, and is influenced by, the total multisensory experience resulting from the combined influence of the various visual, auditory, olfactory, and tactile aspects of the environment (Spence 2002).

At the outset here, it is important to stress that there are at least three different stages (or ways) at which atmospheric (or contextual) cues influence the consumer's eating and drinking behavior: They may bias the food and drink choices that the consumer makes; they may bias the perceived taste and flavor of food and drink, as well as the consumer's hedonic response to whatever they are consuming; and third, atmospheric cues have also been shown to influence how quickly people eat and drink (and possibly also how much they end-up consuming/spending).

Over the years, various mechanisms have been put forward in order to try and help explain why it is that atmospheric cues influence us in quite the way that they do: They may, for instance, prime a certain idea (e.g., Italian, French, or expense/quality, as a function of the type of music playing) and by so doing bias consumer behavior (Areni and Kim 1993; North et al. 1997, 1999); meanwhile, an emerging body of empirical research now suggests that sensory (especially auditory) cues can also change the perceived taste/flavor of food and drink (a phenomenon that goes by the name of "sonic seasoning"; e.g., see Crisinel et al. 2012; Wang et al. 2017); alternatively, however, atmospheric cues may induce a particular mood or emotion (relaxed/aroused) that can, in turn, bias the consumer's choices (e.g., Edwards et al. 2013; Gardner et al. 2014; Giboreau and Meiselman 2018; Leenders et al. 2016; Meiselman 2016), not to mention their hedonic response upon tasting/consumption (e.g., Kantono et al. 2015, 2016; see also Petit and Sieffermann 2007); There is also a sense in which people's behavior may, to a certain extent at least, be entrained to atmospheric cues (i.e., consumers appear to end-up drinking and dining to the beat; Milliman 1986); finally, atmospheric cues (such as desirable food aromas) have even been shown to stimulate our hunger/desire to eat and drink more directly (Zoon et al. 2016; see Spence 2015a, for a review).

Early research showed that dishes were sometimes rated very differently as a function of the particular environment in which they happened to be served (e.g., Bell et al. 1994; Edwards et al. 2003; Meiselman et al. 2000). So, for instance, the very same food has been shown to be rated more highly when it is served in a 4-star restaurant than when evaluated in a private boarding school dining hall, say (Edwards et al. 2003). While such results clearly do, in a sense, demonstrate the impact of the atmosphere on the tasting experience, such findings perhaps have less to do with the specific sensory attributes of the environment than they do with people's expectations concerning the standard of food that one normally finds in different kinds of eating establishment (see Spence 2017a). Hence, while such findings are undoubtedly important/relevant, in this article, the focus will instead be on the psychological effects of those atmospheric sensory cues that are not necessarily associated with any specific kind of dining environment. At the other extreme, low-level (literally) atmospheric cues including everything from the ambient humidity (e.g., Kuehn et al. 2008) through to any changes in air pressure (Burdack-Freitag et al. 2011) have been shown to influence taste/flavor perception. In fact, the profound changes in taste/flavor perception that are observed between the evaluation of food and drink on the ground versus when sampled up at 35,000 feet, say, has attracted much comment/discussion (see Green and Butts 1945, for early work; and Holthuysen et al. 2016, for more recent work). However, once again, such physico-chemical effects will not be discussed here either (see Spence 2017b, for a review). Instead, this review focuses squarely on the more psychological impact of atmospheric cues on consumer behavior around food and drink.

Having outlined the relevant scope of the review, the next section summarizes the evidence relevant to the atmospheric influence of each of our senses in turn (i.e., audition, vision, olfaction, touch, and finally taste), before turning to the few multisensory studies of atmospherics that have been conducted (or, better said, published) to date. One motivation underlying this review relates to the question of whether we should all be worried about the potential influence of sensory marketing to bias our behavior and perhaps make us consume more than is necessarily good for us (some talk of obesogenic environments; Lieberman 2006; see also Wansink 2004). On the other hand, though, if atmospheric cues really do influence consumer behavior anything like as much as the sensory marketers would have us believe then there may also be scope to use environmental cues to help nudge us all toward more healthy/sustainable (both for us and for the planet) food choices in the future.

Auditory Atmospheric Effects on Eating and Drinking

Auditory cues are among the most important as far as the study of atmospherics is concerned. Note here only how it is normally so much easier to change the music playing in a given environment than it is to change the color of the walls, say, or to ensure an even distribution of ambient scent throughout a large retail space. Certainly, the impact of auditory atmospheric cues is the easiest to study empirically, and perhaps for this very reason there is simply far more research concerning sonic context effects than there is for any other type (or modality) of sensory intervention. Crucially, the majority of the evidence that has been published to date demonstrates that auditory atmospheric cues do exert a significant influence over our food and beverage choices, our perception, and ultimately, our consumption behavior (Lock et al. 2016). Furthermore, such effects appear to occur no matter whether we (as consumers) are aware of them or not, and mostly the evidence suggests that we do not believe that auditory atmospheric cues influence us.

Type of Music

In their now classic study, North et al. (1997, 1999) demonstrated a marked reversal in sales of French and German wine in a British supermarket as a function of whether French accordion vs. German bierkeller music happened to be playing in the background. What is more, only six of the 44 consumers who agreed to be questioned after leaving the tills thought that the atmospheric music had influenced their purchasing behavior. This despite the fact that the till receipts told a very different story. More recently, Zellner et al. (2017) demonstrated that people ($N = 275$ students and faculty) given a choice of Spanish vs. Italian meals (seafood paella vs. chicken parmesan; or other dishes) in a university canteen were significantly more likely to choose the former dish when instrumental Spanish rather than Italian music was playing (34% vs. 17%, respectively). Once again, the majority of diners (82 out of 84) quizzed in this study denied that the background music had influenced their meal choice. And while no effect of musical congruency on hedonic responses to the chosen dish was reported (cf. Yeoh and North 2010, for some weak evidence on this score), this latter null result may simply reflect the fact that (as the authors themselves readily admit) the music was not especially audible in the dining area. Other laboratory research, meanwhile, demonstrates that the type (or genre) of background music can modulate flavor pleasantness and people's overall impression of food stimuli (Fiegel et al. 2014).

While not much hangs on the consumer's choice of French vs. German wine in the supermarket, or Spanish vs. Italian meal selection at the cafeteria, there is a question here as to wonder whether there is not a danger that the global popularity of North American pop music might not be subtly biasing people toward American fast-food offerings (which are not known for being especially healthy; see Schlosser 2001; Spence 2012a). Were Mediterranean music to be more popular, might not more of us be benefiting from the well-established health benefits of the Mediterranean diet (e.g., Bonaccio et al. 2017)? While such a suggestion might seem far-fetched, I do think it is, at the very least, worth considering. Of course, one also needs to remember that not all of the foods we associate with the Mediterranean, think only of pizza, pasta, salami, are necessarily particularly healthy.

The available research also demonstrates the influence of classical music on people's behavior. In particular, classical (as compared to other styles of) music (e.g., Top-40 type tracks) has been shown to result in people spending significantly more on their food and drink purchases, in venues as diverse as a wine shop (Areni and Kim 1993), the student cafeteria (North and Hargreaves 1998; North et al. 2016, 2003), and even in an African-themed restaurant (Wilson 2003). Specifically, Wilson's research showed that, on average, the 300 diners whose behavior was assessed spent significantly more when classical, jazz, or popular music was played than when there was easy-listening music, or else when the music was turned off. The suggestion is that this style of music is associated in the mind of consumers with notions of class, and so primes notions of quality/expense (that, in turn, leads to increased spending; though see also de Wijk et al. 2018a, for a recent null result). At the same time, however, it is important to bear in mind that classical music is certainly not to everyone's taste. According to a recent press report, one fast food chain here in the UK has been experimenting with the broadcasting of classical music as a means of deterring feral youths from lingering around the premises (Taylor 2017)!

Musical Tempo and Loudness

Several studies have demonstrated that a range of consumer behaviors are entrained to the tempo of the background music (Roballey et al. 1985). So, for instance, laboratory studies show that people drink faster when high tempo music is played. Intriguingly, similar results have also been reported in restaurants (e.g., Bach and Schaefer 1979; Caldwell and Hibbert 2002; Milliman 1986). In one of the largest studies of its kind, Milliman reported a 30% increase in average dollar spend on the bar tab among 1,400 diners when slow- (rather than fast-) tempo music was played, the idea being that it encouraged them to linger for longer. That some food chains really do control the flow of customers in this way is suggested by the following quote from Chris Golub, the person responsible for selecting the music that plays in all 1,500 Chipotle branches in the USA: "*The lunch and dinner rush have songs with higher bpms because they need to keep the customers moving*" (quoted in Suddath 2013).

Laboratory research has also demonstrated that increasing the loudness of the background music may result in people drinking more (e.g., McCarron and Tierney 1989). Real-world studies confirm that people tend to drink more when the loudness of the music is turned up (Guéguen et al. 2004, 2008). Interestingly, according to a report that appeared in *The New York Times,* the Hard Rock Café chain plays loud music because of the positive effect they believe that it has on sales. Just take the following quote from the newspaper article itself: "*[T]he Hard Rock Café had the practice down to a science, ever since its founders realized that by playing loud, fast music, patrons talked less, consumed more and left quickly, a technique documented in the International Directory of Company Histories*" (Buckley 2012). Meanwhile, according to another report: "*When music in a bar gets 22 per cent louder, patrons drink 26 per cent faster*" (Clynes 2012). That said, the most appropriate loudness level for the music may depend on the style of restaurant or bar. So, for instance, the 80 diners in a study by Lammers (2003) spent around 15% more when quieter (as opposed to louder) background classical or soft rock music was played. According to the author, this result might reflect the fact that quieter music better matched the "serene" atmosphere of the oceanside California restaurant than did the louder music.

There is a growing groundswell of opinion out there suggesting that many restaurants/bars in North America, the UK, Australia, and beyond are becoming louder (e.g., McLaughlin 2010; Moir 2015; Sietsema 2008a, b). It should be noted, though, that this is not solely due to the result of chefs/restaurateurs deciding that loud music in the dining room is a good idea (Spence 2015b). Rather, part of the blame should also be placed at the doors of those who believe that removing all those sound-absorbing soft furnishings (curtains, cushions, and carpets) and replacing them with hard reflective surfaces is a good idea (see Spence and Piqueras-Fiszman 2014). Of course, that being said, the sonic racket is sometimes used as a means of deterring a certain section of the populace from drinking/dining there (Forsyth and Cloonan 2008).

When the music or background sound level becomes too loud, it is classified as "noise" (i.e., sound that is unpleasant), and this may negatively impact people's perception of food and drink. For instance, loud noise (be it white noise or the sound of the engines while flying) actually suppresses our ability to taste sweet and salt while enhancing the perception of umami (Woods et al. 2011; Yan and Dando 2015). Similarly, loud music also appears to interfere with people's ability to determine the alcohol content of drinks (Stafford et al. 2013, 2012; see also Pellegrino et al. 2015). Given the evidence from studies of airline noise just mentioned, one might wonder whether similar increases in sugar/salt might also be needed to make the food stand up to the auditory atmospheric onslaught in overly loud restaurants? Hypothetically, it might also be speculated that those cuisines that are naturally umami-forward would do especially well in such noisy dining environments.

Sonic Seasoning

Recent empirical research has demonstrated that the sensory attributes of music playing in the background can also influence taste/flavor perception via what has come to be known as "sonic seasoning." While much of this research has been conducted in the laboratory and/or at experiential experimental events, the findings have now been extended to the retail environment too. For instance, Wang et al. (2017) recently demonstrated that when "spicy" music was played in a restaurant (in Nashville, TN), diners rate a spicy salad as tasting significantly spicier than when compared to putatively "sweet" music, white noise, or silence was presented instead. Elsewhere, researchers have provided evidence to show that a range of other taste/flavor attributes (including sour, creamy, bitter, and sweet) can also be modulated by what we hear. Taking things one stage further, Blecken (2017) reports on a café in China that plays high-pitched music all day long with the idea that it will help make the cakes, pastries, and drinks taste a little sweeter, and by so doing allow the owners to reduce the sugar content in their product. It is, though, a little harder to say whether this is more marketing-led story than a serious long-term strategy to help with the growing obesity crisis!

Interim Summary

Taken together, it can be seen that the results of a large number of studies published in recent decades have demonstrated the profound impact of the auditory environment on people's behavior around food and drink (see Spence 2012a; Spence and Shankar 2010; Spence et al. 2011; Stroebele and de Castro 2004, for reviews). While the majority of this research has been conducted in the setting of the science lab, there is now a growing body of evidence suggesting that auditory cues also influence the consumers' perception of taste/flavor, as well as their food and drink behavior in restaurants and bars too (see Spence 2017a, for a review). That being said, before closing this section, it is worth noting that not every study has demonstrated a significant effect of the background auditory atmosphere on people's consumption behavior (e.g., see Mamalaki et al. 2017; Peneau et al. 2009; Pettit 1958, for a few null results). It is also important to bear in mind that there may well be a “file drawer problem” in this area, as in many other areas of science (e.g., Rosenthal 1979). Namely, null results are far presumably far less likely to be published than are those studies showing a significant impact of the atmosphere on people’s eating and drinking. So, for instance, Mamalaki et al. reported recently that varying the loudness of the background music (Smokey Bandits’ 2010 debut album played at 67 vs. 90 dB vs. no music) had no observable impact on people’s *ad libatum* consumption at a buffet lunch in a carefully controlled crossover study conducted in a laboratory study in Greece. That said, the number of participants was very low (only 16 normal weight individuals and 10 obese participants were tested). Similarly, in one of the earliest studies to have been published on auditory atmospherics, Pettit (1958) reported that playing prerecorded restaurant noises had no effect on people’s ratings of tomato juice.

Visual Atmospheric Effects on Eating and Drinking

The research that has been conducted to date in order to assess the impact of ambient visual cues on eating and drinking has primarily focused on studies of the brightness (Gal et al. 2007; Xu and Labroo 2014) and hue of the ambient lighting (e.g., Cho et al. 2015; Spence et al. 2014a), on wall/fixture color schemes (Jacquier and Giboreau 2012a, b; Robson 1990). Other researchers, meanwhile, have tried to create a particular ethnic feel in a canteen restaurant by means of the use of semantically meaningful visual cues – think Italian flags, red and white checkered tablecloths, and wine bottles on the tables (Bell et al. 1994). In an unpublished laboratory study, Gal et al. (2007) reported that those who liked strong coffee tended to drink more under conditions where the ambient lighting was bright, while those who preferred weaker coffee drank more under dim conditions. Meanwhile, Xu and Labroo (2014) demonstrated that people tended to order significantly spicier chicken wings under conditions where the ambient lighting was brighter. (Note that chicken wings are ideal for this kind of research since they come in a wide range of spiciness levels.) Interesting here is the suggestion that high-turnover restaurants like Hard Rock Café and Planet Hollywood do not have windows to better control the ambient light levels (Robson 1999; see also Lampi 1973).

Several studies have demonstrated that changing the hue of the ambient lighting can influence people’s perception of the taste/flavor of wine (e.g., Oberfeld et al. 2009; Spence et al. 2014a). Elsewhere, researchers have reported that Scandinavian men consume less breakfast under blue lighting than under regular white lighting (Cho et al. 2015). As yet, however, it is unclear why the latter atmospheric manipulation should only have influenced male participants. According to a number of anecdotal reports, painting the walls Baker-Miller pink (which is close to bubble gum pink) suppresses appetite (cf. Alter 2013; Ferrier 2017). However, there does not appear to be any sound peer-reviewed scientific research to back up this particular assertion. According to other research, yellow lighting increases people’s appetites, whereas red and blue lighting decrease their motivation to eat (see Spence

2017a, for a review). Furthermore, when the color of the food and of the ambient lighting match, it appears to stimulate appetite, whereas complementary colors suppress it (Suk et al. 2012; see also Robson 1999). Although variations in the color of the walls are likely to be an important element of atmospherics, it is somewhat harder to study (or rather, to manipulate, experimentally). That said, there has not been so much published research concerning other visual cues either.

In one early study, though, Bell et al. (1994) were able to demonstrate that giving a cafeteria an Italian theme (with Italian flags on the walls; wine bottles and red and white checked table cloths on the tables) led to more customers choosing the Italian option from those that were available. That said, the names of the dishes were also changed so as to give them more of an Italian flavor. Hence, it is simply not possible to determine the relative importance of these manipulations to the pattern of results that were reported. In summary, then, while visual cues are likely very important in terms of modulating the atmosphere, they have not been studied empirically anything like as thoroughly as have auditory cues. That said, what evidence there is, supports the view that visual atmospherics (be it is terms of lighting, wall color, and / or decorations) does indeed influence people's choice behavior, their flavor perception, and ultimately their consumption of food and drink.

Olfactory, Gustatory, and Tactile Atmospherics

The presence of ambient food aromas often influences people's food and drink choices (e.g., de Wijk et al. 2018b; De Wijk and Zijlstra 2012; see Spence 2015a, for a review). Furthermore, there is plenty of anecdotal evidence to suggest that companies have been strategically using ambient food-related scent in a variety of retail contexts (Nassauer 2014). That said, it is important to stress the discrepancy between the claims of some of those companies that provide the technical solutions to help others release food aromas in various retail settings (and who would, for example, have us believe that aroma release can have a really dramatic effect on sales) and the much more modest effects that have been documented in well-controlled peer-reviewed academic research. According to one company, for instance, introducing a coffee scent at the service station apparently led to a 300% increase in sales of coffee (see Spence 2015a, for a review). Meanwhile, research by Leenders et al. (2016) documented that consumers spent more when there was a fruity aroma in the air. Specifically, the 300 supermarket shoppers whose behavior was assessed in this study ended-up spending 14% more when there was a melon scent in the air as compared to a baseline no-scent condition. What is more, the more intense the scent, the longer the shoppers stayed in store. This aroma intensity-related behavioral response might then help to explain why de Wijk et al. (2018a) observed no effect of the addition of congruent or incongruent scent versus no scent in their Dutch supermarket study. For, as the authors of the latter study themselves stated, they adjusted the intensity of the aroma release until it was barely noticeable even by someone standing directly in front of the relevant display. Elsewhere, Guéguen and Petr (2006) conducted a small study ($N = 88$ diners) in a pizzeria in

Brittany, France. These marketing researchers demonstrated that the scent of lavender resulted in the customers staying longer and spending more than when a citrus scent (or else no scent) was present. In this case, the suggestion was that the lavender might have exerted its influence over diners by relaxing them.

In terms of gustatory atmospherics, there is not much to say other than to think about how offering food and beverage product samples in store may provide an effective means of encouraging exposure to a product or brand and hence increase purchase likelihood (see Spence et al. 2014). One might also perhaps think about the growing tendency to offer amuse bouche in high-end restaurants too (see Spence 2017a).

To date, there has been far less research on the tactile side of atmospherics. However, it would seem reasonable to assume that changes in the ambient temperature might well exert some influence over people's eating and drinking behavior (e.g., Gómez-Corona et al. 2017; Motoki et al. in press; Zwebner et al. 2014; see also Brobeck 1948; Campbell-Arvai et al. in press; Stroebele and De Castro 2004). The use of seating that is more or less comfortable to encourage consumers to linger or not, as the case may be, has also been discussed (Robson 1999; Spence 2017a). It may, of course, also be relevant here to consider interpersonal touch as part of tactile atmospherics. There have, after all, been a number of studies of the "Midas Touch" effect (see Gallace and Spence 2014, for a review). Specifically, people appear to engage in more pro-social behaviors, to tip more generously, and be more likely to go with the waiter's suggestion if they have just been casually touched by another person (Guéguen et al. 2007). What is more, there is evidence to suggest that being touched by the waitress influences alcohol consumption too (Kaufman and Mahoney 1999; though cultural factors will undoubtedly play a role here; see Gallace and Spence 2014, for a review). According to one press report, a number of CEOs actually insist that their staff engage in more interpersonal touch in store. Just take the following from one newspaper article concerning what happens whenever Pret a Manger's chief executive, Clive Schee, visits a branch: "*the first thing he checks is whether staff are touching one another, declaring: 'I can almost predict sales on body language alone*'" (McDermott 2013). At the same time, however, it is important to bear in mind that too much touch from other customers can be stressful in a retail setting (Martin and Nuttall 2017). This is also likely to be true in those environments where people eat and drink as well. In summary, then, olfactory, tactile, and to a lesser extent gustatory atmospherics are an important part of the total multisensory atmospheric offering.

Multisensory Contributions of the Atmosphere to Eating and Drinking

As mentioned already, there have been fewer studies that have manipulated atmospheric cues in two or more senses at one and the same time. That said, one illustrative example of just how profoundly taste/flavor perception can be changed by such interventions is illustrated by Velasco et al. (2013). These researchers demonstrated that simply by changing the auditory, visual, and ambient olfactory atmosphere in a somewhat caricatured manner (to create a grassy room, a sweet room, and a woody room) their participants ($N = 500$) rated a glass of whisky as tasting 10–20% more grassy on the nose, sweeter on the palate, and/or textured on the aftertaste as a function of the multisensory atmosphere in which the whisky was rated. Meanwhile, in another study, Spence et al. (2014) combined red/green lighting with sweet/sour sonic seasoning (i.e., music that had been specifically composed in order to match a specific taste) in order to deliver a 15–20% change in the ratings of over 3000 people who evaluated a glass of red wine served in a black tasting glass. And while the majority of that effect could be put down to the change in the ambient lighting (from red to green or vice versa), these researchers were able to show that adding congruent music led to a significantly larger change in people's rating of the drink.

Wansink and van Ittersum (2012) tested the impact of changing both the lighting and music on diner behavior in a restaurant. There were two dining areas in Hardee's, a North American fast food restaurant. The lighting in one was set at its normal bright level, the color scheme was also bright, and the background music was loud. The other "fine dining" environment had a much more relaxed atmosphere with pot plants, paintings on the wall, blinds on the windows, and indirect lighting. The tables were covered with white-tablecloths and there were candles and soft jazz instrumental ballads in the background. Those who ate in the more relaxed side of the restaurant rated their meal as significantly more enjoyable, while at the same time consuming less (their calorie intake was reduced by an average of more than 150 calories, or 18%). Sester et al. (2013) reported on a couple of studies showing that they were able to bias which beer people chose at a bar by means of different immersive audiovisual environments.

Finally, here, it is important to note (once again) that not everyone has demonstrated an impact of multisensory atmospheric cues on the tasting experience. Jiang et al. (2017), for instance, recently reported that changing the visual atmospherics in a room (introducing flowers, pictures, and colored lighting) did not influence people's ($N = 105$ wine consumers) rating of a red wine. One atmospheric condition had a floral theme, the other, a "green" theme, with the researchers wanting to know whether they could bring out the floral or green notes in the three Cabernet Sauvignon wines that the participants got to taste. Taken together, though, the limited evidence published to date clearly supports the view that the multisensory atmosphere can influence people's taste/flavor perception, their choice behavior, and even how much they end up consuming. When thinking about the design of multisensory atmospherics, the aim is normally to try to ensure that the various sensory cues converge on a particular feeling or mood (Spence 2002; cf. Helmefalk and Hultén 2017). At the same time, however, it is also important to make sure that the combined pattern of multisensory stimulation does not give rise to sensory overload (Malhotra 1984; cf. Rupp 2014).

Sensory Marketing Versus Sensory Nudging

Before closing, it is worth drawing out the tension that can be seen to exist here between the sensory marketing approach to the design of retail atmospherics and the emerging sensory nudging approach to modifying the food environment/landscape.

The stated aim of sensory marketing is, not to put too fine a point on it, to get consumers to buy more "stuff" (e.g., Cooper 2013; Hilton 2015; Lipman 1990; Stevens 1980). To the extent that such strategies are successful, they presumably encourage many of us toward consuming (or at least purchasing) more food and beverage products than perhaps we otherwise might. Intriguingly, one of the few complaints resulting from the release of ambient scent occurred was when a cookie aroma was emitted from bus shelters in California some years ago. The suggestion was that this was insensitive to the homeless who often use such shelters for shelter (Cuneo 2006). By contrast, the stated aim of sensory nudging is to try and help the consumer toward making slightly less unhealthy food choices/behaviors. Achieving that goal is not always as easy as one might wish. For example, Kroese et al. (2016) reported that moving the fruit closer to the till in a supermarket food outlet did indeed nudge customers toward buying more fruit than they otherwise would have done. Unfortunately, however, the consumers also bought the same amount of the less healthy foods as before, thus meaning that this particular nudge led to an increase in the overall amount of food purchased. Not exactly the ideal outcome!

When thinking about the relation between sensory marketing and sensory nudging, it is also worth drawing attention to the fact that sensory marketers often argue that their effects operate at a non-conscious level (see North et al. 1997, 1999; Zellner et al. 2017, for evidence on this score). As such, the consumer may not be aware that their perception/behavior is being affected and hence will, as a result, presumably find it difficult to ignore such effects voluntarily (i.e., at will). By contrast, time-and-again the proponents of nudging (be it of the choice architecture or sensory variety) stress the "libertarian paternalism" underlying their approach (Mathis and Tor 2016; Thaler and Sunstein 2008). Specifically, they want to emphasize that their interventions are for the "greater good" and that they rely on inertia on the part of the consumer/general public. But the key point to remember is that they are said to operate at a conscious level and hence can be ignored or overridden at will (i.e., it is not a matter of removing any choices or options, but rather on making the default choice/behavior the easiest one).

While the majority of the commercial sensory marketing research would appear to have been directed toward increasing sales, it is worth noting that modifying the auditory atmosphere (e.g., by playing the sounds of the sea) has been shown to play a potentially beneficial role in terms of improving the nutritional intake among older patients (Ragneskog et al. 1996) and even psychiatric patients (Goddaer and Abraham 1994, p. 150). The suggestion in the latter case was that the music helped relax the agitated patients and by so doing resulted in their consuming more. There is an emerging literature on enhancing the multisensory design of hospital/care facilities more generally, and part of that revolves around ensuring adequate nutrition through environmental manipulations (see Spence 2017b). In this case, some of the techniques would appear to come straight out of the sensory marketing textbooks but to have an aim (enhancing people's well-being) that is more in line with the principles underlying the sensory nudging approach. Indeed, looking to the future, there may be a fruitful interplay between marketing and nudging, using the most effectively techniques of marketing to more effectively nudge the nutritional behavior of the consumer.

Conclusions

Most people believe that they are in control of their eating and drinking behavior, that they decide what to eat and drink and when, and that they choose when to stop. However, the research that has been published over the last half a century or so clearly demonstrates that atmospheric cues (no matter whether they are auditory, visual, olfactory, tactile, gustatory, or multisensory) can exert a significant influence over many aspects of our eating and drinking behavior. What is more, sometimes at least they can do so without consumers having any awareness that their behavior has been influenced (e.g., see North et al. 1997, 1999; Zellner et al. 2017). So, to the extent that one believes in the power of the sensory marketing approach (see Spence 2015a, on this point), we should all perhaps be rather more concerned about the potential danger of being encouraged, almost subliminally (Spence 2012b), to eat and drink more than perhaps we should (cf. Spence et al. 2016). (Here, it is worth noting that while much of the research on atmospherics has been conducted on student populations (the so-called WEIRDo's; Henrich et al. 2010) in laboratory studies (and hence are of questionable real-world relevance), there are now a growing number of studies demonstrating similar effects in naturalistic environments too.) On the flip side, however, there is also growing interest in the intelligent modification of environmental sensory cues (not to mention the "choice architecture" in those situations where food choices are salient) in order to try and nudge us toward healthier food behaviors (e.g., Guthrie et al. 2015; Kroese et al. 2016; McKie 2017; Campbell-Arvai et al. in press). In the future, it will be interesting to see how "the good and the bad" sides of multisensory atmospheric design play out. And no matter how things turns out, one clear end result would appear to be that people become more aware of the power of atmospheric effects to bias their eating and drinking.

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Social Influences on Eating

14

Suzanne Higgs and Helen Ruddock

Contents

Abstract

Eating plays a central role in many social activities, and there is ample evidence to suggest that social context exerts a pervasive and powerful influence on what, and how much, people eat. This chapter presents an overview of the research on social influences on eating, with a specific focus on three main areas. First, we present evidence that people tend to adapt their food choices to those of other people, which is known as modelling. Second, we discuss evidence that people use their eating behaviors to convey a favorable impression of themselves to other people, which is known as impression management. Third, we present evidence on the social facilitation of eating, which is the tendency for people to eat more when eating with friends/family than they do

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when they eat alone. Throughout the chapter, we discuss the factors which may moderate the strength of these social influences on food intake and consider the mechanisms through which social influences affect eating.

Introduction

Eating is often a social activity. Sharing a meal with friends, family, or work colleagues is common in many areas of the world including the USA, Europe, and Thailand (Oh et al. 2014; Davidson and Gauthier 2010; Yiengprugsawan et al. 2015). Indeed, some people would consider that a meal that is not shared is not really a meal at all (Fischler 2011). Eating with others plays a role in reinforcing social connections, and food choices can be used to communicate and express ourselves to others (Murcott 1983). The social context in which we eat or make food choices also influences what and how much we choose to consume. A large body of evidence has now accumulated to suggest that other people influence our food intake and choices in a variety of ways (Higgs and Thomas 2016). For example, there is a general tendency for people to use others' eating as a guide for what and how much to eat, which is known as modelling. People also use their eating behavior to convey a particular impression of themselves to others and may make particular food choices because they think those choices will portray themselves in a favorable light, which is known as impression management. Another example of how social context affects eating is that when eating in a group of friends, people are likely to eat more than they would if they ate alone, which is known as the social facilitation of eating. The aim of this chapter is to present an overview of research into social influences on eating. We consider the three main research areas of (1) modelling of eating, (2) impression management, and (3) the social facilitation of eating.

Modelling of Eating Behaviors

The decisions that people make about what and how much to eat are influenced by their perceptions of the choices of others. The tendency to adapt one's behavior to be similar to that of other people is known as modelling (Vartanian et al. 2013). It has been suggested that modelling occurs because other people provide a guide as to appropriate behavior (Herman et al. 2003). The appropriate behavior, or what is known as a social norm, can be set by another present person (i.e., another person present at the eating occasion), but may also be communicated by environmental cues (e.g., portion sizes) or by the transmission of information about how other people behave (e.g., messages/text describing the behavior of others). A robust finding from studies conducted in controlled laboratory settings is that both adults and children model the consumption of others. That is, they tend to consume *more* when they eat with someone who is eating a large amount and *less* when they eat with someone who is eating a small amount, compared with when they are eating alone (e.g., Bevelander et al. 2012; Robinson et al. 2013; Salvy et al. 2008).

There is evidence from lab-based experimental studies that people also model the food choices of others. A study of food choices at a buffet found that the choices made by a confederate (a person known to the experimenter who was pretending to be another participant in the study) influenced the food selection of participants who observed these choices. Relative to a choosing-alone condition, and a condition in which the confederate chose predominantly low-calorie food items, the presence of a confederate who made high-calorie choices resulted in the participants choosing and consuming significantly fewer low-calorie items (Robinson and Higgs 2013). Conversely, choice of low-calorie vegetable items at a buffet was increased after students who were low habitual consumers of vegetables were informed about the relatively high vegetable consumption of other students (Robinson et al. 2014). However, Pliner and Mann (2004) found that when the communicated norm was consumption of a "healthy" bad tasting cookie, participants in a lab-based experiment were not inclined to follow this norm and instead chose to consume an "unhealthy" but good tasting cookie. These data suggest factors such as the palatability of food may override the influence of social norms under some circumstances. If someone is sure of what they like to eat, then that person may not look to others to guide their own preferences.

Evidence from field studies supports the suggestion that people do model the food choices of others outside of the laboratory. Teenage girls who shopped with a peer who made high-calorie purchases were more likely to purchase high-calorie food products relative to girls who shopped with a peer who made low-calorie choices (Bevelander et al. 2011). Diners in a restaurant were more likely to make healthier choices when they were provided with information about the healthy choices of other diners in that restaurant (Mollen et al. 2013; Thomas et al. 2017; Collins et al. 2019). Christie and Chen (2018) reported recently that customers in a restaurant modelled the main lunch choices of the person ahead of them in the lunch queue; customers were more likely to choose a vegetarian option if the person in front of them in the lunch queue chose that option.

Data from observational studies further support the idea that modelling of food choices occurs in real-life social relationships. It has been noted that the diets of socially connected individuals tend to be correlated and that people's eating choices are similar to the eating choices of those with whom they are socially connected (de la Haye et al. 2013; Pachucki et al. 2011). For example, it has been reported that women who dined more often with healthy eaters reported a higher diet quality than women who shared meals more frequently with unhealthy-eating companions (Mötteli et al. 2017). In addition, it has been observed that food choices of married couples tend to converge over time (Bove et al. 2003).

Why Model?

One reason why people model the eating behavior of others is because imitating the behavior of another person serves to smooth the social interaction (Chartrand and Bargh 1999). Humans have a strong desire to be liked and this goal may be achieved through modelling (Baumeister and Leary 1995). As the saying goes, imitation is the sincerest form of flattery. The idea that people model the eating behavior of another person in order to affiliate with that person is supported by evidence that traits linked to the need for affiliation, such as self-esteem and empathy, are associated with the tendency to model food intake (Robinson et al. 2011). In addition, modelling of eating behavior has been found to be particularly pronounced in social situations that demand effort to affiliate (e.g., in a situation in which the model is acting in an unsocial manner), relative to situations in which there is less of a need to ingratiate oneself (e.g., when the model is already acting in a friendly manner) (Hermans et al. 2009; Robinson et al. 2011). The results of these studies are consistent with the idea that modelling is a means of gaining acceptance from others (Higgs 2015).

Modelling also occurs because others provide information about what is the "right" way to behave and people are generally motivated to behave in a way that is "correct" (Deutsch and Gerard 1955). We know this because modelling can occur in situations where the social norm is conveyed by *information* about how other people have behaved rather than by *another present person*. In these situations, modelling cannot promote affiliation or a sense of belonging, because there is no other person present to impress. One type of study design that examines how people behave when exposed to such "informational social norms" is known as the remote confederate design. In these types of studies, participants "accidentally" see fictitious accounts of the amount of food consumed by previous participants in that study (e.g., see Feeney et al. 2011; Pliner and Mann 2004; Roth et al. 2001). Amounts consumed by previous participants in a study can also be communicated via cues such as empty food wrappers (assumed to have been left by previous participants) or by text-based descriptive norm messages conveying information about the eating behavior of others. In all cases, there is evidence that people follow the norm provided. For example, people are more likely to choose a "healthy" versus "unhealthy" food item if they see evidence that previous participants have chosen "healthily" (Prinsen et al. 2013), and they are more likely to choose a large amount of cookies to eat if they see that other participants have done so and choose a small amount of cookies if that is the norm in that situation (e.g., Robinson et al. 2013; see Fig. 1). In these cases a likely explanation for the modelling observed is that the normative information that is provided indicates the "right" way to behave (e.g., Roth et al. 2001).

According to the normative account of modelling (Herman et al. 2003), people are often motivated to eat as much palatable food as they can without appearing greedy. In a social situation, the amount that one can eat without appearing to be eating excessively is set by the amounts that other people are eating such that a dining companion with a small appetite will result in a person eating very little, whereas dining with someone who is eating a large amount gives a person license to eat a large amount too. Data to support the normative account come from a study which found that perceived norms of appropriate intake mediated the effects of the social model on participants' food intake (Vartanian et al. 2013).

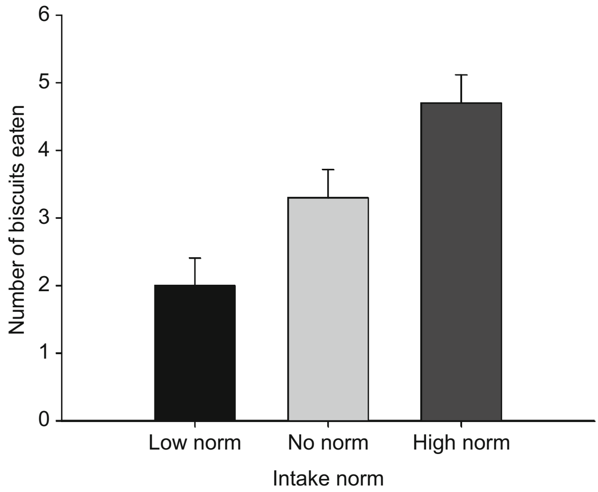

Fig. 1 Number of cookies eaten according to condition: participants eat fewer cookies in the low norm condition compared with the no norm condition, and they eat more cookies in the high norm versus the no norm condition. (Adapted from Robinson et al. 2013)

Factors that Affect Modelling

The results of two systematic reviews of a large collection of studies suggest that modelling of eating behavior is not dependent on current hunger state, dieting status, or familiarity with the model (Cruwys et al. 2015; Vartanian et al. 2015) (Fig. 2). However, there are some circumstances under which modelling is less likely to occur. If the model is from a social group that the participant does not feel a strong connection with, or the model is perceived as dissimilar to the participant, then modelling is reduced (McFerran et al. 2010; Stok et al. 2014; Cruwys et al. 2012; Liu and Higgs 2019). This is probably because the model is not thought to provide a relevant norm. For example, when participants were told that the size of a portion served was based on the behavior of group to which they did not belong, they were less likely to use that portion size as a guide to appropriate consumption (Versluis and Papies 2016).

Modelling is also less likely in situations for which there are established eating habits (Hermans et al. 2010; Leone et al. 2007). There is evidence that people are less likely to model the breakfast consumption of others than they are to model snack intake (Hermans et al. 2010; Leone et al. 2007). Many people have a clear idea about what constitutes appropriate consumption at breakfast as it is an habitual behavior, but they are perhaps less sure about what is "normal" when it comes to snack consumption and so more likely to use the behavior of others to guide their own intake.

Mechanisms Underlying Modelling

The mechanisms underlying modelling have not been fully elucidated, but it is possible that people directly mimic the behavior of others by copying their actions, a tendency that may occur automatically and outside of conscious awareness

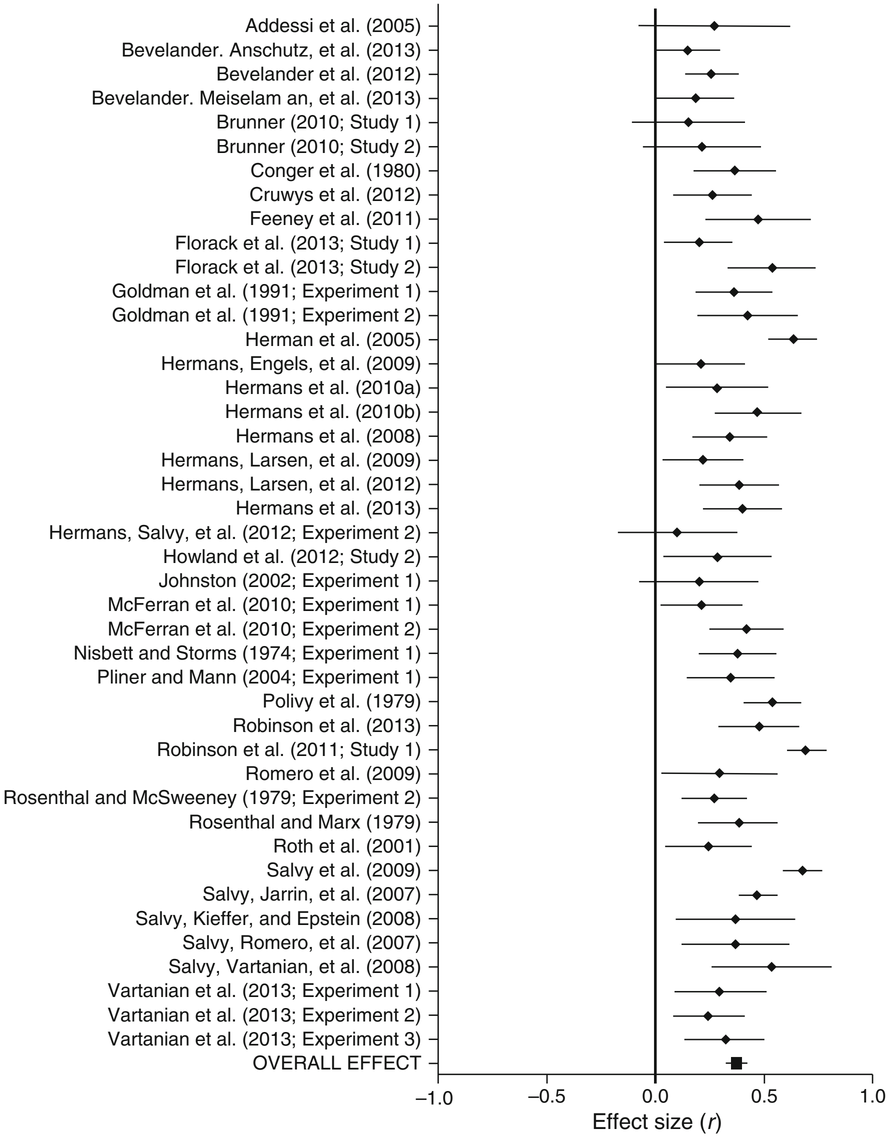

Fig. 2 Forest plot of effect sizes for all studies included in the meta-analysis. For ease of presentation, an average effect size is provided for each individual study. (Source: Reprinted from Vartanian et al. 2015, with kind permission from Elsevier Science Ltd., The Boulevard, Langford Lane, Kidlington OX5 1GB, UK)

(Chartrand and Bargh 1999). In support of this idea, it has been reported that co-eaters coordinate their eating-related actions and take a sip of a drink or reach for food immediately after a model performs the same behavior (Hermans et al. 2012; Sharps et al. 2015). There may also be some explicit tracking of the consumption of another person that facilitates modelling (Vartanian et al. 2013).

Modelling may be facilitated by changes in preferences for food/drink items. Bringing behavior in line with a norm has been reported to be a rewarding experience (Nook and Zaki 2015), and eating in the presence of someone else has been shown to enhance the pleasure derived from eating (Boothby et al. 2014). If we are told that our peers have a preference for a specific food, then we expect to like it too (Robinson and Higgs 2012). These data suggest that modelling is a behavior that is reinforced because it has positive consequences.

Impression Management

Impression management is when we behave in a particular way to convey a specific impression of ourselves to others (Leary 1995). Impression management concerns are usually highest when we are interacting with people whom we do not know very well, and in these situations we are usually motivated to present ourselves in a positive light (Baumeister and Leary 1995). One way in which we can manage the impression we give to others is via the decisions we make about what and how much to eat (Vartanian et al. 2007). This is because we hold shared assumptions with others about the characteristics that are associated with people who make certain consumption choices. These assumptions are known as consumption stereotypes. We tend to make judgments about others based on these stereotypes, but we also use them to manage others' perceptions of ourselves (Vartanian et al. 2015). For example, we may choose to eat a salad over a pizza in some social situations because we know that eating the salad will convey something to those around us about our personality. Interestingly, even children have been found to judge others based on their food choices and to make negative judgments about people who deviate from conventional eating habits (DeJesus et al. 2019).

Consumption Stereotypes

There is ample evidence that certain foods and food choices are associated with specific characteristics, particularly attributes associated with gender. For example, meat eating is associated consistently with masculinity (Rozin et al. 2012; Rothgerber 2013), whereas meat avoidance and consumption of vegetables, salad, fish, and sweet foods are associated with femininity (Cavazza et al. 2015; Jensen and Holm 1999; Rothgerber 2013; Ruby and Heine 2011). In general, eating "good/healthy" foods is seen as feminine, and eating "bad/unhealthy" foods is seen as masculine. Men who ate "bad" foods (i.e., high-calorie foods thought to be bad for health) were rated as more masculine (and less feminine) than were men who ate "good" foods (i.e., low-calorie foods thought to be good for health) (Stein and Nemeroff 1995). Consumption of low-fat foods is seen as more feminine and less masculine than is eating high-fat foods (Barker et al. 1999). This may be because people automatically think of foods as either feminine or masculine and attribute these characteristics to the eater (Kimura et al. 2009). Similarly, consumption of "good" foods may result in the eater being perceived as having a "good" character.

People who eat “good” foods are perceived as being “better” people than are those who eat “bad” foods: they are rated as more attractive, healthier, more moral, and more intelligent than are consumers of “bad” foods (Stein and Nemeroff 1995). On the other hand, consumers of “good” foods are also judged as more serious and less likable (Barker et al. 1999), whereas consumers of “bad foods” are perceived to be fun-loving, happy, and sociable (Barker et al. 1999).

People also hold stereotypes about the characteristics associated with eating small versus large amounts of food. Eating a large portion is associated with masculinity and eating small portion is associated with femininity (Bock and Kanarek 1995). Women who eat small meals are rated as more attractive than are women who are depicted eating large meals (Chaiken and Pliner 1987; Bock and Kanarek 1995).

Do Consumption Stereotypes Guide Behavior?

The majority of studies on eating and impression management have focused on the consumption stereotypes that people hold rather than investigating whether these consumption stereotypes actually explain eating choices. However, some studies have found that women tend to eat lightly in the company of men, and this may be motivated by attempts to portray an impression of femininity and behave in a socially desirable manner (e.g. Pliner and Chaiken 1990; see Table 1). Cavazza and colleagues (Cavazza et al. 2015) reported that women’s intentions to consume particular dishes were influenced by the perception of the dish as feminine or masculine: women reported that they intended to consume a small portion of salad when it was elegantly presented, because they perceived it to be more feminine. There is also evidence that the food choices made by men may be motivated by impression management under some circumstances (White and Dahl 2006; Gal and Wilkie 2010). In one study, participants were asked to imagine that

Table 1 Mean cracker consumption as a function of participant sex and partner sex. Females but not males ate less in the presence of a desirable partner than in any other conditions. (Source: Reprinted from Pliner and Chaiken 1990, with kind permission from Elsevier Science Ltd., The Boulevard, Langford Lane, Kidlington OX5 1GB, UK)

		Male subjects		
		High desirability	Low desirability	Combined
Sex of partner	Male	12.5(11)	17.3(14)	15.2(25)
	Female	14.3(15)	12.4(9)	13.6(24)
		Female subjects		
		High desirability	Low desirability	Combined
Sex of partner	Male	8.8(10)	12.1(14)	10.7(24)
	Female	12.5(13)	14.0(10)	13.2(23)

Note. Amounts are expressed in terms of number of crackers. *N*’s are in parentheses they had been in workshops all day as part of a training course and that they were planning to order from the room service menu for dinner. To encourage choice of a small steak, the participants were told: “You aren’t feeling too hungry because you had a late lunch; however, you are tempted to select steak for dinner.” They were then asked to select from a hypothetical menu and to evaluate each menu option. Men were less likely to choose a small steak (versus a large steak) when it was described as a ladies’ cut than when it was described as a chef’s cut, but only when they thought they would be eating the steak in public and not when they thought they would be consuming it in private, which suggests that their choice was motivated by the effects they thought their choice would have on others (White and Dahl 2006). In another study, men who had their masculine identity challenged as part of the study were less likely to choose stereotypically feminine foods, compared with those who had their masculine identity affirmed, perhaps because they were motivated to counter the challenge to their identity using their food choices (Gal and Wilkie 2010).

Social Facilitation of Eating

The mere presence of other people at a meal can result in increased food intake relative to eating alone, which is known as the social facilitation of eating. The first studies that documented the social facilitation of eating were food diary studies that involved participants recording what and how much they ate over 7 days and with whom they ate (de Castro and Brewer 1992; de Castro and de Castro 1989). It was a surprise to the researchers that one of the most significant influences on food intake was the social context in which people said they ate: people reported eating much more food when they ate in company than when they ate alone. Social facilitation appears to occur at all meal types including breakfast, snacks, meals eaten at home, and meals eaten without alcohol (de Castro 1991). Social facilitation also occurs for meals eaten at the weekends and weekdays. These findings are particularly interesting because they suggest social facilitation of eating is not an artifact that arises because people eat more, and are more likely to eat with others, during certain meals/eating occasions, e.g., meals taken at the weekends or meals taken with alcohol (de Castro 1991).

The conclusions based on the data from diary studies have been corroborated by results obtained from studies examining social facilitation within laboratory and field settings. For example, Berry et al. (Berry et al. 1985) found that participants ate much more ice cream in three- or four-person groups than when alone. Similarly, Klesges et al. (1984) found that people dining out in a restaurant ate more in groups than when eating alone. Evidence to support the suggestion that eating in a group facilitates intake comes from numerous studies employing different methodological approaches (see Herman (2015) for a review). However, it is important to note that social facilitation of eating is confined to meals that involve friends/family (see Fig. 3).

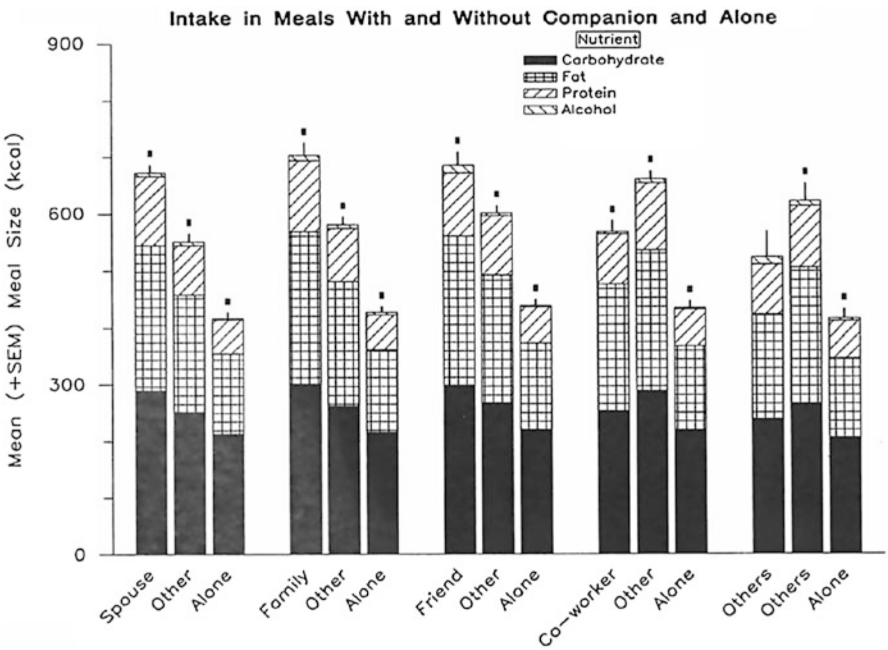

Fig. 3 Mean (± SEM) amounts (kcal) ingested per meal of carbohydrate (solid portion of each bar), fat (crosshatched portion), protein (hatched upward), and alcohol (hatched downward) for meals eaten with a particular companion type (first bar of each set of three), with others but not that companion type present (second bar of each set of three), and alone (third bar). The above the bar indicates a significant difference ($P < 0.05$) between the total meal sizes as assessed with a *t*-test. The above the first bar signifies the "with companion-with other" comparison, above the second bar signifies the "with other-alone" comparison, and above the third bar signifies the "with companion-alone" comparison. (Source: Reprinted from Physiol. Behav., 56(3), J.M. de Castro, Family and friends produce greater social facilitation of food intake than other comparisons, 445–455, 1994, with kind permission from Elsevier Science Ltd., The Boulevard, Langford Lane, Kidlington OX5 1GB, UK)

When Does Social Facilitation of Eating Occur?

Social facilitation of eating appears to occur only in groups of people who are known to each other (de Castro 1994). When people eat in a group of strangers, they may actually eat less than they would if they were eating alone (e.g., Hetherington et al. 2006; Péneau et al. 2009). When eating in a group of strangers, some people may restrain their intake to convey a positive impression (and avoid appearing "greedy"), and this tendency to restrain may be the overriding factor affecting total intake. In other words, social facilitation of eating in this context is trumped by impression management concerns (Herman 2015). Impression management concerns, and in particular, concerns about the stigma associated with appearing to eat excessively, might also explain why people with obesity have been observed to consume fewer calories in a group than when dining alone (Krantz 1979; Schüz et al. 2017).

Similarly, an observational study found that, unlike males, female diners eating in larger mixed-sex groups did not eat more than those eating in same-sex pairs (Brindal et al. 2015). This may be because they are restricting their intake to convey a feminine impression (Pliner and Chaiken 1990).

Why Does Eating in a Group Facilitate Consumption?

Several explanations for the social facilitation of eating have been forwarded, but to date few studies have formally examined the underlying mechanisms. One explanation that has been suggested is that social meals are longer than are solo meals and this extended meal duration provides greater opportunity for eating (e.g., Feunekes et al. 1995; Pliner et al. 2006). However, this explanation does not account for the fact that, in order for people to eat more, there is probably more food available at social meals. Indeed, given that most people tend to clear their plates (Hinton et al. 2013), it is unlikely that lone eaters serve themselves (or order) the same amount of food as social eaters, but do not finish all of their portion. A more likely explanation is that people anticipate that they will eat more at social meals, and so they plan to provide more food or order more food when they know they will be eating socially (Herman 2015). In support of this idea, Cavazza et al. (2011) observed that customers in a restaurant ordered more dishes as the number of people in the party increased. In other words, more food was made available for consumption in larger versus smaller groups. However, this social "precilitation" hypothesis remains to be investigated experimentally.

Another explanation of the social facilitation of eating that has yet to be formally tested is that social context affects eating via its effects on hunger, satiety, or food reward. For example, social facilitation may be due to an increased "liking" for foods eaten socially. This is supported by evidence that eating in company enhances food palatability (Boothby et al. 2014). Furthermore, social interaction during social meals may distract people from monitoring how much they are eating or their awareness of internal cues that might inhibit eating. Indeed, one study found that people spent longer looking away from their meal and ate more food, when eating with a friend, relative to when eating alone (Hetherington et al. 2006). Another possibility is that meals eaten alone are smaller than are social meals because eating alone is not as enjoyable as eating with company. However, there is only indirect evidence in support of this assumption. de Castro (1990) found that people were generally happier when eating with others than when eating alone, but his analysis found that mood and the number of people present contributed independently to variance in intake.

Conclusions

Social context plays an important role in determining what, and how much, we eat. Research has highlighted the tendency for people to model their food intake on the consumption patterns of other people, to eat *more* when with friends/family relative to when alone, and to use food to convey positive impressions to others. While the relative contribution of each of these factors varies across individuals and situations, together they exert a pervasive and powerful influence on food intake.

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Conflict of Interest Suzanne Higgs and Helen Ruddock declare they have no conflict of interest.

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Satiety

15

Martin R. Yeomans

Contents

Abstract

When we consume any nutritive product (i.e., foods or drinks), those ingested nutrients provide signals that act to reduce our desire to eat and drink for some time after consumption. This is captured by the concept of satiety, the state of

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inhibition of appetite post-ingestion. Likewise, our desire to eat decreases during a meal, and the processes which lead to that reduction are referred to as satiation. Simplistic models have traditionally interpreted satiation and satiety simply as a function of ingested nutrients. However, there is now an abundance of evidence that both satiation and satiety are influenced by multiple factors, including beliefs and information about products prior to ingestion, the specific sensory characteristics of the product experienced during ingestion, and the volume, weight, macronutrient profile, and energy density of the consumed product and the social context in which food is ingested. Thus satiation and satiety are viewed as the product of a cascade of signals which interact to generate the overall satiety state. Expectations about how filling a product will be modifies portion size selection and influences subsequent satiety. Sensory cues such as oral processing time and flavor intensity modify satiation, while liking for the consumed product, but not unrelated products, decreases. Once ingested, gut-based signals, including the release of satiety hormones stimulated by nutrient sensing, interact with cognitive and sensory cues from ingestion to produce satiety. But how much individuals respond to these cues varies, with weak satiety responsiveness a risk for subsequent weight gain. Overall, satiation and satiety are highly complex phenomena, but our increased understanding of this complexity paves the way for the food products of the future.

Introduction

Why and when we initiate and end a particular eating episode involves highly complex processes, yet the outcome of decisions about what, when, and, critically, how much we eat ultimately determines our overall intake. Satiety, the state of inhibition of our desire to eat in the period after ingestion, is one of the key motivational processes controlling the amount we consume. Behaviorally, the importance of satiety can be seen in the patterning of meals, where consumption of large meals may be followed by longer intervals before eating again and/or subsequent smaller meals, although it is important to recognize that satiety is just one of the many factors underlying decisions on what, when, and how much to eat (de Castro 2013). This chapter sets out to summarize our current understanding of satiety from a sensory, psychological, and physiological perspective.

Defining Satiety

Satiety has been an important concept underpinning theoretical models of appetite control for as long as researchers have tried to explain what makes us start and stop eating. The idea that the brain has separate “centers” for hunger and satiety (Stellar 1954) was one of the most influential neural models of appetite control, and although neural models of satiety have moved away from the concept of a “center” per se to a more complex and detailed neural network approaches involving feedback and feedforward processes (see Andermann and Lowell 2017; Berthoud 2011), the basic premise of a key role for satiety in determining overall intake is enduring. Surprisingly, however, the precise definition of satiety is subject to debate. Even dictionaries struggle to give a consistent definition: Webster's defines satiety as the quality or state of being fed or gratified to or beyond capacity (Satiety 2006); the Cambridge English gives a broader definition of "the state of being completely satisfied, especially with food or pleasure, so that you could not have any more" (Satiety 2012); and Oxford English defines satiety as the "feeling or state of being sated" (Satiety 2012), a definition which requires an understanding of "sated" and which is close to a circular argument! What these attempts have in common is that satiety represents a markedly reduced desire to eat, in contrast to hunger, the desire to eat. But the subtle differences in meaning reflect considerable confusion in the lay and scientific literature about the nature of satiety, probably arising from the inherent complexity of the factors that are involved in the suppression of appetite. The current separation of the processes leading to meal termination (satiation) and the inhibition of appetite post-ingestion (satiety) was largely founded in the detailed analysis of animal feeding patterns (Le Magnen 1971). Both satiation and satiety are now recognized to reflect a multitude of influences arising from cognitive, sensory, post-ingestive, and postabsorptive signals arising as the stimuli from the ingested food are detected at various stages of the ingestive process, from the first sight of food to the final stages of processing of the ingested nutrients (Bellisle and Blundell 2013). It is probably this complexity that has made satiety such a debated phenomenon, but the current consensus suggests satiety is best defined as the suppression of appetite after the termination of ingestion, with satiation defined as the processes leading to the cessation of ingestion.

The Satiety Cascade

Although a lay interpretation of satiety might be that it reflects our awareness of the presence of ingested nutrients in our gut (i.e., our awareness of a state of "being full"), a plethora of data argue against such a simplistic model. The multifactorial nature of satiation and satiety was captured elegantly by John Blundell and colleagues (1987) over 25 years ago. Their initial "satiety cascade" model has subsequently been refined as more has been learned about the signals that modify satiety into a widely cited descriptive account of the multiple factors that interact to generate satiety (Fig. 1) and has been the subject of several more recent reviews (Blundell 2010; Tremblay and Bellisle 2015), which provide more detailed descriptions. Blundell and colleagues highlighted that even before food arrived in the gut, cognitive and sensory signals generated by the sight and smell of food, and by the sensory experience of food in the oral cavity, influenced not only how much was eaten at that eating episode (moderating satiation) but also afterwards (influencing satiety). In their descriptive model, satiety then is the sum of the effects of sensed signals from ingestion which suppress appetite. This approach further recognized

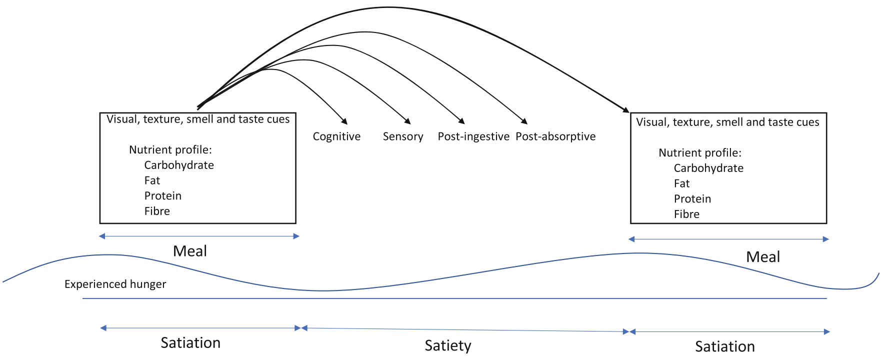

Fig. 1 The satiety cascade. (Blundell 1995)

that satiety does not reflect an absolute state of inhibition over eating, evincing the common experience that even when feeling "full" after eating a large meal, it remains hard to resist a particularly tasty morsel.

Measuring Satiation and Satiety

How satiation and satiety can be measured in humans has been the subject of a detailed recent review (Forde 2018). In studies with humans, satiation is indexed in some way by measuring behavior during an eating episode. Since satiation is defined as the process leading to the cessation of eating, the amount of food consumed at a particular eating episode can be used to infer satiation. For example, if we contrasted intake of two or more products differing on a dimension that theoretically might relate to the processes that generate satiety (example might include the overall energy density of the product or the relative amount of protein or fiber it contains, etc.), and people voluntarily consumed less of the version that contained more of the component predicted to impact satiety, we could interpret that as support for the role of the manipulated component on satiation. In practice, however, changing the level of any ingredient that might impact satiation may also alter other features of the product which in itself might impact intake. The biggest potential confound is palatability: people reliably consume more of products that they find more palatable (Yeomans et al. 2004). How then to dissociate whether altered meal size is due to altered satiation or palatability? One approach has been to incorporate more detailed behavioral measures, such as the rate of eating, bite size, and the intensity of self-reported measures of appetite collected within that meal (Yeomans 2018). These measures allow further inferences about the mechanisms that drive satiation, allowing satiation to be separated from other influences, such as the enhancement of appetite by palatability. Typically, altering palatability modifies the initial increase in appetite when food is first tasted, whereas satiation is reflected more in the rate at which appetite declines as a meal progresses, and these effects are behaviorally dissociable.

The assessment of satiety also involves measuring appetite and food intake, but now this is in the period after a particular ingestive episode. The general study design used here is widely described as a "preload" experiment, with the impact of a fixed amount of one food (the preload) measured by assessing appetite in the period after ingestion. By altering different aspects of the test preload (e.g., macronutrient profile, caloric content, energy density, sensory characteristics, labelled information, etc.), it is possible to explore how different features of that product influence satiety. After the preload has been ingested, satiety can be inferred by the suppression of appetite, relative to an appropriate control, in the period immediately after preload. Appetite ratings have been used widely to assess satiety, and the questions which should be asked are standardized to allow clearer comparisons between studies (Blundell et al. 2010). However, while measures of the subjective experience of satiety have value, the extent to which manipulation of the features of the fixed test preload alters subsequent intake at an ad libitum test meal or meals arguably provides a more objective measure of the likely impact of that manipulation on energy balance. The satiety preload design is one of the most widely used experimental approaches to the study of satiety.

To give some idea of the degree to which different versions of a product generate satiety, the relative reduction in ad libitum intake at a test meal relative to a control can be converted into a measure of compensatory eating or satiating efficiency (Kissileff et al. 1984). As an example, consider how much might be eaten at a test meal consumed 2 h after a preload which contained 100 kcal on the first day and 300 kcal on second day. If on average the test meal was 200 kcal smaller on the day the 300 kcal preload had been consumed, the inference is that the level of satiety that preload had induced was sufficient to allow the consumer to fully compensate for the extra preload energy by adjusting their intake by the exact amount of energy needed to maintain a perfect energy balance. Many studies use a simple equation (the "satiety quotient") to calculate the percentage compensation seen with different foods (Green et al. 1997), and these values in turn can offer insights into the extent that different nutrients, etc. generate short-term satiety signals. Perfect (100%) short-term compensation is rarely seen. A systematic review of 256 studies using the preload method (Almiron-Roig et al. 2013) found an average (median) of only 62% of preload energy compensated for, but the range of outcomes in those studies varied from −370% (undercompensation) to 450% (overcompensation). Thus, short-term compensation is highly variable and affected by numerous factors including the time between the preload and test meal, the form (solid, liquid, etc.) of the preload, and numerous individual difference factors. These variations in turn provide further insights into the factors that drive the experience of satiety.

As food progressively enters the digestive system, the detected nutrients trigger the release of a cascade of chemicals from various cells, many of which are the key enzymes which help break down the ingested nutrients into the form the body needs for processing and storage. Among these chemicals are specific hormones which have been demonstrated to play roles in the gut-based signalling of satiety: cholecystokinin (CCK), glucagon-like peptide 1 (GLP), pancreatic polypeptide (PP), and peptide YY (PYY) have all been demonstrated to involved in satiety signalling

(Zanchi et al. 2017). Our current understanding of the role of these key satiety hormones is discussed later, but the measurement of the circulating levels of these hormones post-ingestion can be useful adjunct measures of satiety, although they cannot be seen as a substitute for behavioral measures (de Graaf et al. 2004).

The Need for Multiple Measures to Assess Satiation and Satiety

Because of their multifactorial and subjective nature, no single measure of behavior or physiology can in itself fully capture satiation or satiety, and so most studies use multiple measures. For example, if we relied solely on food intake as a measure, it is possible that a particular manipulation could cause people to eat less not by enhancing the state of satiety, but by producing other effects which indirectly cause people to eat less, such as inducing nausea. This problem is highlighted in Fig. 2: here two manipulations had almost identical effects on food intake but through different mechanisms. The first manipulation (Fig. 2a) altered the sensory appeal of the

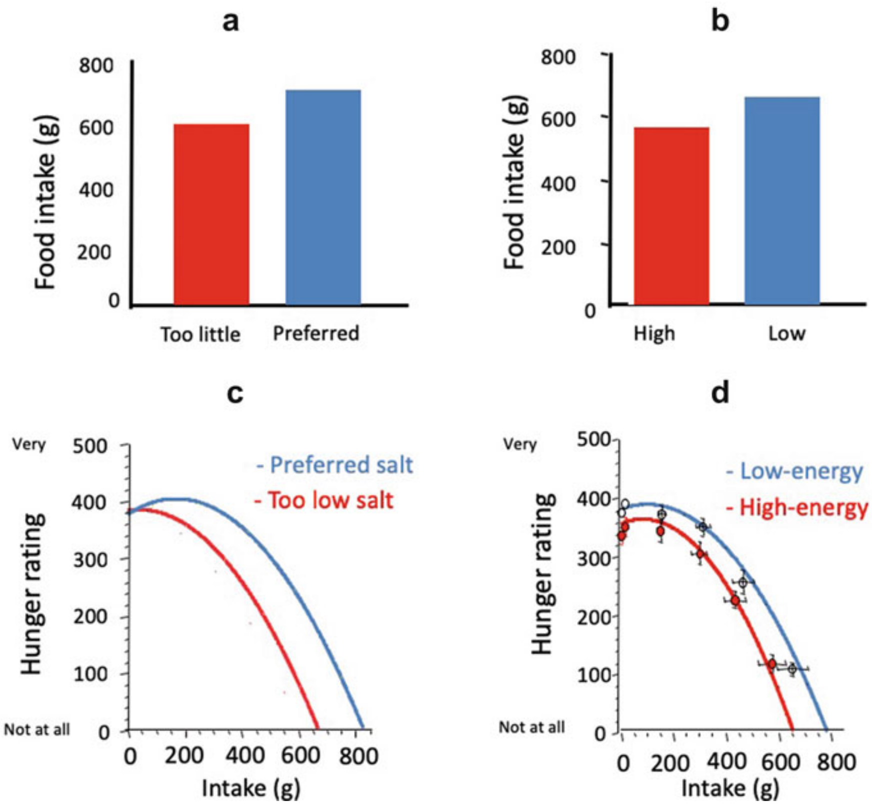

Fig. 2 The effects of manipulating salt content (panels **a** and **c**) or preloading with high- or low-energy soup (panels **b** and **d**) on intake and the rated experience of appetite within a meal

food by modifying salt content, while the second had the same food consumed after either a low- or high-energy soup preload (Fig. 2b: Yeomans et al. 1998). Analysis of the pattern of change in rated appetite within these meals clearly shows different causes for the reductions in intake: when salt content was altered (Fig. 2c), the rated hunger was the same at the onset of eating but increased during the early phase of the meal with the more liked food. In contrast, consumption of a higher-energy soup preload 30 min before the meal resulted in lower hunger at the start of the meal (Fig. 2d), which can be interpreted as satiety. The key point is that manipulations that reduce food intake need to be interpreted with some caution to exclude extraneous causes if we are to truly understand the key drivers of satiety.

Understanding Satiation

What factors ultimately determine the size of an eating event? The widespread lay belief is that meal size is the direct consequence of the accumulation of food in our stomach as we eat: these cues make us feel full and so cause us to stop eating. But in practice, cues from the gut are likely to play a minor role only in determining how much we consume at most meals. How little impact postoral cues have on immediate meal size is illustrated in Fig. 3. These data came from a study where healthy volunteers ate ad libitum, while at the same time, different amounts of soup varying in energy density and volume were infused into their stomach: either a small (150 ml) or large (450 ml) volume of soup with lower (1.4 kJ/ml) or higher (4.2 kJ/

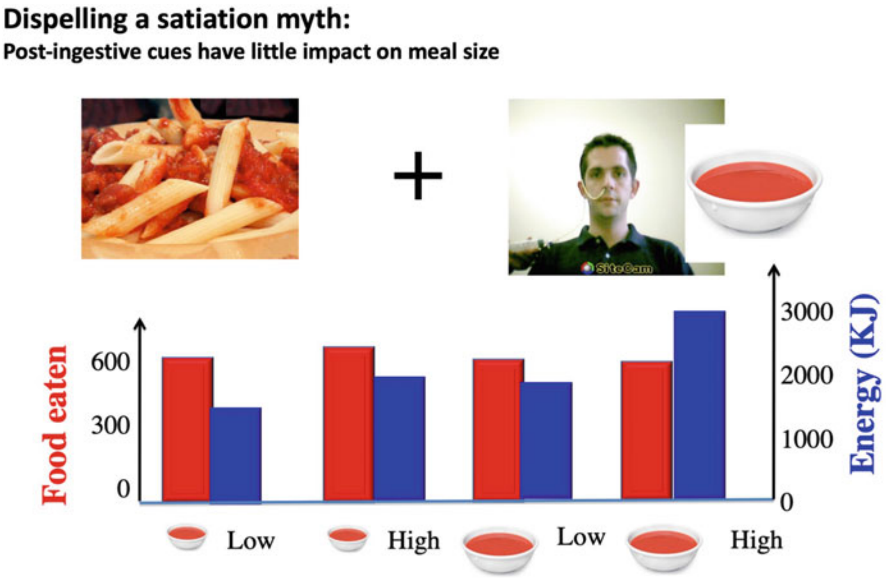

Fig. 3 The effects of intragastric infusions of soup varying in volume and energy density on voluntary intake (red bars) and total energy consumption (blue bars) for a lunchtime meal

ml) energy density (Yeomans 2010). The amount of food consumed was virtually unaffected by these infusions, even though actual energy intake (the sum of food consumed and soup infused) more than doubled from 343 kcal to 702 kcal. One obvious suggestion might be that participants used the served portion as the cue to determine intake, but while portion size is a strong predictor of intake in general, the procedure used in this study prevented participants having an empty bowl. These data and others show that feedback from detection of ingested nutrients probably only contributes to satiation for very large meals, and the general consensus is that normal meal size in humans is determined by a combination of pre-planning, portion size, sensory factors, oral metering, and cues from the social context.

Expected Satiation and Satiety

One of the key cognitive factors now known to influence meal size is the expectations that the consumer has about the product prior to ingestion, which are used to plan the appropriate portion to consume. These expectations have been separated between the expectation of how full the consumer will feel immediately after product ingestion (expected satiation) and the extent to which ingestion will suppress their appetite after a product has been consumed (expected satiety). These expectations are activated by the visual appearance of foods, and perceived volume and variety are some of the visual cues now known to influence these expectations (Brunstrom et al. 2010; Keenan et al. 2015). Likewise, these expectations can be modified by the weight of the serving vessel (Piqueras-Fiszman and Spence 2012), showing that these cognitive components of satiety are malleable beyond the nature of the food itself. But the key food-related factors that drive these expectations include flavor characteristics like creaminess, oral processing time, and the overall protein content and energy density of the product (Forde et al. 2013; McCrickerd et al. 2015).

Both expected satiation and satiety have been shown to modify self-determined portion size (Brunstrom 2011; Forde et al. 2015). Once the portion has been selected, the typical consumer habit is to eat that portion in full: one study found that 91% of meals were consumed in their entirety, and how much was consumed was pre-planned in 92% of cases (Fay et al. 2011). This habit of plate-clearing is likely to explain why people reliably consume more when served larger portions, but the work on expectations also suggests that where the consumer has control of portion size, these expectations can promote appropriate choices.

Satiety-related expectations are a product of the knowledge consumers have about the effects that different foods and drinks are likely to have on their personal experience of satiety (Brunstrom 2011): critically, the mismatch between measures of expected satiety and actual energy content of foods is greater when foods are unfamiliar. Interestingly, evidence suggests that in general we overestimate how filling a novel product will be and then adjust these expectations through a learning process that aligns the expectations more closely with actual nutrient content (Yeomans et al. 2014). In this way, expectations become an important cognitive component of our nutrient regulation.

Sensory-Specific Satiety

In relation to sensory influences on satiation, an important early observation was that although the desire for the specific sensory characteristics of the food being eaten decreases to a point where ingestion stops, other foods with different sensory characteristics retain the ability to stimulate further intake (Rolls 1986), a phenomenon defined as sensory-specific satiety (SSS: see Hetherington and Havermans 2013). SSS as a phenomenon further highlights the importance of sensory control of ingestion: if consumption ended through a generalized inhibition of appetite (as satiety is commonly conceived), then the nature of the food on offer should have little influence. SSS is expressed at the level of sensory characteristics: thus, SSS for a consumed savory food generalizes to other savory items, but sweet items are largely unaffected. In this way, SSS promotes dietary variety and also explains the tendency in human cuisine to serve contrasting courses of food within a meal. The traditional explanation for SSS was that it is a form of habituation to the effects of the sensory characteristics of the food being ingested on appetite, although more recent studies suggest that a simple habituation model is inadequate and SSS may be better characterized as satiation to the sensory characteristics of the ingested food (Hetherington and Havermans 2013).

Specific Sensory Drivers of Satiation

Whereas SSS reflects a broader process of progressive reduction of interest in the sensory characteristics of the food being ingested, another evidence suggests that certain aspects of those sensory characteristics can result in faster or slower satiation, implying a more direct role for some sensory characteristics in satiation. In particular, texture cues have been shown to be important in satiation (James 2018) and in particular that more solid items lead to earlier meal termination than do more liquid items across a wide range of food products (Tucker and Mattes 2013). The critical factor underlying this effect appears to be oro-sensory exposure time (de Graaf 2012), defined as the degree of contact time of the ingested food with the key sensory systems (taste, touch, etc.) in the oral cavity. According to this theory, solid foods require greater oral processing and so lead to greater overall stimulation of the oral sensory systems that perceive flavor and texture. This enhanced oro-sensory exposure could then lead to more rapid SSS but has also been shown to lead to more rapid satiation beyond SSS (de Graaf 2012).

The role of specific taste cues (sweet, umami, etc.) in satiation is still subject to debate. However, most data suggest that while these taste cues may act as nutrient predictors, the evidence that modify satiation beyond more general SSS effects is limited. For example, sweet taste is known to promote appetite, but satiation for sweet-tasting products does not obviously differ from any that are seen from non-sweet carbohydrates (Hogenkamp 2017), and sweetness itself is not a strong predictor of satiety expectations. There is stronger evidence for certain taste cues influencing post-ingestive processing of the ingested foods, so affecting satiety, as discussed later. Although taste cues do not appear to have a specific role in satiation, they may do so indirectly by contributing to overall flavor intensity, which is now believed to be an additional sensory factor which can modify the rate of satiation and so affect meal size (McCrickerd and Forde 2016), again with oro-sensory exposure a plausible explanation for why more intensely flavored products lead to more rapid meal cessation independently of effects of palatability. Since many of the sensory cues that impact on meal size also have been shown to generate satiety expectations (Forde et al. 2015), it may be that these sensory factors impact on meal size through the same cognitive mechanisms combined with SSS, although this is less clear with flavor intensity.

Social Influences on Satiation

Although the traditional approach to appetite control has focused on cues from the food being ingested, ingestion usually occurs in a social context, and an additional perspective on satiation relates to the extent to which consumers judge their fullness by reference to the amount being consumed by the people they are eating with. The two key social influences are firstly that people consume more in groups than when alone (social facilitation: Herman 2015) and secondly that the amount consumed can be specifically altered by modelling a confederate who eats more or less than would be consumed when eating alone (Cruwys et al. 2015). These issues are covered in full elsewhere in this handbook (see ▶ Chap. 14, "Social Influences on Eating"). However, in relation to satiation, it is notable that where people's intake has been altered by modelling a confederate, their state of satiation at the end of the meal is the same as if they had eaten their normal meal size. Thus the experience of fullness at the end of a meal is partly contextually derived. This effect is most pronounced where people overconsume and suggests that in a social context, people are less able to pay attention to the cues that normally drive satiation (Higgs 2015). Notably, when people have consumed more by modelling the behavior of a confederate, when asked what factors determined how much they consumed, they typically refer to the food (taste, liking, etc.) and rarely note the social influence (Vartanian et al. 2008). This suggests that social influences have a pervasive effect on intake, reducing the individual ability to respond to food-derived satiety cues and thereby promoting overconsumption.

Satiation in Summary

Satiation is a complex process, where signals arising from expectations, sensory exposure, oral nutrient detection, and the oral sensing of food volume all contribute to the increasing desire to terminate ingestion. However, for the vast majority of meals, ultimately humans are driven more by how much food they have served themselves, where they have that choice, or the amount they are served where that is externally determined and the social context in which they are eating, than they are by the myriad signals that arise during ingestion. Thus, the processes involved in satiation do not regulate energy intake directly, but once food is consumed, the effects of having consumed that food on subsequent appetite (satiety) have much clearer effects on overall energy balance, and so next we consider in detail what drives satiety.

Understanding Satiety

Whereas satiation appears to be controlled mainly by cognitive and sensory influences, satiety is more complex, with evidence for cognitive, sensory, and nutritional cues all interacting to generate how full people feel after consuming a particular food or drink. The volume, energy density, macronutrient profile, food form, sensory characteristics, and satiety expectations of an ingested product have all been shown to impact on subsequent satiety, with these factors interacting in complex but predictable ways. To illustrate this point, varying the form of a food alone can have a major effect on how filling it is. For example, the same amount of apple was more filling when consumed as apple pieces, than as apple puree or apple juice, despite the same nutrients being ingested in all three versions (Flood-Obbagy and Rolls 2009). To unpack this complexity, first the key evidence for cognitive, sensory, and nutrient influences on satiety are summarized in turn, and then current ideas on how these different components are integrated are explained.

Cognitive Influences on Satiety

Since how filling we believe a food to be has a major influence on how much we serve ourselves, could it also influence our experience of satiety after consumption? Particularly striking evidence that beliefs impact satiety came from a study where volunteers consumed the same product (a fruit smoothie) but with the (misguided) belief that the product contained either a small or large amount of actual fruit (Brunstrom et al. 2011). Participants consistently reported greater satiety (i.e., lower levels of rated hunger) across the 3 h after consuming the smoothie when they believed it had contained a larger rather than smaller amount of fruit even though the actual product was the same in both conditions.

However, simply telling someone that a product will be more filling in itself does not necessarily generate satiety by itself, but rather expectations modify the way the sensed nutrient signals arising from actual ingestion are interpreted. A powerful demonstration of that effect came from a study where participants consumed the same level of nutrients either as a liquid or jelly (Cassady et al. 2012), under the belief that the product either was liquid or jelly once in the stomach (in practice all versions would have been liquified by the acid in the stomach). Both the actual form of the ingested product and the belief of whether it was solid or liquid affected satiety: satiety was strongest when ingested jelly was believed to be jelly in the stomach and weakest when a liquid product was expected to liquid in the stomach. This elegant study demonstrates the power of top-down control on satiety. But in that study, the same level of nutrients was ingested in all conditions. Another research has since demonstrated that satiety is maximized when the expectation generated by label and sensory cues implies a product will be filling and crucially the product contains sufficient nutrients (Chambers et al. 2015; McCrickerd et al. 2014). Where a product generates an expectation of satiety but the level of ingested nutrients generates weak post-ingestive physiological satiety responses, the mismatch between expected and actual satiety can lead to rebound hunger and overconsumption. This critical interplay between expectation- and nutrient-based signals may explain why beverages tend to generate weaker satiety but soups stronger satiety even when the actual energy content is similar: drinks are not expected to be filling but soups are.

Beyond the role of expectations at the point of consumption, explicit memory for what has been recently consumed also plays a role in determining the amount consumed at the next meal (Higgs and Spetter 2018). The most striking evidence for this comes from studies of meal taking in amnestic patients. For example, Henry Molaison (HM) was left with severe amnesia following brain surgery to relieve intractable epilepsy. Notably, HM rarely reported feeling hungry or full, and when tested, he readily ate a second main meal almost immediately after eating a first (Hebben et al. 1985). Although the extent of HM's damage has suggested possible effects beyond amnesia (Eichenbaum 2013), a subsequent report of multiple meal consumption in other amnesiac patients with more defined impairments lends further support to a memory effect (Rozin et al. 1998), and notably these patients also showed no evidence of changes in the experience of appetite as a consequence of food ingestion. While these studies demonstrate the importance of the neural circuitry involved in memory and also in regulating awareness of interoceptive states including satiety, it does not in itself demonstrate memory is normally involved in the experience of satiety. But more recent data suggest this is so: asking people to recall what they consumed at a previous meal just before they have an eating opportunity reliably reduces intake, while a lack of attention to what is being consumed by being distracted during one meal can cause reduced satiety and increased intake at subsequent meals (Higgs and Spetter 2018). Thus, processes of memory and attention are important elements of the cognitive systems underlying satiety. One of the brain regions known to have been damaged in HM is the hippocampus, an area long known to be important in many aspects of memory. The hippocampus is also now thought to play an important role in regulating food intake, integrating information about cognitive and sensory aspects of the food to be ingested with the interoceptive signals relating to hunger and, crucially in this context, satiety (Stevenson and Francis 2017). Indeed, one theory of obesity is that excessive intake of an unhealthy diet leads to dysfunction in the hippocampus and reduces individual sensitivity to interoceptive satiety cues (Hargrave et al. 2016).

Taste and Satiety

Of the five primary tastes, the only taste which appears to have a role in satiety is umami (Yeomans and Masic 2017), and although sweet taste is often discussed as having evolved to enhance engagement with potential foods that will be a safe source of nutrients, there is no clear evidence that sweet taste or associated sugar ingestion has effects on satiety which differ from that of non-sweet carbohydrates (Bellisle et al. 2012). However, one possible role of taste in relation to satiety is that the savory "taste" of protein-based products acts as a cue for the likely presence of protein which triggers changes in post-ingestive processing of the ingested food which in turn result in a modified satiety response. In line with this, the finding that the addition of MSG, the compound most closely associated with umami taste, to protein-enhanced, but not carbohydrate-enhanced, soups increases the satiety response suggests that the detection of MSG orally might act as a taste cue for protein, and there is now growing evidence that the umami taste may itself enhance satiety (Yeomans and Masic 2017).

Nutrient Cues and Satiety

Ultimately satiety is primarily a state generated by the effects of ingested food, and the degree to which foods generate satiety has been shown to vary depending on the volume, nutrient density, and overall nutrient profile of the ingested food or drink. A full discussion of all of the evidence for these factors is beyond the scope of this chapter and has been subject to many valuable and detailed reviews (e.g., Benelam 2009; Tremblay and Bellisle 2015). The focus here is to provide sufficient summary of the current state of understanding to allow a more detailed evaluation of how these more physiological aspects of satiety integrate with the cognitive and sensory influences which are the primary focus of this chapter.

Some of the key nutrient-derived signals that contribute physiologically to satiety are generated by the ingestion and digestion of the three main macronutrient energy sources (carbohydrates, fats, and proteins), supplemented by actions of other food components such as fiber. A large body of satiety-related research has focused on these signals and the relative efficiency of the different macronutrients in generating satiety. This led to the suggestion of a hierarchy of satiating effects of macronutrients in the order protein > carbohydrate > fat (Poppitt et al. 1998), and it is now widely accepted that, when matched by caloric content, protein-rich products are most effective at generating satiety (Johnstone 2013). Likewise, there is good evidence that the addition of fiber can also enhance satiety (Wanders et al. 2011). These different nutrient effects then interact: for example, a recent study contrasted different reformulations of pasta supplemented with different sources of protein and fiber and found significant effects of both protein and fiber, with the strongest satiety when protein and fiber were combined (Martini et al. 2018).

There have been many theories of how different nutrients generate satiety, with the current view that nutrient detection in the gut leading to release of satiety hormones that then act to suppress appetite is the most widely accepted mechanism, and these effects are detailed more fully later. Satiety has also been related to the extent to which ingested food results in changes in glucose availability, with the classic glucostatic theory of appetite control positing that higher levels of glucose suppressed appetite but lower levels induced hunger (Mayer 1955). Although a simplistic model of appetite control based on glucose as a regulated signal remains controversial, there is evidence that the pattern of glucose release from foods does modify the way that they generate satiety. Here, a key concept is the glycemic index, which describes the pattern of change in circulating glucose across the time period post-ingestion. Products that cause a rapid rise and then fall in glucose are referred to as high glycemic, while those causing a lower but more sustained rise in glucose as low glycemic. Notably, low-glycemic foods tend to cause stronger satiety responses (Anderson and Woodend 2003).

Cognitive Nutrient Interactions in Satiety

There has been a tendency to assume that effects of nutrients on satiety are purely derived from gut-based signals during digestion, but there is increasing evidence that the sensory and expectation cues discussed earlier also play a role in modifying the effects of nutrients. A key issue is that it is very hard to modify the macronutrient or fiber content of a product without also altering its sensory characteristics, and these often subtle sensory changes can themselves then influence satiety, and indeed subtle flavor cues have long been known to modify satiety responses (Warwick et al. 1993). For example, when the sensory characteristics of a carbohydrate-enriched drink were manipulated to match the sensory characteristics of a similar drink fortified with whey protein, the two products generated the same satiety response (Bertenshaw et al. 2013), suggesting that the apparent enhanced satiety usually seen with protein may have been generated by the oro-sensory rather than post-ingestive effects of the protein. Similarly, satiety expectations are related to perceived creaminess in products (McCrickerd et al. 2015), and this percept may be in part driven by oral sensing of protein. But creaminess is a complex percept, and there is also the possibility that detection of fat in the mouth may act as a cue which could in turn modify the way the gut processes ingested fats. Whether the ability to detect fat orally can be described as the sixth dimension of taste remains unclear (Keast and Costanzo 2015); however some data on individual differences in oral fat sensitivity do fit with the notion that an enhanced ability to detect ("taste") fat orally is associated with lower body weight (Costanzo et al. 2017) which could be caused by stronger fat-based satiety responses. For this to be plausible, there would need to be evidence that oral detection of fat increased satiety. Again, recent evidence suggests this may be so. Varying the droplet size of oils in a water-oil emulsion changed the perception of how "creamy" these stimuli were, with smaller oil droplets leading to enhanced creaminess, and these small-droplet emulsions generated stronger expected and actual satiety responses than did the same water-oil emulsion with larger oil droplets (Lett et al. 2016).

Gut-Based Signalling Systems for Satiety

One of the key ideas in current biological models of satiety is that the sensed presence of ingested nutrients in the gut triggers the release of specific endocrine signals, the satiety hormones, which feedback to key regulatory structures in the brain and thereby inhibit our desire to eat. A large body of physiological research has started to unravel the complex detail of these signalling pathways, and here there is space to highlight the key findings only. The first satiety hormone to be identified, cholecystokinin (CCK), is now known to be released from specific endocrine cells in the small intestine, particularly the duodenum, in response to the sensed presence of nutrients, with stronger responses to fat and protein than to carbohydrates (Karhunen et al. 2008; Zanchi et al. 2017). Consequently, the concentration of CCK in blood increases after food consumption, and circulating levels of CCK correlate negatively with rated hunger (Sepple and Read 1989). Glucagon-like peptide 1 (GLP-1) is also established as a satiety hormone, with GLP-1 injections reliably reducing rated hunger and subsequent food intake in humans (Flint et al. 1998) and circulating levels of GLP-1 rising after meals, particularly with carbohydrate and fat intake. Finally, two related compounds, pancreatic polypeptide (PP) and peptide YY (PYY), also act as satiety signals. PP is the least understood of the satiety hormones and is released from the pancreas in response to nutrient ingestion. Low circulating levels of PP have been reported in obese individuals, while injection of PP has been shown to suppress appetite (see Hellström 2013). PYY is a more established satiety hormone, and suppresses rated appetite and food intake in humans (Batterham et al. 2002). PYY is secreted into the bloodstream by cells in the ileum and colon, so it appears to have a role in the later stages of satiety.

Even this very short summary illustrates the complexity of physiological satiety signalling: different mixtures of nutrients will cause subtly different patterns of release of multiple satiety hormones, which differ in time profile after ingestion and effects on appetite. We are still some way from clearly establishing the exact role of each hormone and from understanding how these different signals interact.

There is also now evidence that release of these gut-based satiety hormones is not simply a response to locally sensed nutrients but may be in part mediated by the sensory and cognitive cues experienced during ingestion. Traditionally, the idea that gut-based responses can be cued by pre-gastric signals was encapsulated in the concept of cephalic-phase responses (Smeets et al. 2010), founded in the principle of Pavlovian conditioning, suggesting that cues that predict the arrival of nutrients in the gut cause conditioned preparatory responses including hormone secretion (Woods 1991). There is now, however, evidence that these effects extend beyond conditioned responses, which are acquired by repeated cue-nutrient associations, to more cognitive control. Thus, believing a food would be solid in the stomach moderated GLP-1 release (Cassady et al. 2012), and the belief that a product would be filling stimulated PP release and enhanced the CCK response to nutrient ingestion (Yeomans et al. 2016). Thus gut-based signalling of satiety is in part controlled by people's beliefs and experiences with a food, with clear top-down modulation of the gut-based satiety response.

Individual Differences in Satiety Sensitivity

One important idea in our understanding of the relationship between satiety and ingestion is that people vary in the extent to which they are aware of, or respond to, satiety signals. In the earliest theory of individual differences in this context, it was suggested that normal-eating control involves a balance of sensitivity to internal appetite cues, including satiety, and external food cues (Schachter 1968). According to this externality theory, people who are prone to overeat and so gain weight were conceived as over-responding to external cues and under-responding to internal cues. Although the original externality theory fell out of favor, the key idea of a role for individual differences in satiety sensitivity relating to propensity to become obese is now attracting considerable attention. In adults, satiety responsiveness has been tested using the preload method, and here there is evidence of reliable individual differences, with those with weaker satiety responsiveness (the low satiety phenotype) more prone to weight gain (Dalton et al. 2015). Satiety responsiveness in children has been assessed using a standardized questionnaire measure, and scores on that measure predict subsequent weight gain even in very young children (e.g., Mallan et al. 2014). Whether sensitivity to satiety is a trait, or is a product of the way we have been exposed to foods, remains unclear, although there is some evidence that satiety responsiveness can be retrained if people are placed on diets which have been designed to generate stronger satiety signals (Arguin et al. 2017), suggesting that the extent to which an individual experiences satiety is to some extent malleable, so opening up the potential to retrain satiety responsiveness as a way of counteracting overeating.

Satiety in Summary

Unlike satiation, which appears largely controlled by cognitive, sensory, and behavioral factors, satiety is primarily a response to ingested nutrients, with a sequential series of post-ingestive signals arising from effects of nutrients at different stages in transit through the gut. However, whereas there has been a tendency to focus exclusively on these post-ingestive effects, there is now clear evidence that this gut-based processing can be affected by cognitive and sensory factors at the point of ingestion and that these factors alone can influence satiety both independently and in interaction with gut-based signalling. Moreover, the finding of big individual differences in satiety responsiveness which cannot be explained by differences in gut-based signalling clearly shows that satiety ultimately depends on the way these different signals are processed in the brain. Thus satiety is not a simple result of intrinsic cues generated by actual consumption but is a more complex interaction between these intrinsic cue and extrinsic cues relation to what the consumer knows about that product before it is consumed. Whether social context acts as an additional extrinsic influence on satiety is less clear: the majority of work on social influences have focused on satiation (Cruwys et al. 2015), and whether adjustments to meal size through social facilitation and modelling result in modifications to subsequent satiety remains unclear.

Integrating Multiple Cues: Optimizing Satiation and Satiety in Product Development

As knowledge about the cognitive, sensory, and nutrient-based signals that lead to satiation and satiety become clearer, it is increasingly possible to make predictions about how different changes in the way food is formulated, marketed, and served are likely to impact on our ability to regulate food intake. A perhaps surprising conclusion from some of the influences summarized here is that reducing the nutrient content of a product may not always be a helpful approach to regulating overall energy intake: if a product is consumed under the belief that it is a diet version, it may generate expectations of low satiety, which may be reinforced by changes in sensory characteristics and the actual experience of weaker post-ingestive satiety. Consequently, diet products may lead to rebound hunger and greater temptation to overconsume later (Chambers et al. 2015). The recent finding that people lost weight when placed on a diet which did not reduce their overall energy intake directly, but instead was designed to increase satiety (Arguin et al. 2017), reinforces the idea that re-establishing a strong satiety response in those prone to overeat may be the way forward in behavioral approaches to counteracting obesity.

Conclusions

Our understanding of satiation and satiety has come a long way from the simplistic idea that they reflected the impact of ingested nutrients on our appetite. As more evidence emerges that beliefs about products, and the sensory experience products provide during ingestion, modify the way we subsequently experience satiety, so the underlying models of satiety have to become more complex and nuanced. The effects of ingestion of a particular product on satiety will, ultimately, depend on the consumer's familiarity with that product, their individual sensitivity to satiety, and the actual nutrient profile of the product. Social influences clearly impact satiation, and all of these factors interact to modify overall appetite. Our increased understanding of these complex interactions is paving the way towards innovative approaches to producing products of the future which consumers will be able to enjoy without the concomitant risk of overeating and obesity.

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Disgust and Eating Behavior

16

Christina Hartmann and Michael Siegrist

Contents

Abstract

Disgust is a human emotion that prevents us from having contact with something that might be pathogenic, because it triggers behavioral avoidance of the stimulus. People can vary in their tendency to react with disgust towards cues that indicate the presence of pathogens such as certain odors (e.g., smell of decayed food) or visual cues (e.g., mold, runny nose). This disgust sensitivity was linked to a broad range of behavioral and attitudinal concepts in previous research. After an overall introduction to the concept of disgust, the present chapter focuses on the measurement of disgust sensitivity in adults and the various tools that are available to measure disgust sensitivity. A special focus will be on the domain of

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eating and food behavior and the introduction of a new scale that enables measurement of disgust sensitivity in the domain of food. Furthermore, the influence of disgust sensitivity on eating behavior in a functional and dysfunctional way will be outlined. In particular, its relationship with selective eating behaviors (e.g., food neophobia) and the acceptance of new food sources (e.g., insects) and food technologies (e.g., cultured meat) will be highlighted. Lastly, the relationship between disgust and hygiene behavior, food hygiene behavior in particular, will be outlined.

Introduction

Functional Domains of Disgust

When considering evolutionary processes and the drivers of natural selection, we would expect that humans have developed threat-detection systems and responses. Evidence suggests that a disgust reaction is one such highly functional system that aims to reduce the contact with and thus the likelihood of infection from bacteria, parasites, and viruses. Researchers consider disgust to be a component of the so-called behavioral immune system, which aims to avoid health threats by cognitively triggering disease preventive behavior (Terrizzi et al. 2013).

A commonly known first line of defense is distaste. In particular, bitter-tasting compounds can be found in unpalatable plants and are prototypical stimuli for innate oral rejection. This can naturally be observed in children who have an innate preference for sweetness and an inborn dislike of bitter tastes (which makes acceptance of certain liquid formulations such as medicine and of certain foods such as dark-green vegetables rather difficult during childhood) (Mennella and Bobowski 2015). Bitter taste typically leads to spitting out the unpalatable, probably toxic material (Chapman and Anderson 2012). Apart from distaste, disgust is triggered by cues that symbolize hazardous items and the presence of pathogens such as certain odors (e.g., smell of decayed food) and visual (e.g., mold, runny nose) and tactile (e.g., slime) cues as well as auditory input (e.g., clear one's throat) (Curtis and Biran 2001). Likewise, objects that have had contact with a disease vector can become contaminated and a trigger of disgust. Disgust is not restricted to the oral route, and the role of contamination and contact disgust in defending against infectious diseases might relate to the perceived invisible spread of microorganisms from one substance or organism to another (Chapman and Anderson 2012).

Individuals differ in their concerns about disease transmission and their perceived vulnerability to diseases. Persons with higher germ aversion reported heightened discomfort in situations with an increased likelihood of disease transmission such as having a sneezing person around or sharing a water bottle with a friend (Duncan et al. 2009). These individual differences in germ aversion also predicted variability in people's sensitivity and reactivity towards potential disgust elicitors (Hartmann and Siegrist 2018). Disgust is an emotional response that triggers disease avoidance behavior (Curtis et al. 2004). However, very low disgust sensitivity and heightened disgust or disgust oversensitivity can become dysfunctional. On the one hand, insensitivity to disgust cues might inhibit the necessary preventive behavior, and people might expose themselves to higher risks. On the other hand, oversensitivity to cues that are not pathogen-related or overgeneralization based on crudely defined cues triggers false alarms and might lead to neglecting viable resources. Heightened disgust responses have even been linked to the development and maintenance of various psychopathological symptoms related to anxiety disorders. In particular, disgust sensitivity seems to be involved in the etiology and maintenance of blood-injection-injury phobia, spider phobia, and obsessive-compulsive disorder (for a review see Olatunji et al. 2010). Disgust is considered a regulatory emotion, and rejection of ingestion of substances is a prominent behavioral domain. Therefore, researchers have also investigated a potential influence of disgust oversensitivity in the development and maintenance of eating disorders (Bell et al. 2017; Troop et al. 2002). Recent research has also shed light on disgust sensitivity and its effects on everyday food choices in nonclinical samples. Later in the present chapter, new findings in that area will be outlined. Noteworthy, some researchers also proposed a link between disgust and attitudes and behaviors in non-food-related domains encompassing social interactions such as sexuality, moral evaluations, and political orientation (Oaten et al. 2011; Rottman 2014; Tybur et al. 2009). However, within the course of the present chapter, we focus predominantly on the domain of eating. Disgust sensitivity in other domains such as moral or sexual disgust is not part of the present chapter (Tybur et al. 2009).

The “Disgust Face”

A typical “disgust face” has certain main characteristics expressed in combination or alone depending on the context: retraction of the upper lip, nose scrunch, narrowed eyes, lowered brows, as well as a tongue extension (Pochedly et al. 2012; Rozin et al. 1994). All the activities center around the face orifices nose, mouth, and eyes in order to hinder entry of dangerous agents. They also have an informational function by indicating to group members that something should be avoided (Rozin et al. 1994). Variations of facial expressions of disgust are considered as having different communicative values. For example, the nose wrinkle was recognized as a sign of a bad smell, while the tongue extension was linked more to oral irritation (Rozin et al. 1994). Next to happiness, anger, fear, and surprise, disgust is one of the emotions that are reliably recognized by facial expression in people from a variety of Western and non-Western societies (Ekman and Friesen 1971; Hadit and Keltner 1999). Technological advances nowadays allow coding and analyses of facial expression for research purposes. This enables researchers to observe, for example, the different variations of a disgust face in behavioral experiments. The intensity of a disgust response or variations in facial expressions depending on the elicitor can be studied.

Development of Disgust in Children

Disgust activates cognitive and affective mechanisms that motivate the avoidance of, e.g., pathogen cues. Individuals can differ in what they find disgusting as well as the intensity of their experienced disgust. The ability to experience disgust is innate, and researchers stated that genetics also determine an individual's disgust sensitivity (Sherlock et al. 2016). However, disgust evolves within cultural boundaries and is primarily shaped through social learning (Rottman 2014). Parental influences during early childhood play a substantial role (Stevenson et al. 2010). Disgust reactions to, for example, bitter substances are an innate response to distaste in children, but apart from distaste, new disgust elicitors are probably learned during the first developmental stages of the child. Stevenson et al. (2010) provided a good example of a situation in which a parent-child transmission might lead to the acquisition of a new disgust elicitor: "The child encounters a stimulus (e.g., a dirty candy on the ground) and begins to make contact with it. The parent then facially (disgust face), vocally ("Urghh, don't touch that!"), and behaviorally (moves stimulus or child away) intervenes." (Stevenson et al. 2010, p. 166). Another argument for a parental impact in the acquisition of disgust elicitors is the observed positive parent-child correlation for disgust sensitivity and contamination sensitivity (Rozin et al. 1984). Unfortunately, the evidence described so far does not necessarily explain why people then vary in the intensity of experienced disgust and which other environmental factors shape people's disgust experiences (Tybur et al. 2018). Future research is needed in order to better understand the developmental stages of such a highly functional system as the disgust emotion.

Factors Influencing Disgust Responding

Researchers argue that an individual's level of immunocompetence is linked to disgust sensitivity. The more susceptible an individual is to infections, the higher the value of behavioral avoidance of potential health threats and dietary selectivity (Fessler et al. 2005). Following this argument, a compensatory behavioral prophylaxis theory was suggested which proposes that progesterone-linked decreases in immune functioning during pregnancy should be accompanied by elevated levels of disgust and behavioral avoidance (Fessler et al. 2005). Especially during the first trimester of pregnancy, when immunosuppression is most pronounced, Fessler and co-workers found heightened disgust sensitivity (Fessler et al. 2005). Food-borne illnesses in particular pose a hazard for both the mother and the fetus, and increases in disgust sensitivity should predominantly occur in the food domain (Fessler et al. 2005). Moreover, some researchers even found a link between women's stage in the menstrual cycle and the accompanying changes in immunocompetence and disgust sensitivity (Fleischman and Fessler 2011; Zelazniewicz and Pawlowski 2015), while others did not find such a relationship (Jones et al. 2018). Nevertheless, a well-established and reliable finding across different assessment methods is that women are more disgust sensitive than men. This holds true for state (e.g., Rohrmann et al.

2008) and trait disgust sensitivity (e.g., Berger and Anaki 2014; Hartmann and Siegrist 2018) as well as for Western and Eastern cultures (Olatunji et al. 2009). However, this gender pattern was not observed in children (Stevenson et al. 2010). Al-Shawaf et al. (2017) proposed different hypotheses that might explain women's higher pathogen-related disgust sensitivity. The most important one is based on the mothers' central role and close physical contact with the offspring during gestation, lactation, and parenthood and thus their greater impact on the health of the offspring (Al-Shawaf et al. 2017). However, based on cross-sectional data, the level of pathogen disgust sensitivity seems not to further increase after the birth of a child (Prokop and Fančovičová 2016). Only longitudinal studies might reveal how strongly disgust sensitivity might fluctuate over a women's life span and the influence of different life stages such as motherhood on disgust sensitivity.

Apart from sex, the relationships between other demographic variables and disgust sensitivity are not clear or rather weak. For instance, weak negative correlations were found for education: those with lower education levels were more disgust sensitive (Berger and Anaki 2014). However, this finding might suggest that disgust is a basic emotion that might not be easily changed through knowledge (Berger and Anaki 2014). Likewise, no correlation (Petrowski et al. 2010), a weak positive correlation (Eickmeier et al. 2017), as well as a negative correlation (Curtis and de Barra 2018) between measures of disgust sensitivity and age were reported. Therefore, no overall conclusion can be drawn regarding the relationship between education and age on the one hand and disgust sensitivity on the other hand.

Measuring (Food) Disgust Sensitivity

Disgust sensitivity is defined as an individuals' tendency to respond with disgust to aversive stimuli (Haidt et al. 1994; Olatunji et al. 2007). Haidt et al. (1994) asked university students to list disgusting items and another sample to rate these items related to their disgust response. Based on factor analyses and theoretical considerations, Haidt et al. established a 32-item disgust scale (DS) that measures disgust sensitivity in eight domains: *food*, *animals*, *body products*, *sex*, *body envelope violations*, *death*, *hygiene*, and *sympathetic magic/contagion* (contact with or visual appearance of a disgust elicitor). Later on, Olatunji et al. (2007) proposed a revised version of the DS-scale (DS-R) with a reorganized item structure and a reduced number of subscales (*core disgust*, *contamination-based disgust*, *animal-reminder disgust*). Subsequently, various researchers suggested new disgust measures (Table 1). For example, Tybur et al. (2009) proposed a disgust model based on three domains of disgust. Their 21-item Three Domains Disgust Scale (TDDS) measures disgust sensitivity in the domain of *pathogen disgust*, *sexual disgust*, and *moral disgust*. van Overveld et al. (2006) published a disgust propensity and disgust sensitivity scale (DPSS, revised by Fergus and Valentiner 2009), which aims to measure the frequency of experiencing disgust and the bodily and emotional impact of experienced disgust. A rather new developmental approach was used by Curtis and co-worker (Curtis and de Barra 2018), who identified main transmission

Table 1 Scales to measure disgust sensitivity in different domains for adult populations. The different measurement scales show similarities and differences in the domain-specific conceptualization of disgust

Author	Abbr.	Domains
Haidt et al. (1994)	DS	Disgust scale: food, body products, sex, death, body envelope violations, animal, hygiene, contagion
Olatunji et al. (2007)	DS-R	Disgust scale – revised: core disgust, animal-reminder disgust, contamination disgust
Kleinknecht et al. (1997)	DES	Disgust emotion scale: animals, injections, blood draws, mutilation, death, rotting food, smells
Tybur et al. (2009)	TDDS	Three domain disgust scale: pathogen disgust, sexual disgust, moral disgust
Curtis and de Barra (2018)	–	Six-factor model: hygiene disgust, animal disgust, sex disgust, atypical appearance disgust, lesion disgust, food disgust
Hartmann and Siegrist (2018)	FDS	Eight different categories of food disgust: animal flesh, poor hygiene, human contamination, mold, decaying fruit, fish, decaying vegetables, living contaminants
Ammann et al. (2018a)	FDPS	Food disgust picture scale based on pictures that display disgust cues from the categories of the FDS

pathways for human pathogens and then generated a set of cues derived from five diseases from each of these identified transmission pathways. They developed a six-factor model that categorizes disgust cues in six categories: hygiene disgust, animal disgust, sex disgust, atypical appearance disgust, lesion disgust, and food disgust.

Recently, a new disgust scale was published that focuses on the domain of food (Hartmann and Siegrist 2018). This new scale enables measurement of an individual's tendency to experience disgust when confronted with various food-related cues that indicate, for example, pathogen presence, unhygienic food preparation, or animal origin of the food. The food disgust scale is a reliable and valid self-report measure for adults which can be applied as an 8-item short version or a comprehensive 32-item long version. Figure 1 shows the distribution of food disgust sensitivity among a sample of Swiss adults. The long version consists of eight subscales with which eight distinct factors of food disgust can be measured: animal flesh, human contamination, poor hygiene, decaying fruit, decaying vegetables, mold, fish, and living contaminants. The food disgust scale was tested in different countries around the world including France, China, and England. Figure 2 displays that the results are quite similar in the different countries, and only small deviations in the mean values for the eight subscales between countries were observed.

In a subsequent study, a picture-based food disgust scale was developed to supplement the word-based food disgust measure (Ammann et al. 2018a). The Food Disgust Picture Scale presents participants with eight pictures that depict a range of potentially disgusting food items (Fig. 3). In contrast to the word-based food disgust scale, participants' perception of certain disgust cues is not subject to imagination, they are directly confronted with pictures that show potentially disgust eliciting food items. However, Descriptions of foods and food situations can evoke

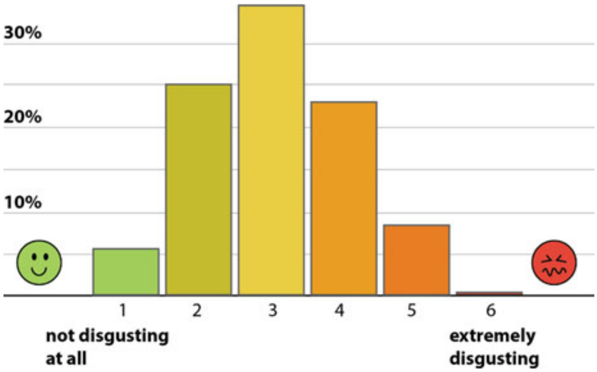

Fig. 1 Percentage distribution of overall food disgust sensitivity (FDS total score) among a sample of Swiss adults. Some people are not food disgust sensitive at all, most participants are medium disgust sensitive, and a few are very disgust sensitive. (Based on data from Hartmann and Siegrist 2018)

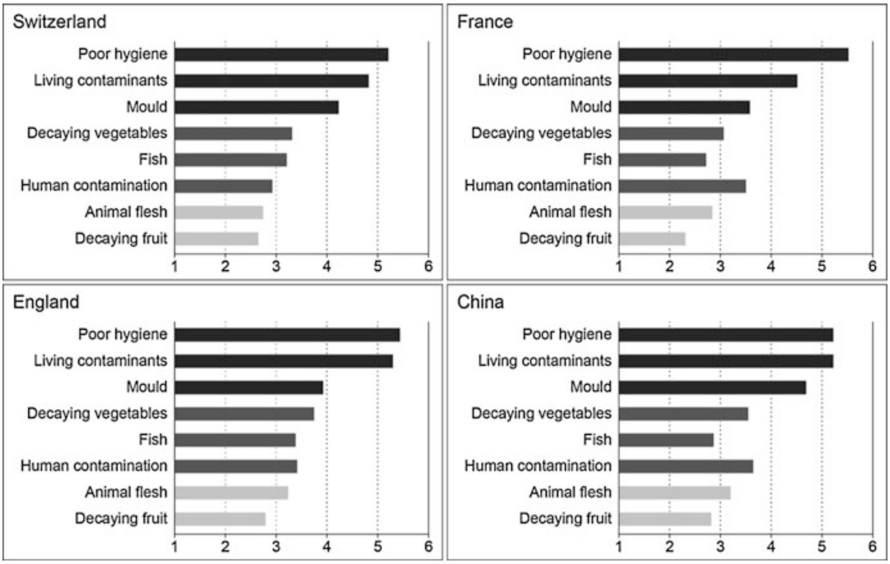

Fig. 2 Mean values for the eight subscales of the food disgust scale measured in Switzerland, France, England, and China. Poor food hygiene, food contamination, and mold on food were considered as most disgusting in all four countries. (Data from Swiss adults are published in Hartmann and Siegrist 2018)

more powerful salient memories and emotional responses that specific food preparations or pictures might not evoke (Cardello et al. 2012). This might explain why the Food Disgust Picture scale and the Food Disgust Scale correlated highly in previous research (Ammann et al. 2018a), but not as highly as expected. Nevertheless, both food-related scales were comprehensively tested, and it was shown that they correlate with eating behavior (Ammann et al. 2018b; Egolf et al. 2018).

All disgust scales and their underlying conceptualizations of disgust introduced above were developed in Western societies such as England (Curtis and de Barra 2018), Switzerland (Hartmann and Siegrist 2018), or the USA (Olatunji et al. 2007).

Fig. 3 Three pictures from the Food Disgust Picture Scale measuring disgust sensitivity in the domain of food (Ammann et al. 2018a). Studies showed that the worm-contaminated maize received the highest disgust scores. Cues related to decay or aging of fruit are considered disgusting by some persons. The old tomatoes were considered as medium disgusting by study participants. The situation depicted in the third picture points towards an unhygienic food behavior with raw meat. The rings as potential germ carriers, the direct contact with the hands, and the slightly gray color of the meat are potential disgust cues. The picture was, however, rated as least disgusting by study participants. (Picture source: Jeanine Ammann (picture 1, 2), Pixabay.com/yaron86 (picture 3))

Some of them were also successfully tested in other cultural contexts than those in which they were developed, however (e.g., Olatunji et al. 2009). Culture shapes the stimuli that provoke a disgust reaction and the behavioral consequences. Therefore, differences in mean values for disgust sensitivity between different cultural contexts are reasonable and were observed in previous cross-cultural studies (Olatunji et al. 2009). However, the results of the food disgust scale in different countries suggest that the ranking of various disgust elicitors (i.e., what people consider most disgusting and what they consider least disgusting) seems to be rather similar in different cultural contexts.

Disgust and Eating Behavior

Culture and social influences play a huge role when it comes to food that we consider acceptable or unacceptable, those food sources we like and those we dislike. Aversion and disgust towards certain foodstuffs might correspond to a personal or a collective attitude that certain foods are considered edible while others are considered disgusting. But apart from the cultural basis of food-related disgust, certain food-related cues indicate the presence of pathogens (e.g., mold) on a food or give an indication about aging of the food. People can react differently to these cues and consequently vary in their sensitivity to experience food-related disgust. However, disgust sensitivity comes with a trade-off between neglecting valuable food sources and potential benefits of avoiding risky items. Therefore, disgust sensitivity exerts functional and dysfunctional effects on eating behavior. Studies that directly assessed the influence of disgust on eating behavior in nonclinical populations are scarce, however. One problem was that there was no food-specific disgust scale available that measures individual differences in disgust sensitivity in the food domain. Disgust scales that assess overall disgust sensitivity or disgust sensitivity in certain domains apart from food might not capture relevant relationships. The newly developed food disgust scales with a particular emphasis on food items enables specialized research related to the link between eating behavior and food disgust sensitivity.

Disgust, Selective Eating Behaviors, and Food Choice

Human ability to adapt to new environments and potential new food sources was a big advantage for our species. However, it poses the risk of consuming potentially toxic plants and animals. Thus, humans show an ambivalent reaction towards new foods, a mixture of fear and interest. A psychological and behavioral tendency to reject unfamiliar food is called food neophobia (Pliner and Hobden 1992). Food neophobic behavior is a stable part of children's eating behavior development. Between the ages of 2 and 6 years, they show the strongest food neophobic reactions and reject unfamiliar, new foods. With age, food neophobic tendencies normally decrease, and strong food neophobic behavior in adults is even considered pathological. Aspects such as perceived mouth feeling, aversive textural properties, or a product's animal origin are considered main drivers of food rejection based on food neophobia (Martins and Pliner 2006). Considering the functional basis of disgust to prevent contact with potential disease vectors, a link between disgust sensitivity and food neophobia seems reasonable (Al-Shawaf et al. 2015; Nordin et al. 2004). In one study, Al-Shawaf (2015) found – utilizing the Three-Domain Disgust-Scale by Tybur et al. (2009) – a small correlation in women between food neophobia and pathogen disgust as well as sexual disgust. Utilizing a food-specific disgust scale, correlation coefficients between the FDS and food neophobia were as high as 0.37 in a survey study (Hartmann and Siegrist 2018). Further results showed that when it comes to willingness to eat unfamiliar foods, food disgust sensitivity explains variance over and above food neophobia (Ammann et al. 2018b; Hartmann and Siegrist 2018). Thus, the two constructs seem to be associated, and high disgust sensitivity might be a motivational force behind food neophobia.

The opposite of food neophobia, variety seeking, defined as the willingness to try new unknown foods (Lenglet 2018), was linked to disgust sensitivity too in previous research. Utilizing the Varseek-scale by Van Trijp and Steenkamp (1992), results of a survey study in Switzerland showed that food disgust sensitivity explained 4% of the variability in variety seeking. Food disgust is a defense mechanism that aims to avoid risks, while variety seeking in new food comes with an increased risk taking. Hence, the relationship between both constructs was negative (Egolf et al. 2018). Also, picky eating in adults, which is defined as aversion to or refusal to eat a wide range of virtually familiar foods, has been associated with disgust (Egolf et al. 2018; Kauer et al. 2015). Kauer et al. (2015) suggested that picky eating may be based on a hypersensitivity to certain sensory properties (e.g., texture, taste, appearance), and the rejection of certain textural properties was also linked with food disgust sensitivity (Egolf et al. 2018).

On the level of everyday food choices, disgust seems to have a small but relevant influence too. In one of the first studies that investigated the link between food disgust sensitivity and food choices measured with a food frequency questionnaire, results showed that food disgust sensitivity was associated with lower consumption frequencies of foods that pose high contamination risks and have special textural properties such as eggs and seafood (Egolf et al. 2018). Similarly, negative correlations between food-related disgust and consumption of several types of meat and fish products were observed in another study from Germany (Eickmeier et al. 2017). Moreover, lower consumption frequencies of vegetables were observed in high food disgust sensitive people. From the previous mentioned research, one might conclude that disgust sensitivity is not linked to food groups in general (e.g., meat) but that people may avoid certain preparations or special kinds of foods (e.g., animal innards).

Today, there is a clear separation between meat consumption and meat production, and modern meat marketing reduces, for good reason, evocative cues that remind consumers of the slaughtering procedure of the animals. It has often been reported that seeing, handling, or the idea of eating meat provokes disgust reactions in some people. In a study with university students, next to aversive textural properties, reminders of livingness/animalness accounted for most of the variance in disgust ratings for certain food-related scenarios. In particular, disgust sensitive participants were susceptible to react with disgust when they were confronted with cues that reminded them of the animal nature of the foods (Martins and Pliner 2006). Disgust reactions also come into play when people avoid meat based on moral convictions. Moral vegetarians find meat images more unpleasant and more disgusting and seem to avoid a wider range of animal foods than health-motivated vegetarians (Anderson et al. 2019; Rozin et al. 1997). Vegetarian-induced disgust reactions towards meat seem to be a consequence of the moralization of meat eating and the accompanied conversion of preferences into values (Fessler et al. 2003; Rozin et al. 1997). Research into promoting meat reduction within public health campaigns has even used disgust-oriented persuasive messages to influence meat attitudes (Palomo-Vélez et al. 2018). However, it is not completely clear why people are more susceptible to experience disgust when it comes to meat and animal products, and different explanations are possible. In the end, it might be a mixture of moralization and the idea of incorporating another living creature as well as the higher pathogen and contamination risk associated with animal-based foods.

Disgust and Acceptance of New Food Sources and New Food Technologies

Our daily food choices have a huge impact on the environment. Production of meat has a much larger impact compared with the production of vegetable-based proteins, for example. New food technologies (e.g., cultured meat, genetic modification) and new food sources (e.g., insects) may help reduce the environmental impact of people's food behavior (Bonny et al. 2015; Smetana et al. 2015). However, consumer acceptance of these new food sources is a challenge, and among other factors, disgust plays a role in the rejection of novel foods and technologies.

To feed a growing population worldwide, researchers around the world are searching for new food technologies and resources. Interest in alternative protein sources of high nutritional value, such as edible insects, has increased remarkably in recent years (Huis et al. 2013). A positive attitude towards such novel foods is a prerequisite for consumer acceptance. Factors such as food neophobic tendencies, previous experiences with eating insects, male gender, and attention to the environmental impact of food influence consumers' readiness to eat insects (Hartmann et al. 2015; Hartmann and Siegrist 2017; Verbeke 2015). Even though insects are a valuable food source in many cultural regions around the world (Costa-Neto and Dunkel 2016), a lot of people in Western societies are disgusted by the prospect of eating insects and by the insect itself (La Barbera et al. 2018). Not surprisingly, insects were long considered more as an indicator for food contamination and a health risk than as a valuable food source in most Western societies (Kellert 1993; Looy et al. 2014), and the presence of insects might even be considered as an indicator for low hygienic standards. Accordingly, an individual's susceptibility to be disgusted by poor food hygiene (subscale of the food disgust scale) was a significant predictor for willingness to eat products made with processed insects (Hartmann and Siegrist 2018). Moreover, food disgust sensitivity and food neophobia together explained 37% of the variance in the willingness to eat insect products. In another study, consumers were confronted with chocolate, which was decorated with dried mealworms. In this behavioral experiment, participants' food disgust sensitivity was strongly inversely correlated with the amount of the insect chocolate consumed (Ammann et al. 2018b). Therefore, food disgust sensitivity in previous research was not only linked to the hypothetical consumption of insect products but also proved to be a significant predictor for actual eating behavior. In addition, disgust was by far the most frequently mentioned reason for rejecting eating insects in another study with Indian and US adults (Ruby et al. 2015). Results of that study further showed that those persons who scored high on the core disgust subscale of the disgust scale (Haidt et al. 1994; revised by Olatunji et al. 2007) were less willing to eat insects. Core disgust sensitivity even reduces the likelihood that people get in contact with insect eating events (Hamerman 2016). An individual's disgust sensitivity is an important predictor for willingness to eat when it comes to insects. Whether it has a similarly high relevance for the acceptance of other familiar or unfamiliar foods needs to be determined in future research.

Disgust has also been proposed as one of the factors that influence acceptance of gene technology (Scott et al. 2016). According to these authors, gene technology is often perceived as unnatural, and it may be perceived as contaminating consumers by ingesting GM (genetically modified) foods. Furthermore, the idea that a gene from animals may be inserted in a plant may increase the disgust reaction. Scott and colleagues (Scott et al. 2016) showed that disgust evoked by gene technology was associated with support for GM restrictions. In other words, people who experienced a high level of disgust by GM food were more in favor of restrictions related to GM foods compared with people who experienced a low level of disgust. Even more interesting, people's general disgust sensitivity influenced people's acceptance of GM foods. Overall, the available evidence suggests that people with a higher affective disgust response towards a food technology (state disgust) and people who are generally more disgust sensitive (trait disgust) seem to report lower acceptance ratings to new food technologies (Clifford and Wendell 2016; Prokop et al. 2013). Even evoked disgust by elicitors that are unrelated to the food technology of interest, slightly motivates opposition to GMO containing food (Clifford and Wendell 2016).

The most important motivations underlying consumer's everyday food choices are sensory and health factors (Martins and Pliner 2005). Likewise, "natural" seems to be a positive quality for most people in Western countries (Rozin 2005). For example, a survey conducted in the USA showed that consumers perceived pesticide-related risks as greater than either natural toxin or microbial pathogen risks (Williams and Hammitt 2001). Perceived naturalness is an important factor when it comes to consumer acceptance of foods and food technologies. The attributes that are used for defining a food as natural vary between stakeholders and consumers (Román et al. 2017). Perceptions of naturalness are also relevant when it comes to the acceptance of cultured meat. Cultured meat was developed as a substitute for conventionally produced meat that exactly mimics meat but is less resource consuming and may be more morally justified from various ethical perspectives (Hopkins and Dacey 2008; Pluhar 2010). It is based on stem cell technology (Post 2012), and if technological hurdles could be overridden, cultured meat might be a promising approach for the production of so-called clean meat. Consumers' willingness to eat cultured meat considerably varied between study samples and countries (Bryant and Barnett 2018). Some reported an overall positive view among US consumers (Wilks and Phillips 2017), while others concluded that acceptance ratings are rather low (Hocquette et al. 2015). Focus groups in Belgium, Portugal, and the UK revealed that after being informed about cultured meat, perceived unnaturalness and feelings of disgust towards the novel meat product are prevalent initial reactions of consumers towards the idea of consuming it (Verbeke et al. 2015). Moreover, study results showed that perceived naturalness of cultured meat had a direct and an indirect effect via disgust towards that meat on the participant's willingness to eat it (Siegrist et al. 2018). The production process characteristics of cultured meat seem to evoke a disgust reaction which is probably related to the heavy processing and consumer's perception of humans tampering with nature (Siegrist et al. 2018; Verbeke et al. 2015).

Disgust and Hygiene Behavior

Hygiene behavior is, next to healthy eating, regular physical activity and medical checkups, a fundamental part of health behavior. It aims to avoid infections and illness by preventing contact with potential pathogens. Hygiene behavior is relevant in different domains such as the body or food preparation. Food preparation in particular is a risk area where a lack of hygiene could have detrimental health effects. Food-borne diseases are a serious public health problem, and more than 200 diseases are spread through food via microorganisms (e.g., fungi). They can even lead to deaths in vulnerable population groups such as the elderly, children, or immunocompromised persons. A relationship between disgust, which aims at avoiding infections and illness, and hygiene behavior was suggested (Curtis 2007). Initial studies showed that disgust is one motivation among others for hand washing behavior in developing countries (Curtis et al. 2009), and it was also shown to be a key driver in nurses infection control behaviors (Jackson and Griffiths 2014). However, there has been little discussion on the relationship between disgust sensitivity on the one hand and hygiene in food preparation, an essential behavior for health promotion, on the other hand. In a recent study, 1122 participants in the German-speaking part of Switzerland were asked how frequently they practice 24 different hygienic behaviors in the kitchen (Ammann et al. 2019). The behaviors varied from washing fresh fruit and vegetables before consumption, checking for insect contamination in dry products, cleaning the refrigerator to changing the tea towel regularly. Results showed that people's food disgust sensitivity, i.e., their disgust responsiveness following exposure to food-related potential disgust elicitors, was strongly correlated with kitchen hygiene behaviors. Those who were more food disgust sensitive also practiced these hygiene behaviors more frequently. Another important outcome of that study was that people who were more food disgust sensitive reported heightened disgust responses following descriptions of situations that included food-related unhygienic behavior (e.g., food that dropped to the floor). Thus, disgust sensitivity leads to both stronger disgust reactions towards unhygienic food behavior (by others) and more frequently practiced hygiene behavior. Very low disgust sensitivity seems to inhibit necessary preventive hygiene behavior and adequate evaluation of the behavior of others, and consequently people might expose themselves to higher risks of food-borne diseases.

Nevertheless, disgust sensitivity comes with a trade-off between preventive behavior and neglecting valuable resources. In the domain of food, a small but significant positive relationship between people's food disgust sensitivity and their frequency of throwing away food was found (Egolf et al. 2018). This is of high relevance considering the fact that food waste accounts for the largest percentage of food losses in the value chain in industrialized countries (Parfitt et al. 2010). People with high levels of food disgust sensitivity seem to react more strongly towards cues related to decay or the aging of the food. Food that is not as fresh anymore might then be considered inedible or dangerous. It is probably rather difficult, if not impossible, to convince people to eat food that is still edible but that they consider disgusting. Therefore, it seems more promising for educational campaigns aiming at reducing food waste production in the domestic area, to focus on processing techniques for old food so that disgust-eliciting cues are not visible anymore (Egolf et al. 2018).

Conclusion

Disgust is a protective rejection mechanism that is supposed to decrease the likelihood that we have contact with or even consume potentially risky items. Disgust is linked to psychological constructs of selective eating behavior. In fact, food-related disgust sensitivity exerts an effect on food choices, eating habits, textural preferences, and even food hygiene behavior. A growing body of literature has suggested that especially animal-based foods can provoke a disgust reaction. Disgust is a factor that might even prevent people from making favorable food choices. Nevertheless, the link between disgust sensitivity and how it shapes our eating behavior is still under researched, and future research will provide more insights into how disgust shapes our eating behavior in functional and dysfunctional ways. In addition, consumer acceptance of new food technologies and resources is an obstacle not least because of product attributes or characteristics of the production technology that provoke disgust in consumers. People with a higher affective disgust response towards a food technology, and people who are generally more disgust sensitive reported lower acceptance ratings to new food technologies. Overcoming such negative affective reactions in consumers is a challenge, and marketing approaches need to prevent evocative cues that provoke a disgust response.

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The Role of Ritual in Eating

17

Jonathan Brumberg-Kraus

Contents

Abstract

Rituals of eating refer to the behaviors regarding what, with whom, when, where, how, and why people eat. They are patterned, repeated, sometimes automatic, sometimes intentionally mindful, often talk-enhanced practices that *humanize* the ways people nourish themselves. Rituals of eating might be, but are not necessarily "religious" in that they are associated with specific religious traditions. The difference between religious and nonreligious rituals of eating is better understood as between "rituals in a strong sense" and in a "weak sense" (Kripal et al. 2014). On one hand, they may be intentional "reenactment of myths – sacred

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stories – that make worlds come into being" or they may be something like the daily cycles of breakfast, lunch, and dinner with appropriate foods at appropriate times.

Eating rituals also can be classified more specifically according to their form and sequence, their function, the emotions they evoke, and their meaning. This chapter addresses the roles of ritual in eating in the following: (1) as types of behaviors (order of meals, seasonally cued practices, table etiquette, taboos, eating, and reading); (2) as rituals of different kinds of relationships (to nature, to other humans, and to the supernatural); (3) as components of meals besides eating (preparation, acquisition, and cooking of food); (4) in the emotional affect they encourage (rituals of disgust, elevation, and gratitude); and (5) as the different strategies and contents of meaning they create. The role of ritual in eating is to make it meaningful to people – affectively, cognitively, socially, culturally, and religiously.

Introduction

Margaret Visser suggests in her book *The Rituals of Dinner* (1991) that table manners originated to curb human instincts to use one's knives on their fellow diners rather than on their dinner. Table manners however are but a subset of the many different rituals people apply to what, with whom, when, where, how, and why they eat. All animals eat, but rituals, that is, patterned, repeated, sometimes automatic, sometimes intentionally mindful, often talk-enhanced behaviors are apparently what *humanize* the ways the human species nourishes itself. Jean Anthelme Brillat-Savarin (1825/1986), the early nineteenth-century father of modern Euro-American gastronomy and food writing, famously distinguished "the pleasures of the table. . .from the pleasure of eating, *their necessary antecedent*," as follows:

The pleasure of eating is the actual and direct sensation of satisfying a need.

The pleasures of the table are a reflective sensation which is born from the various circumstances of place, time, things, and people who make up the surroundings of the meal.

The pleasure of eating is one we share with animals; it depends solely on hunger and what is needed to satisfy it.

The pleasures of the table are known only to the human race; they depend on careful preparations for the serving of the meal, on the choice of place, and the thoughtful assembling of the guests.

The pleasure of eating demands appetite, if not actual hunger; the pleasures of the table are most often independent of either one or the other...

During the first course, and at the beginning of the feast, everyone eats hungrily, without talking, without paying any attention to what may be going on about him, and no matter what his position or rank may be he ignores everything in order to devote himself to the great task at hand. But as these needs are satisfied, the intellect rouses itself, conversation begins, a new order of behavior asserts itself, and the man who was no more than an eater until then becomes a more or less pleasant companion, according to his natural ability. (p. 182)

What are "careful preparations for the serving of the meal, on the choice of place, and the thoughtful assembling of the guests. . .[and] conversation . . .a new order of behavior" but rituals that not only shape the meal as a communal activity, but also enhances the *pleasure* of those eating at it?

Eating rituals, therefore, can be classified according to their form and sequence, their function, the emotions they evoke, and their meaning. To be more precise, one can categorize the roles of ritual in eating by as types of behaviors (order of meals, seasonally cued, table etiquette, taboos, eating, and reading); as rituals of different kinds of relationships (to nature, to other humans, and to the supernatural); as components of meals besides eating (preparation, acquisition, and cooking of food); by the emotional affect they encourage (rituals of disgust, elevation, and gratitude); and by the different strategies and contents of meaning they create.

Religious and Nonreligious Rituals of Eating: Rituals in the Strong Sense and in the Weak Sense

The word ritual often leads many to assume it refers to religious activities and interactions with deities. On the contrary, implicit in any discussion of ritual, including food rituals, is (or should be) the distinction most assume between "religious rituals," like Christian Communion or the Jewish Passover Seder, and more ordinary ritual patterns of behavior, like breakfast in the morning, lunch midday, and dinner at night (which nowadays in modern industrialized societies are more honored in the breach than observed).

A more precise way to describe this sort of difference in rituals, which is especially applicable to the role of rituals in eating, is the distinction the critical scholars of the comparison of religions Jeffrey Kripal et al. (2014) draws between "ritual in the weak sense" and "ritual in the strong sense." The weak sense of ritual "encompasses virtually all of human social behavior, taken as a coded and scripted set of actions that serve particular social and psychological functions" (Kripal et al. 2014, p. 117). The strong sense of ritual "requires something else: an invocation of superhuman powers and a fundamental orientation toward an order of reality and an eventual state of salvation that transcends the social world and its material and pragmatic needs" (Kripal et al. 2014, p. 117). This clearly corresponds to the differentiation between ordinary daily rituals and religious rituals made above but are preferable, because not all "religious" rituals, that is, rituals in the strong sense, can be associated with specific recognizable religious traditions. For rituals in this strong sense are "re-enactments of a myth," with a myth being "a sacred story that founds and grounds a particular world" (Kripal et al. 2014, p. 116). Thus, this kind of a ritual is "is the reenactment of the myth that makes that world come into being." The North American Thanksgiving dinner is a good example of a nonreligious ritual that nevertheless reenacts a myth that makes the world come into being, in this case the world of the US nation. Though ostensibly associated with American Protestantism (a commemoration celebrating the Puritan pilgrims' meal with the native Americans who helped them survive their first winter in Massachusetts according to legend), both historically and in practice is far from that. Indeed, Gurinder Chadha's movie *What's Cooking?* (Taylor & Chadha 2000) delightfully demonstrates how four contemporary quite ethnically different families in LA, African American, Jewish American, Mexican American, and Vietnamese American, each make try to make the "traditional" American Thanksgiving turkey dinner their own. In other words, it is precisely because of its symbolic significance as the myth of American origins that the ethnically diverse families in the movie appropriate the Thanksgiving turkey dinner to enact their American identity as participants in America's story.

Eating Rituals in the Strong Sense

What's Cooking?'s representation of multiethnic American Thanksgiving rituals and "religious" meal rituals have in common two features Kripal defines as characteristic of ritual in the strong sense. First, as already stated, they are rituals that reenact a myth, that is, "a sacred story that founds and grounds a particular world" in order to make "that world come into being." In other words, when modern Mexican Americans roast a turkey on Thanksgiving for a big family meal (even if they adapt it to their own flavor preference) or when Christians eat bread and drink wine in the ritual of communion or when Jews reenact the Biblical Exodus story at the Passover Seder meal, they are in effect "inscribing" themselves in the same stories and therefore in the same worlds imagined and mapped in those stories. Meals like this, ritualized in the strong sense, are thus important mechanisms for what modern sociologists call "the social construction of reality" (Berger 1990). In these kinds of meal rituals in the strong sense, participants get to make their worlds and eat them, too, that is, make them so real they can taste them. A second feature religious and nonreligious meal rituals in the strong sense share is that they accomplish this "*through scripted and repeated actions* (*"ritual"*), *usually performed in a culturally prescribed space and time* and often by a religious specialist, who performs the myth through this ritual" (Kripal et al. 2014, p. 116). In other words, they take place at special prescribed times (e.g., religious and secular holidays or life cycle events) at special places (e.g., a church, a temple, a family dining room) and are conducted by "specialists" knowledgeable in the sacred lore (family matriarchs or patriarchs – keepers of the family recipes – or a priest, a rabbi, a religiously skilled layperson, etc.). These kinds of rituals do not happen at random places and times, nor are they conducted without some sort of expert exercising quality control. These specialist experts end up being boundary keepers, the ones who assure that the social groups the meal rituals are intended to form and the social worlds they are intended to enact maintain their integrity – so that they are perceived as authentic. But perhaps most importantly, it's these specialists who accentuate the specialness of the eating rituals in the strong sense by evoking or literally invoking "the something else," the "superhuman powers and a fundamental orientation toward an order of reality and an eventual state of salvation that transcends the social world and its material and pragmatic needs" (Kripal et al. 2014). Thus often rituals in the strong sense have participants say certain words over foods to attribute to them their special symbolic quality, such as repeating the words of Jesus saying "This is My body, this is My blood," over bread and wine in the Christian Eucharist ritual, or Jewish Passover Seder participants applying verses from the Biblical story Exodus like "The bitter herb, because *the Egyptians embittered our lives*" to bitter greens or horseradish root. Or sometimes the context or occasion, not to mention the officiation of ritual specialists like priests or shamans, is enough to convey the symbolic quality of foods for the gods, even if words do not make it explicit, as in sacrifices when one is sharing food at a temple or shrine devoted to one or more gods. Indeed, the context and choreography of most food sacrifices, e.g., sending food "up" cooked in smoke, "bringing it near," or "setting it apart" (to use the literal translation of some of the typical Biblical Hebrew verbs for sacrificing: *le-ha'alot, le-hekriv,* and *le-hakdish*, respectively) to where God or the gods "dwell," imply the logic of what scholar of religion Ninian Smart (2000) calls "*do ut des*" [Latin for "I give so that you give"]. In other words, in sacrificial settings, participants understand that they're giving something to the gods with the expectation that they will get something back in return: "material and pragmatic needs" like ecological and climatic conditions conducive to the fertility of their crops and livestock (or to their own fertility), forgiveness or atonement, victory in battle, or simply the pleasures of God or the gods' company (etymologically, "sharing bread").

Perhaps by this standard, Thanksgiving dinners like those in *What's Cooking?* are not quite eating rituals in the strong sense, since the family dinner specialists don't notably invoke superhuman powers or suggest that observance of the Thanksgiving meal festivities will brings about a "state of salvation that transcends the social world and its material and pragmatic needs." Or don't they? What if the American nation were to be substituted for superhuman powers, and the sense of belonging to the America of the Thanksgiving story were a kind of salvation for the Black, Mexican, Vietnamese, and Jewish families not so secure about their status as real Americans? However one answers this, it's important to make the point that the distinction between eating rituals in the strong sense and in the weak sense is not meant to be a value judgment that one type is more important or more meaningful than the other. Rather, it's meant to acknowledge differences in the consciousness, intentionality, and relationship to recognizably acknowledged religious traditions in the practices of those who perform eating rituals when describing them. In a certain sense, all eating rituals are both weak and strong. They are weak in the sense that they are all "coded and scripted set of actions that serve particular social and psychological functions." They are strong in the sense that they all "re-enact myths that make the world come into being," even if strictly speaking, in rituals in the weak sense this is not a particularly conscious intent. Thus, Kripal correctly summarizes the ritual functions of food when he says, "Food helps make a world. Food is belonging. Food is boundary. Food is story. Food is performance. Food is self (p. 149)."

Eating Rituals in the Weak Sense

The point of calling attention to food rituals in the weak sense is that they do not only have to be experienced as extraordinarily special or “sacred” (to use the religious studies term) to nevertheless convey these world-making, belonging-making boundary-making, and story-making, self-performing powers of food. There are many day-to-day ritual practices of food taboos which habituate patterns of preferences for some foods over others. Some, like Jewish “keeping kosher,” Muslim observance of the rules of halal or daylight fasting during the month of Ramadan (the reader is referred to the Handbook Chapter by Regenstein on kosher and halal food), Indian Brahmin or Jain avoidance of meat, or Catholic fish on Friday and no meat all during Lent are religiously motivated, at least in their origins. However, even among members of those religious communities, there is a wide variation of practice. Some follow the rules out of custom or habit rather than for consciously “religious reasons,” and some even deliberately transgress them to express their identity (like Jews who eat pork to make a point that they are not bound by religious law or Muslims who drink alcoholic beverages for similar reasons). And people practice many other day-to-day food taboos and preferences that are not necessarily religiously motivated, such as vegetarianism and veganism done for ethical, ecological, health, and aesthetic reasons (the reader is referred to the Handbook Section on Ethics); eating local, sustainably produced, and/or organic foods; various diet regimens intended for weight loss or other health concerns; paleo diets; raw food diets, etc. Carbs, fats, and sugar can be just as taboo to practitioners of these diets as pork chops are to observant Jews, Muslims, or Jains.

Another significant example of regular food rituals in the weak sense is the daily cycle of breakfast, lunch, and dinner typical in many societies around the world, which do vary from culture to culture (such as continental vs. full breakfasts, lunch as the main meal of the day vs. dinner, or even what constitutes typical breakfast, lunch, or dinner foods). For example, Americans who are used to eggs or cereal for breakfast are often surprised when travelling to Middle Eastern countries how much more prominent vegetables are on the breakfast menu. And in much of modern western industrialized, workaholic cultures today, the three-meals-a-day pattern is observed more in the breach than in actual practices. People skip meals, substitute a power shake for meals with courses, and grab something to eat on the work commute. Or they may “graze” throughout the day at their own pace, eating when they’re hungry, rather than at the societally specified breakfast, lunch, and dinner times, or at high and low tea times in places still under the influence of the of the meal culture of the British Commonwealth. And yet, institutions such as schools, colleges, restaurants, hospitals, prisons, and airline companies (albeit less so recently) still tend to structure their service of meals around the basic ritually repeated practice of morning, midday, and evening meals.

The most well-known and influential discussion of this sort of regular system of daily, weekly, and seasonal meals is the anthropologist Mary Douglas’ classic essay “Deciphering a Meal” (1972). By analyzing the typical patterns of the British meals of her native culture, Douglas demonstrated that the system of meals worked a lot like a language, in which the order, number, and specific components of a meal, and of meals during the day, week, and year functioned like syntax or grammar, to make meals and their parts follow very predictable patterns. All meals, from the simplest breakfast to the most complicated Sunday or Christmas dinner, were more or less related to one another, through the multiplication of dishes with varying connotations. "Mains," "sides," soups, drinks, sweets/desserts, starches, vegetables, and fruits each have a significance in comparison to one another, as well as in combination. Breakfast, a lighter meal, may have very few courses, a main that is not a meat (eggs, a cereal), though meat (like sausage or bacon) may be as a side, and a drink (juice, coffee, tea). But compare that to a Sunday dinner, or something like an American Thanksgiving dinner that might have a soup or other appetizers, two meat mains, two starch sides, two vegetable sides, more than one sweet for dessert, and different kinds of drinks (some alcoholic, some not) served at the beginning, during, and after the main course. Moreover, mains and sides are usually savory (though sometimes sweetened to mark a special holiday meal); desserts sweet. Sides are usually a combination of starches and vegetables, not just only one or the other. Nor would one normally expect to have scrambled eggs or hot oatmeal as a main for a Christmas or Thanksgiving dinner or chocolate mousse for an appetizer before the mains. One knows this because of the implicit codes Douglas says are at play in the British system of meals but by implication could be "deciphered" analogously in any system of meals in any human culture. And these are not just codes to impose order on chaos, though of course they do that. They are "coded and scripted set of actions that serve particular social and psychological functions" (Kripal et al. 2014), that is, rituals in the weak sense that serve to create and maintain the social boundaries of family, culture, ethnicity, and class. Table etiquette, which likewise varies from culture to culture (e.g., Euro-American eating with forks, knives, and spoons; Indian and Arab etiquette of eating with one's hands; East Asian etiquette eating with chopsticks), performs similar, complementary functions. This becomes quite clear, sometimes awkwardly, for guests at meals in the home of people whose culture and accompanying table etiquette are quite different from their own (Visser 1991; Harvey 2013).

Types of Eating Rituals: A Formal Classification

In addition to differentiating eating rituals by their social functions, or better, the degree of their practitioners' intentionality and awareness of them as rituals with world-making, group-defining social functions, eating rituals may also be classified according to their form. Though the list of types of eating rituals to follow reiterates some of the rituals used as examples in the discussion above of rituals in the strong and weak senses, and cannot be claimed to be exhaustive, it nevertheless provides a good overview of the most generally recognizable forms of eating rituals. They are

1. **Orders of meals**: both the "courses" within them (e.g., appetizer, main course, dessert; drinks, before, during, and after the main course) and where they fit in the

day, e.g., breakfast, lunch, dinner, in between meal snacks, high and low teas, happy hours for drinks, etc.) with variations from culture to culture

2. **Seasonally cued meal rituals** (harvest festival meals like Jewish Sukkot or American Thanksgiving, Halloween trick or treating; Christmas dinners; the Jewish Passover Seder or Persian New Year's day Nowruz festive meals in the spring; 4th of July picnics in the summer, evening Muslim "break fasts" *iftar* meals during the month of Ramadan; or annual meals commemorating other sorts of historical events, like Scottish Robert Burns Day or African American Juneteenth meals)
3. **Meals occasioned by rites of passage**, like wedding banquets, birthday parties, *quinceañeras*, baby namings, or funerals
4. **Table etiquette rules** governing seating, table settings (what kinds of utensils if any and how they're arranged), what to wear, guest and host responsibilities, respect for social hierarchies and gender roles, appropriate postures and behaviors (like eating with your mouth shut, not burping or farting), etc. which of course also vary from culture to culture
5. **Dietary taboos**: prohibited or permitted foods as discussed above, which involve not only specifying from which plant, animal, and nonorganic sources foods may or may not be eaten but also how they are prepared (e.g., kosher meat must be salted and drained of blood; organic produce cannot be grown using certain pesticides or fertilizers), and official or semiofficial authorities who supervise their production and preparation and certify that the foods have met the required standards (e.g., the Jewish Orthodox Union, the US FDA, Muslim halal inspectors, etc.)
6. **"Scripted meals,"** that is, meals that involve the saying, singing, and/or reading of specific words accompanying the eating, which can range from improvised or prescribed food blessings, to reading and performing actual scripts like the Jewish Passover Haggadah, to suggested talking points, to shared song sheets, short readings brought or composed by the participants, to formal speeches

Particularly, notable literary representations of this are the speeches praising the god of Love in Plato's *Symposium* or General Löwenhielm's speech at the banquet in the movie *Babette's Feast* (Betzer et al. 2003, based on the short story by Isak Dinesen [1950/1993]; Brumberg-Kraus 2008). In short, since rituals are "scripted and repeated actions. . .usually performed in a culturally prescribed space and time and often by a religious specialist" (Kripal et al. 2014, p. 116), it makes sense to categorize eating rituals formally according to which sort of scripts and repeated actions they are comprised of (not to mention what "ingredients" and other "props" are used in them), where and on what occasions they are performed, who conducts them, and for whom.

Eating Rituals as Rituals of Relationship

Since eating rituals are fundamentally social activities – even when eating alone one follows the types of socially determined codes and patterned behaviors discussed above – they are inherently relational. In other words, eating rituals typically construct human relationships with the natural world, with other human beings, and with supernatural beings.

With Nature

It is not precisely accurate to say human beings construct relationships with "nature" through eating rituals, since in the ecology of things, humans are a part of nature, not apart from it. In this sense, Graham Harvey's (2013) definition of religion aptly applies to eating rituals as well. They are about respecting relationships between human and other than human persons – including other animals, plants, rivers, rocks, gods, mountains, celestial bodies, and so on. In terms of nature, humans, like other animals, are evolutionarily, cognitively "hard-wired" to recognize and distinguish between three main ways of relating to things in the environment in order to survive: Is it food? Is it a potential mate? Or is it a predator? Perhaps the taboos against eating other humans, having sex with animals or inanimate objects, or eating other animals that might see humans as food (not that any of these taboos are absolute given the variety of human practices) are rooted in these basic distinctions. Eating rituals, to the extent they maintain these categories, code and pattern relationships to fellow beings in the natural world as food, partner, or predator. That certainly puts Visser's (1991) observation with which this chapter opened in the proper light: table manners originated to curb our instincts to use our knives on our fellow diners rather than on our dinner. In any case, to have rituals designated for how to treat food implies that there are *different* rituals designated for how to treat potential mates, as well as for how to treat – that is, fight or flee from – potentially dangerous predators or rivals for resources. In other words, eating rituals are part of a whole system of rituals that are nothing less than "reenactments" of the myths that found and ground particular worlds to make those worlds "come into being" (Kripal et al. 2014, p. 116). Put differently, these ritual systems presume and imply "sacred stories" that cast all the denizens of the natural world in specific roles – relationships – vis-a-vis one another, which in effect constructs a cosmos, an ordered world of relationships between all that is. Most pertinently for conscious beings like humans, these ritual reenactments map out what is food, (and what isn't), who could be a mate (and who or what isn't), and who or what is out to get us (or isn't). Thus, in his aptly titled book *Food, Sex, and Strangers: Understanding Religion as Everyday Life,* Graham Harvey (2013) focuses on the world-making *rituals* of "religion" – understood as respecting *relations* between humans and other than human persons – by describing religions (or for a more neutral term, worldviews) as kinds of "cosmic etiquette" varying across cultures.

With Other Human Beings

Nevertheless, eating rituals are still quite concerned about relations with other people. Meals are basically social rituals that form and shape boundaries between people. Some meal rituals are rituals of inclusion (e.g., "family style" vs. serving people their meals on separate dishes; potlucks; the free vegetarian meals open to all served from the *langar*s [communal kitchens] in Sikh temples; anticipating or asking guests beforehand what their dietary constraints are and providing accordingly; inviting non-Jewish guests to Passover seders, non-Christian guests to Christmas dinners, etc.). Others are rituals of separation, such as when one's own food taboos prohibit them from eating in others' homes; arranging children's and adult tables; distinguishing head tables from other tables, like the faculty tables in British colleges; seating segregated by gender; rules for admission and membership for exclusive eating clubs; "no shoes, no shirts, no service"-type dress codes at restaurants; pricing menu items beyond the reach of most consumers at high-end restaurants; the rituals of first class, business class, and economy class seating and food service on airlines; segregation or exclusion of people from eating establishments because of their race, ethnicity, religion, or sexuality; restriction of certain parts of Biblical sacrifices to male hereditary priests and their families; etc. The practice of many elderly as well as young "unattached" adults to eat alone is also a kind of "ritual of separation," regardless if that is the eater's choice, or a matter of circumstance beyond the eater's control (e.g., loss of one's spouse or other significant other[s]) economics, social isolation because of where one lives, being socially ostracized as a pariah, etc.). Finally, the specific rules and responsibilities of host and guests are often codified in lists of meal rules, such as those enumerated in ancient Jewish rabbinic *derekh eretz* literature, Greek and Roman eating club rules parodied by the second-century CE writer Lucian, and this passage from the Gospel of Luke 14:7–14 (New Revised Standard Version) in the Christian New Testament attributed to Jesus:

> When he noticed how the guests chose the places of honor, he told them a parable. "When you are invited by someone to a wedding banquet, do not sit down at the place of honor, in case someone more distinguished than you has been invited by your host; and the host who invited both of you may come and say to you, 'Give this person your place,' and then in disgrace you would start to take the lowest place. But when you are invited, go and sit down at the lowest place, so that when your host comes, he may say to you, 'Friend, move up higher'; then you will be honored in the presence of all who sit at the table with you. For all who exalt themselves will be humbled, and those who humble themselves will be exalted." He said also to the one who had invited him, "When you give a luncheon or a dinner, do not invite your friends or your brothers or your relatives or rich neighbors, in case they may invite you in return, and you would be repaid. But when you give a banquet, invite the poor, the crippled, the lame, and the blind. And you will be blessed, because they cannot repay you, for you will be repaid at the resurrection of the righteous.

One could find similar rules for proper host and guest behavior in modern etiquette advice columns (e.g., Galanes 2012) or etiquette books (e.g., Post 1994; Martin 2005) in the appropriate sections.

With Supernatural Beings

Eating rituals that establish and maintain relationships with supernatural beings are of two types: those that involve the supernatural beings as companions, hosts, or guests at meals, or those in which the supernatural beings are themselves the food which is consumed, literally or figuratively. Supernatural beings may include God, the gods, deceased ancestors, nature spirits, ghosts, demons, in short, any other beings perceived as being somehow "more" than those ordinarily met in nature. That said, in most non-Christian or Biblically based, non-monotheistic religious or cultural traditions, such as the indigenous cultures of Native Americans, the Maori of New Zealand, or the Yoruba of Nigeria, or Shinto in Japan, these kinds of beings are not considered to be unnatural or apart from nature; they are simply other than *human* beings (Harvey 2013), though perhaps they may be *super*human (Kripal et al. 2014). The most well-known example of a ritual in which God, incarnate in his Son Jesus Christ, is food and drink to be consumed, is Christian communion, the Eucharist. But in many other traditions, there are gods who are foods, such as the *soma* consumed in the Hindu Rig Veda hymns, or the Aztec and Mayan corn (maize) god or goddess. Moreover, in some cultures, deceased ancestors may also be consumed (often as ground bones or burnt into powder mixed with other foods but sometimes in smellier, earthier, less refined forms), in what Visser (1991) calls endocannibalism, as part of mourning rituals.

Perhaps more typical are rituals that treat gods, ancestors, or other supernatural beings as hosts or guests at meals. Sacrifice rituals in which animal or plant food offerings are made to the gods in their temples or other shrines devoted to them, that is, shared with them in their "houses," have already been mentioned. These shrines may also be located in family homes, such as shrines in Hindu homes where images of deities are offered foods, bathed in clarified butter, and dressed (what Eck [1981] describes as "playing house with the gods"), or the idea in post-Biblical rabbinic Jewish traditions that the dinner table is a *mikdash me'at* – a "mini-temple" – where God can still be served through sharing food, in lieu of the sacrifices that can no longer be performed in the Jerusalem Temple destroyed in 70 CE. The Jewish tradition of separating *hallah*, a portion of dough set aside when making bread and burnt (for God), which has become the term for the braided or round egg breads typically served for Sabbath and holiday meals, is another way of sharing food with God even after the temple sacrifices are no longer possible (Brumberg-Kraus 2018). The traditions across cultures for verbally invoking the gods by name are ways of acknowledging them as the hosts of one's meals, such as the classical Greek and Roman invocations of the gods before meals, Christian grace, or Muslims uttering *bismillah* ("in the name of God") before eating or slaughtering animals for meat. The opening blessing before the Jewish grace after meals is literally called "the blessing of invitation" (*birkat ha-zimmun*), in which the meal participants explicitly acknowledge that it was from God's table they ate, "Blessed are You Our God, from Whose table we have eaten." The presence of dead ancestors may also be acknowledged as if they were guests at meals, whether formally, in home shrines especially in East Asian cultures where food is offered to them or when the yet unburied bodies of family members might be present in the homes where the living family members live (such is in the funeral practices of the Toraja in Indonesia [Montagnon et al. 1977/2001; Crystal 1974], or the roots of some Halloween traditions featured in Ray Bradbury's animated movie based on his novel *The Halloween Tree* [Kirschner et al. 1972/1993/2016]), or informally, in the conversations recalling deceased or otherwise absent family members that typically arise during family seasonal or rite-of-passage meal celebrations. Nature spirits too may be considered as guests welcome to partake of food consumed by humans, as the Indonesian Toraja who shared their rice harvest with rats, understood as the embodiment of such spirits. However, this could go awry, as when the rats consumed too much of the rice harvest, which some Toraja understood as retribution for the increasing adoption of Christianity in place of their traditional indigenous ways (Hollan 1988). In a sense, all acts of eating directly or indirectly involve some kind of violence between humans and other than human beings which threatens their fundamental "relationality" and must somehow address and repair the breaches that living in the world requires. (The reader is referred to the Handbook Section on Ethics). In Graham Harvey's view (informed especially by the modern Maori religious thinker T. P. Tawhai), the basic point of religions is to provide rituals to negotiate this necessary oscillation between acts of violence and reconciliation basic to our existence in the real world. As Harvey puts it, "[R]eligion occurs when people face their victims," – animal, vegetable, and mineral; natural and super-natural –

> fully cognisant that reciprocity is integral to relationality, and seek to enhance intimacy with others despite violence. Religious activity is undertaken when, *in ritual and etiquette*, in restraint and celebration, and in honouring mana and taboo, people seek permission and offer placation either for necessary but nonetheless wrongful acts of violence. (p. 116)

In other words, if indeed, "religion is etiquette in the real world" (Harvey, p. 199), then rituals of eating, which are all about structuring people's relationships to the real world, engage people in "religious," or at least religion-like behavior, whether conscious of it or not.

Eating Rituals Are More Than Just *Eating* Rituals

Since much of the violence related to eating usually has occurred long before the food has actually arrived at the table to eat – e.g., in the killing of animals for food, in the harvesting of produce out of the soil, or in the often inequitable economics of production and distribution of food – one must point out the importance of the rituals of food preparation when discussing the role of rituals in eating. The two main categories for food preparation rituals are (1) the rituals of acquiring foods and (2) the rituals of cooking foods. In the first, by whom and how are foods acquired? Grown oneself, bought in open markets, in grocery stores or chains, prepared at restaurants (fast food and more formal and/or expensive), ordered and delivered on-line, etc.? Is the food acquired by begging, either necessitated by the eater's poverty, or to make a symbolic point, that the eater is detached from material things and striving for them, as in the case of Theravada Buddhist and Jain monks, or the practice of the Jesus and earliest apostles as itinerant charismatic healers and preachers, to demonstrate their faith in God to supply their needs (albeit through the hospitality of their sympathizing communities). Gerd Theissen (1978) aptly calls this practice "charismatic begging." This also benefitted the ordinary Buddhists, Jains, and Christians who acquired merit or blessing for feeding their teachers. And each of these stages or options of food acquisition has its own set of patterned and repeated typical behaviors. Is it daily, weekly, less frequent, seasonal, or hunger impulse driven? Jewish Biblical and post-Biblical traditions are particularly notable for their extensive rules not only for eating food but also agricultural rules: how and when plants are to be harvested; how animals are to be raised, slaughtered, and apportioned between ordinary Israelites, priests, and their families, and God in the sacrificial system; which rules are to be practiced when the sacrificial system no longer exists after the destruction of the temple and exile of Jews from the land of Israel after 70 CE? (Brumberg-Kraus 2015). And one can find similar kinds of rule books for agriculture in other traditions (not to mention farmers' almanacs) as well as for sacrifices. As for rituals of shopping for foods, everyone who has themselves or knows others who observe the kinds of dietary restrictions discussed above is familiar with the rituals of checking labels for ingredients and/or appropriate certifications. Likewise, when dining out, there are the rituals of checking for problematic ingredients by asking if something is made with chicken stock, is gluten free, contains nuts, etc. And cooking food also has its own set of rituals, from following family customs and traditions for preparing certain dishes, to intentionally using inherited family heirloom cookware (e.g., a favorite pot or knife), to the religious rules governing the preparation of halal or kosher foods in the kitchen (like discarding eggs with bloodspots or using separate sets of dishes and cookware for dairy and meat preparations, to the conventions "inscribed" and also varying in time and place in the phrasing and order of instructions in cookbooks. And as in the rituals of food acquisition, so in food cooking, one can ask: Is it males or females, parents or children, professionals or nonprofessionals, members of particular social classes or from specific racial and ethnic backgrounds who are assigned or who have voluntarily taken on the tasks of cooking? Indeed, the significant decrease of people who do their own cooking at home from scratch in contemporary Western industrialized societies is itself a remarkable shift in the ritual practices of cooking. Michael Pollan, in his book *Cooked* (2013), intended to stem this trend, nevertheless acknowledges the views of some that pretty soon home cooking will be as rare or obsolete as making one's own clothes. Given this trend, the rarer occasions for home cooking tend to be ritualized – for seasonal holidays, like Thanksgiving, Christmas, Passover, or for birthdays. That said, the occasions for opting not to cook (that is, paying others to cook) by going out to dinner or arranging caterers to celebrate a birthday, wedding, anniversary, retirement, school graduations, etc., may also be understood as seasonal, life cycle, or otherwise patterned and predictable rituals.

Rituals and the Psychology of Taste

Whatever social constructing, world-building functions the rituals of eating and preparing food have, especially in negotiating people's complex relationships in and with the real world, they are able to do so because of the tremendous psychological power rituals have on the human experience of eating. First, certain emotions can be specifically associated with eating (Rozin 1999), namely, disgust (Rozin et al. 1997), "the emotion of elevation," (Haidt 2003) and gratitude (Algoe and Haidt 2009). According to Algoe and Haidt (2009), elevation is the emotion

> elicited by acts of charity, gratitude, fidelity, generosity, or any other strong display of virtue. It leads to distinctive physical feelings; a feeling of 'dilation' or opening in the chest, combined with the feeling that one has been uplifted or 'elevated' in some way. It gives rise to a specific motivation or action tendency: emulation, the desire 'of doing charitable and grateful acts also.'

While disgust for social vice (elevation's "opposite") is obviously associated with food preferences, in that bitter tasting foods tend to trigger the same disgust reflex (Rozin et al.), the connection between the "other-praising" emotions of elevation and gratitude to eating is a bit more complicated. The link is oxytocin, the so-called love hormone, which plays a role both in modulating preferences and satiation for the taste of sweetness (Leng and Sabatier 2017) and is released when people experience the emotions of elevation and gratitude (Algoe & Haidt). Without going too deeply into the chemistry, suffice it to say that when oxytocin is released in diners' brains during a meal either because of eating tasty sweets or because of their admiration for their company's behavior and/or their ritualized expressions of gratitude, the ensuing emotion of elevation may make the meal (ful)filling even without eating as much food as the diners may have initially craved. In other words, good company and the emotions that go with it may be as satisfying as eating the food itself. The right words and gestures at the meal, that is, rituals of eating, already discussed above, can prompt this emotional effect. Moreover, in their study, Vohs et al. (2013, p. 1715) demonstrate that rituals per se, defined as "symbolic activity that often includes repeated and unusual behaviors occurring in fixed, episodic sequences," can make food actually taste better. Finally, rituals can have the psychological effect of *changing* one's taste preferences, in what Prescott (2012) calls "evaluative conditioning." Though people may be "hard-wired" to like or dislike particular flavors – most children prefer sweet to bitter foods, and some people for genetic reasons cannot abide the taste of cilantro – none of this is written in stone. Human taste preferences are nearly infinitely malleable, depending upon situation and habituation. A case in point is that while many children do not like the bitter tastes of coffee or beer, acquiring a taste for them is somewhat incentivized by their association with adulthood. Practiced as rituals of adulthood, such acquired tastes exemplify evaluative conditioning. And the reverse can happen. A traumatic experience associated with a food once liked can turn one off to it from then on. Most of the taste preferences for celebratory seasonal foods, family dishes, or the familiar cuisines of one's own culture discussed above were acquired through the evaluative conditioning of regular habitual ritual practices. Indeed, it is the psychological effect of rituals of eating to associate "powerful, pervasive, and long-lasting moods and motivations" (Geertz 1973 pp. 90, 94) to specific foods, situations, places, and people that give these rituals in the strong sense their world-making power.

Conclusion

The role of ritual in eating is to make it meaningful to people – affectively, cognitively, socially, culturally, and, yes, religiously. However, the meaningfulness of eating rituals is not "religious" in the sense that they necessarily require or imply adherence to specific faith traditions or belief systems. Rather, the rituals involved in the daily and necessary acts of human eating are "religious" in the role they play in coding and "scripting" sets of actions that serve particular social and psychological functions, in reenacting myths that make worlds come into being, whether those who practice them are aware of it or not. In particular, because food is so "fundamental, fun, frightening, and far-reaching" (Rozin 1999), the rituals associated with it are nothing less than a kind of implicit or explicit "cosmic etiquette." Rituals of eating form the fundamental *relationships* people have with the human and other than human persons with whom *we* cohabit in the real world. Are they food, foes, or friends? Fellow diner or dinner? Rituals of eating are a subset of *all* the *rituals of respecting relationships* between human and other than human persons in the world. In other words, how should we behave with them appropriately? The first step toward this respect is to abandon the omniscient third person objective pose, a linguistic ritual of hyperseparation that as scholars we are somehow outside or above this network of relationships in nature (Harvey 2013).

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Emotions of Eating and Drinking

18

Herbert L. Meiselman

Contents

Abstract

The study of emotions has grown in the last 20 years from both the health orientation and the commercial product development orientation. The field continues to discuss the definition of emotion and the theory of emotions, both of which have implications on how to measure emotions, which is the main focus of this chapter. Emotion is usually defined as a rapid reaction to a stimulus, which could be a food or drink. Longer-term feelings are usually called moods. Existing emotion lists, in many languages, help the researcher to determine whether their method (questionnaire) contains real emotion words. Emotion questionnaires include some traditional ones from earlier days of emotion research to newer questionnaires often developed in the commercial product-development context. These questionnaires have produced a large number of research studies on food and drink products. One of the biggest challenges of emotion research is doing emotion research cross-culturally. This is especially true with questionnaires that use words; often the original research was done in English or another western

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language and then transported to another western country or to an Asian or other country. It is sometimes not clear whether the original emotion concept exists in the other country, and what words express that feeling – sometimes the emotion term does not clearly exist, and sometimes more than one word is used to express that feeling.

Introduction

Eating and drinking are behaviors surrounded with emotions. We experience emotions before we drink or eat, we experience emotions while eating and drinking, and we experience emotions after eating and drinking. Further, since we eat and drink multiple times every day, food and drink are major sources of emotions in our daily lives. Studying the connection between food, drink and emotions is both relatively old and relatively new. For many years, emotions have been studied as the precursor to eating, especially overeating and overdrinking. This is the more clinical side of food-emotion research, with an emphasis on health. For example, the health-oriented journal *Appetite* has had 1,066 papers dealing with "emotion," mainly since 2005, with a general increase after 2010, and the journal *Eating Behaviors* has had 400 papers, mainly since 2007 (numbers accurate as of August 2019). More recently emotions have been studied as a measure of how people react to food and beverage products. This is the more commercial food-emotion research, with an emphasis on product development and testing. The journal *Food Quality and Preference* shows 391 papers dealing with "emotion" mostly since 2010; the journal *Food Research International* shows 95 papers dealing with "emotion" mainly since 2015 (numbers accurate as of August 2019). There have been major increases in interest in emotion for both types of food related emotions – health oriented and product development oriented. The first book on the topic of emotion measurement was the book by Meiselman (2016); most earlier books dealt with emotion theory.

When combined together the study of emotions leading to (over)eating and the study of food products leading to emotions represent a large field of research worldwide in both academia and commercially (Macht 2008; Meiselman 2016).

Defining Emotions

Before examining the research on eating, drinking and emotions, it is appropriate to define some terms. The broadest term in this field is affect or affective behaviors or feelings. These terms refer to all subjective events which are valenced, meaning they can be positive or negative (Desmet 2008 in Schifferstein and Hekkert, Product Experience). Affective states is the broadest category, and they include emotions, attitudes, traits, and moods (Ferdenzi et al. 2013). *Thus, affective states and emotions are not synonyms*; "All emotions are affective, but not all affective conditions are emotions" (Clore et al. 1987).

The definitions of emotion and mood to follow are meant to assist the reader with the remainder of this chapter; however, it is important to point out that arguments continue within the field about the exact meaning of affect, emotion and mood, and also how to measure them (Coppin and Sander 2016; Barrett 2016). Copin and Sander (2016) summarize the situation by noting that “The topic of emotion rarely leaves individuals unemotional”(Coppin and Sander 2016). These authors further note, “The difficulty of defining emotion, and delineating its boundaries to other affective phenomena (e.g., mood, preference, attitude, passion, affect) is not the only challenge. . ..The issue of defining emotion is still a contemporary one (Russell 2012), and strongly impacts current models of emotion (Sander 2013).” Feldman Barrett (2016) summarizes the state of emotions the same way, “a perplexing situation: there are a *multitude* of emotion theories that vary a great deal from one another in almost every way imaginable; they disagree on the details of how an emotion should be defined,. . .” (Feldman Barrett 2016).

An emotion is an affective response to a stimulus (person, statement, thing, etc.). Usually the person can identify the stimulus that produced the emotion. They are of short duration, usually measured in seconds or minutes. Emotions have multiple components including a cognitive, a behavioral, and physiological components.

Mood is also an affective behavior, but one cannot identify a specific stimulus that led to the mood. Emotions develop quickly and last a short time; moods develop more slowly and can last a (very) long time. Moods can be described as more diffuse, less intense (Desmet 2008).

Why is it important to define emotions and to differentiate them from other affective states? Because if one wants to conduct research on emotions or to measure emotions, one needs to know where to draw the line on what to include, and what to exclude. The literature on emotions is filled with examples of supposed emotions that do not fit these definitions, and which are not found on emotion lists (see the section “Emotion Lists”). Part of the problem in getting general agreement on emotion definitions and emotion theory is the very wide practices of including/excluding emotions. This is especially true because emotion measurement takes place in a number of very different fields, including Clinical Psychology, Consumer Research and Marketing, Advertising, Hospitality, etc.

Emotion Lists

Emotion lists are very helpful in conducting research on emotions, and were reviewed by Jiang et al. (2014) and Grühn and Sharifian (2016). Emotion lists provide guidelines on what to include in emotion research and what to exclude or to at least question. Just as there are many views of emotion, there are many lists of emotions, so the recommended approach is to not depend on one list of emotions but to use several or many lists of emotions. The lists of emotions include word lists, picture/image files, face files, and motion picture files (Table 1). Grühn and Sharifian (2016) discuss each method in terms of the following criteria: ecological validity, temporal resolution (processing time), controllability (for the stimuli), complexity

Table 1 Sample lists of emotional stimuli by type of stimulus

Authors	List	Type and number	Ratings
Words			
Bradley and Lang (1999)	ANEW		Dimensional on 9-point SAMs • Valence, arousal, dominance
Whissel (2009)	DoA	8742 English words	Dimensional on 3-point bipolar scales • Pleasantness, activation, and imagery
Warriner et al. (2013)		13,915 English lemmas	Dimensional on 9-point bipolar scales • Valence, arousal, and dominance
Grühn (2016)	EMOTE-A	985 English adjectives	Dimensional on 7-point bipolar scales • Valence, arousal, emotionality, concreteness, imagery, familiarity, clarity of meaning, control, desirability, and likeableness
Grühn (2016)	EMOTE-N	1287 English nouns	Dimensional on 7-point bipolar scales • Valence, arousal, emotionality, concreteness, imagery, familiarity, and clarity of meaning Objective word characteristic: • Memorability
Images			
Lang et al. (2005)	IAPS	956 images	Dimensional on 9-point SAMs • Valence, arousal, dominance
Marchewska et al. (2013)	NAPS	1356 images	Dimensional on 9-point bipolar scales • Valence, arousal, and dominance
Grühn et al. (2015)	AID	7,232 images	Dimensional on 7-point SAMs • Valence and arousal
Faces			
Ekman and Friesen (1976)	POFA	110 images	Discrete facial expressions • Happiness, sadness, surprise, fear, disgust, anger
Minear and Park (2004)	PAL faces	1,142 images by 576 persons	Dimensional
Ebner et al. (2010)	FACES	2,052 images by 171 persons	• Discrete – Neutral, anger, disgust, happiness, fear, and sadness
Film clips			
Philippot (1993)		12 film clips	Discrete – 6 emotions • Amusement, anger, disgust, fear, neutral, and sadness
Gross and Levenson (1995)		16 film clips	Discrete – 16 emotion terms
Schaefer et al. (2010)		70 film clips	Dimensional • Arousal on 7-point bipolar scale • Positive and negative affect on subscales Discrete – 7 emotions

(continued)

Table 1 (continued)

Authors	List	Type and number	Ratings
			• Anger, fear, disgust, sadness, amusement, tenderness, neutral
Sharifian and Grühn (2015)	SEEMS	21 film clips	Dimensional on 7-point SAMs • Valence and arousal Discrete – 20 emotion terms

(of the stimuli), and emotional intensity. Word lists are lower for ecological validity, complexity and intensity, but higher for temporal resolution and controllability, whereas film clips show the reverse scores (higher for ecological validity, and emotional intensity, etc.)

When developing an emotion questionnaire including an emotion list, it is important to keep in mind that there are more negative emotion words than positive emotion words, but positive emotion words are more frequent in speech. Positive words tend to be shorter, while highly arousing words tend to be longer and less frequent.

Grühn and Sharifian (2016) point out that high frequency words are better remembered in recall tasks, but low frequency words are better recognized in recognition tasks.

Two helpful traditional lists of emotion words are the lists of Clore et al. (1987) and the list of Laros and Steenkamp (2005) who list 313 emotions drawn from the literature (173 negative, 140 positive). They provide a code to attach each emotion to those who have included it in their previous lists; thus, is a good summary list of work done before 2005. Ortony et al. (1987), Clore et al. (1987) developed their emotion lexicon starting with 585 “emotion” words, which was then reduced to 234 based on their criteria for defining emotions.

Laros and Steenkamp (Table 2):

Gmuer et al. (2015) argued that previous emotion lists were not based on linguistic analysis (Table 3).

Finally, as we observe more automated emotion research, using social media and other sources of words, we should mention the LIWC word list. The Linguistic Inquiry and Word Count (LIWC) (2001) used in on line research, contains 615 emotional/affective terms including 251 positive and 345 negative. The newer, revised LIWC (2015) contains 1393 affective words with 620 positive and 744 negative.

The reader should note that all of these lists contain more negative words than positive words, although positive words used with food might be more frequent. In fact, Gmuer et al. (2015) note that their Swiss convenience sample categorized 49 affective food terms as positive ($n = 34$) much more than negative (n-12 or neutral ($n = 3$), even though there were more negative affective terms in their overall list of 272 food-related terms.

Another approach to developing emotion lists is to get information from consumers, especially when one is interested in emotions relative to a specific product category (e.g., pasta or chicken). One can ask how consumers feel before they decide

Table 2 Emotion words

Negative emotion words	Positive emotion words
Aggravation[a,b,c], Agitation[a,b,c], Agony[b,c], Alarm[b,c,d], Alienation[b], *Anger*[a,b,c,d,e,f,g], Anguish[a,b,c], Annoyance[a,b,c,d,e,f,h], Anxiety[a,b,c,e], Apologetic[c], Apprehension[a,b,c], Aversion[e], Awful[c], Bad[c], Bashful[c], Betrayal[c], Bitterness[a,b,c], Blue[a,c,i], Bothered[c], Cheerless[a], Confused[h], Consternation[c], Contempt[b,c,e,g], Cranky[c], Cross[c], Crushed[h], Cry[c], Defeat[b], Deflated[a,b], Defensive[c], Dejection[a,b,c], Demoralized[c], *Depression*[a,b,c,d,h], Despair[b,c], Devastation[c], Different[c], Disappointment[a,b,c,e,f], Discomfort[c], *Discontent*[a,c], Discouraged[c], Disenchantment[c], Disgust[a,b,c,e,g,h], Dislike[b,c,g], Dismay[b,c], Displeasure[a,b,c], Dissatisfied[a,c], Distress[a,b,c,d,g,i,j], Distrust[c,e], Disturbed[c], Down[a,c], Dread[b,c], Dumb[c], Edgy[c], *Embarrassment*[a,b,c], Empty[a,c], *Envy*[a,b,c], Exasperation[b], *Fear*[b,c,d,e,f,g,h,i,j], fed-up[a], Ferocity[b], Flustered[a], Forlorn[c], Foolish[c], Frantic[c], Fright[a,b,c,h], *Frustration*[a,b,c,d,f,g], Fury[a,b,c], Gloom[b,c,d,h], Glumness[b], Grief[a,b,c,f], Grouchiness[b,c,i], Grumpiness[b,c,i], *Guilt*[b,c,e,g,j], heart-broken[a,c], Hate[b,c], Hollow[c], *Homesickness*[a,b,c], Hopelessness[b,c], Horrible[c], Horror[a,b,c,f], *Hostility*[b,c,h,i,j], *Humiliation*[b,c], Hurt[a,b,c], Hysteria[b], Impatient[a,c], Indignant[c], Inferior[c], Insecurity[b], Insult[b,c], Intimidated[h], Irate[a,c], Irked[a], *Irritation*[a,b,c,h,j], Isolation[b,c], *Jealousy*[a,b,c,e], Jittery[i,j], Joyless[a], Jumpy[c], Loathing[b], *Loneliness*[a,b,c,i], Longing[c], Loss[c], Lovesick[a], Low[a,c], Mad[a,c], Melancholy[b,c], *Misery*[a,b,c,d], Misunderstood[c], Moping[c], Mortification[a,b], Mournful[c], Neglect[b,c], *Nervousness*[a,b,c,i,j], Nostalgia[c], Offended[h], Oppressed[c], Outrage[a,b,c], Overwhelmed[a], Pain[c], *Panic*[b,c], Petrified[a,c], Pity[a,b,c], Puzzled[h], Rage[b,c,e], Regret[a,b,c,e,g], Rejection[b,c], Remorse[a,b,c], Reproachful[c], Resentment[a,b,c], Revulsion[b], Ridiculous[c], Rotten[c], *Sadness*[a,b,c,d,e,f,g,h,i], *Scared*[a,c,h,j], Scorn[b,c,i], self-conscious[c], *Shame*[a,b,c,e,g,j], Sheepish[c], Shock[a,b,c], Shy[c], Sickened[a,c], Small[c], Sorrow[a,b,c,e,i], Spite[b], Startled[e,h], Strained[c], Stupid[c], Subdued[c], Suffering[b,c], Suspense[c], Sympathy[b], *Tenseness*[b,c,h], Terrible[c], Terror[a,b,c], Threatened[h], Torment[a,b,c], Troubled[c], Tremulous[c], Ugly[c], Uneasiness[a,b,c], *Unfulfilled*, Unhappiness[a,b,c,i], Unpleasant[h], Unsatisfied[c], Unwanted[c], Upset[a,c,e,j], Vengefulness[b,c], Want[c], Wistful[c], Woe[b,c], *Worry*[b,c], Wrath[b,c], Yearning[c]	Acceptance[c,h], Accomplished[c], Active[i,j], Admiration[c], Adoration[b,c], Affection[b,c], Agreement[c], Alert[h,j], Amazement[b] Amusement[a,b,c], Anticipation[b,c], Appreciation[c], Ardent[c], Arousal[a,b,d], Astonishment[b,d,i], at ease[a,d], Attentive[h,j], Attraction[b,c], Avid[c], Bliss[b], Brave[c], *Calm*[a,d], Caring[b,c], Charmed[a], Cheerfulness[a,b,c,h], Comfortable[c], Compassion[b,c], Considerate[c], Concern[c], *Contentment*[a,b,c,d,i], Courageous[c], Curious[h], Delight[a,b,c,d,h], Desire[b,c], Determined[j], Devotion[c], Eagerness[b,c], Ecstasy[a,b,c], Elation[a,b,c,i], Empathy[c], Enchanted[c], *Encouraging*[c], Energetic[f], Enjoyment[b,c,f], Entertained[c], Enthrallment[b], *Enthusiasm*[b,c,e,f,i,j], Euphoria[b,c], Excellent[c], *Excitement*[a,b,c,d,f,i,j], Exhilaration[b,f] Expectant[c], Exuberant[c], Fantastic[c], Fascinated[e], Fine[c], Fondness[b,c], Forgiving[c], Friendly[c], *Fulfillment*[c], Gaiety[b,c], Generous[c], Giggly[c], Giving[c], Gladness[a,b,c,d], Glee[b,c], Good[c], Gratitude[c], Great[c], *Happiness*[a,b,c,d,e,f,h,i], Harmony[c], Helpful[c,h], High[c], *Hope*[b,c,g], Horny[c], Impressed[c], Incredible[c], Infatuation[b,c], Inspired[j], Interested[f,j], Jolliness[b], Joviality[b], *Joy*[a,b,c,e,f,g], Jubilation[b,c], Kindly[c,i], Lighthearted[c], Liking[b,c,g], Longing[b], *Love*[a,b,c,e], Lust[b,c], Merriment[c], Moved[a], Nice[c], Optimism[b], Overjoyed[a,c], Passion[a,b,c], Peaceful[c,f], Peppy[i], Perfect[c], Pity[c], Playful[c], *Pleasure*[a,c,d,f,i], Pride[a,b,c,e,f,g,j], Protective[c], Rapture[b], Reassured[c], Regard[c], Rejoice[c], Relaxed[c,d,f], Release[c], *Relief*[a,b,c,e,f,g], Respect[c], Reverence[c], *Romantic*[c], Satisfaction[a,b,c,d,f,i], Secure[c], Sensational[c], Sensitive[c], Sensual[c], *Sentimentality*[b,c], Serene[d,c], Sexy[c], Sincere[c], Strong[i,j], Super[c], Surprise[b,e,f,i], Tenderness[b,c], Terrific[c], Thoughtful[c], *Thrill*[a,b,c], Touched[a], Tranquility[c], Triumph[b], Trust[c,h], Victorious[c], *Warm-hearted*[c,i], Wonderful[c], Worship[c], Zeal[b], Zest[b]

Note: The emotion words of Richins' CES (1997) are in italics
[a]Morgan and Heise (1988)
[b]Shaver et al. (1987)
[c]Storm and Storm (1987)
[d]Russell (1980)
[e]Frijda et al. (1989)
[f]Havlena et al. (1989)
[g]Roseman et al. (1996)
[h]Plutchik (1980)
[i]Watson and Tellegen (1985)
[j]Watson et al. (1988)

to have the food or after they eat the food. If one uses this approach you must use a large representative sample of consumers., not a small convenience sample. One could then check the terms developed against the lists above – if the words appear in the lists above, they are probably emotions; Of the words cannot be found on any lists of emotion, they are probably not emotions. Developing a new food questionnaire is a labor-intensive process. Which is why many researchers use an already published questionnaire, even when that might not be a perfect fit.

Methods for Measuring Emotions

Emotions can be measured in several ways. Lucas et al. (2009) list the methods and their strengths and weaknesses. *Self-reports of emotion* are captured by questionnaire or interview, and these methods might suffer from a number of biases including social desirability and extreme responding. Also respondents might be unwilling or unable to report their feelings, especially in certain cultures (add a ref. on cultures?). Instead of self-reports one can use *observer reports of emotion* which correlate moderately with self-reports. *Facial measurement* has been suggested as a measure of emotion for some time, including the Facial Action Coding System (FACS)(see below). The method is based on measurement of muscle activity, but when it is done by observers it might be subject to both personal and cultural bias. In addition, substantial training is required for data collection and the actual measurement is time consuming. In addition to facial measurement by trained observers, several automated methods are available, such as from Noldus (see below). There is some evidence that facial measurement distinguishes different positive affective states, but has trouble differentiating positive emotions. *Physiological measures*, especially those from the autonomic nervous system, are also used to measure emotions (see below). Once again, these measures tend to differentiate negative emotions but not positive ones. Finally, there are a number of *behavioral measures or emotion-sensitive tasks*, such as mood boards (see below). Interestingly, no one method has emerged as the preferred method; many studies of food use self-report questionnaire methods, but some use facial and physiological methods, and behavioral methods. This partly depends on the theoretical and practical orientation of the researchers, but also involves practical testing considerations like training time, testing time, budget, how fast one needs the results, the cooperation of the test subjects, and many other factors.

Self-Reports of Emotions

Emotion questionnaires are probably the most commonly used method for measuring emotions, because of practical considerations. They require little preparation, can be done almost anywhere (both on site and remotely), require no professional administration, and can be done inexpensively with small or very large numbers of respondents. In commercial work, they fit in easily to consumer testing, where the

Table 3 Comparison of domain- and product-specific emotion and feeling lexicons in the sensory science literature[A]

Absent minded[g]. Active[a]. Admiration/Admiring[d,f,g], Adoring[f], Adventurous[a,g,k], Affectionate[a,g], Aggressive[a,g,h,k], Alone[g], amusement/amused/Amusing[b,c,d,f,h], anger/Angry[c,d,f,i], Annoyed[i], Anxious[g], Approval[i], Arrogant[g,j], Astonishment[b], at ease[i], Attentive[i], Attracted[c,d,e], Belittled[g], Bland[h], Bliss[c], boredom/Bored[a,f,i], Calm[a], Caring[g], Cautious[i], charmed/Charming[f,g], Cheerfulness[c], Clean[d,e], comforted/Comforting[e,f,i,k], Confident[g,k], Confused[g,i], Contempt[c], Content[b], Crabby[g], Critical[g], Curious[h,i], Daring[a], Delight[b,c], Depressed[f], desire/Desirable[d,e,f,h,i], Despairing[g], Dirty[d,e,f], disappointment/Disappointed[b,c,i], Disapproving[g], Discontented[c,g,i], disgust/disgusted/Disgusting[a,b,c,d,e,f,g,h,i], disinterested lethargy[g], Displeasure[i], Dissatisfactions[d] Doubt[b], Dreamy[e], Drowsy[e], Dull[g], Eager[a], Easygoing[k], Elegant[h], Embarrassment[b], Energetic[a,c,d,e,f,g,h], Enthusiastic[a,c], Envy[c], Euphoric[h], Excited[c,d,g], Exhausted[g], Famished[e], Fascinated[f], Fear[c], feeling awe[d], Feminine[k], Free[a,c], Friendly[a], Frustration[b], Fun[k], Furious[g], Glad[a], good[a,i], good-natured[a], guilt/Guilty[a,b,i], happiness/Happy[a,c,d,f,g,h,i], heart-stricken[g], Hesitation[b]. Horrible[f], Horrified[g], Impatience[b], in a good mood[e], in love[d,e,f]. Indifference[b], Infatuation[c], Inferior[g], Inhibited[g], interest/interested/Interesting[a,b,f,h,i], Invigorated[d], Irate[g], Irritated[d,f], Jealous[g], joy/Joyful[a,c,h], Keen[h], Lassitude[b], light[d], Light-hearted[g], Lively[g], Loving[a], Lustful[e], Luxurious[k], Marvel[c], Masculine[k], Meditative[e], Merry[a], Mild[a], Nauseous[e], Neglected[g], Nervous[g], nostalgia/Nostalgic[a,b,c,d,e,g], not refreshed[i], Ordinary[k], Overjoyed[g], Overwhelming[h], Passionate[g,h], Passive[g], peaceable/Peaceful[a,b,c,i], pleasant[a,c,d,f,h], Pleasure/Pleased[a,b,c,i], Polite[a], Powerful[k], Pretentious[k], Pride[b], Protected[e], Purposeful[g], Quiet[a], Reassured[g], Refreshed[c,d,e,f,i], regret/Regretful[b,g,i], Reinsured[d], Rejoicing[b], Rejuvenated[e], Relaxed[d,e,f,g], Relief[c], religious feeling[f], Reminiscence[i], Repelled[e], Resentment[i], Respectful[g], Revitalized[d,e,f], Romantic[d,e,i], sadness/Sad[c,f,g], Salivating[d,e], satisfaction/Satisfied[a,b,c,i], Scared[g], Skeptical[i], Secure[a], Sensual[d,e,f,k], Sentimental[e], Serene[b,c,d], Serious[k], sexually aroused[f], Sexy[d,e,f], Shivering[d], Shocked[i], Shy[g], sick/Sickenmg/Sickly[d,e,f,i], Silly[g], Sluggish[g], Sociable[g,k], Soothed[d,e], Sophisticated[k], spiritual feeling[f], Steady[a], Stimulated[d,e], Strange[g], Stressed[f], Subdued[g], Superior[g], (un-/Pleasant) surprise/(un-/pleasantly) Surprised[c,d,e,f,g,i], Suspicious[g], Tacky[k], Tame[a], Tender[a,c], Terrific[g], Thirsty[e], Thrilled[b], to feel intimacy[e], to like/Likings[b,c], Touched[g], Traditional[k],Trembling[c], Troubled[c], Trust[i], Trustworthy[k], Uncomfortable[e,f,i], Uncomplicated[k] Understanding[a], Uneasiness[b], Unhappy[i], Unpleasant[d,e,f], Vigilant[b], Warm[a,c,i,k], well-beings[c,d,f], Whole[a], Wild[a], Willful[g], Worried[a,i], Youthful[k]

Domain-specific
[a]King and Meiselman (2010)
[b]Rousset et al. (2005)
[c]Pionnier Pineau et al. (2010)
[d]Chrea et al. (2009) – GEOS
[e]Ferdenzi et al. (2011) – LEOS
[f]'Ferdenzi et al. (2011) – SEOS
[g]Thomson and Crocker (2013)
Product-specific
[h]Ferrarini et al. (2010)
[i]Ng et al. (2013)
[k]Thomson et al. (2010)
[A]Comparisons were conducted based on the English translations provided by the authors in cases in which the lists were originally published in another language than English

consumer is usually being asked questions anyway. They have a major potential problem with various response biases so the administration of questionnaires needs to avoid these as much as possible with carefully worded instructions and comments during testing (see Jaeger and Cardello 2016). Obviously testing branded products within a company might lead to biased responses.

Emotion questionnaires have been designed for clinical applications aimed at the health perspective, and emotion questionnaires for food product applications aimed at the commercial perspective. The former questionnaires are often given before consuming food, based on the view that negative emotions lead to overeating in certain individuals (restrained eaters) (Macht 2008; Macht and Simons 2000). Since this type of research had been going on for some time, these questionnaires tend to include some of the traditional affect questionnaires. Examples of these questionnaires include the Positive and Negative Affect Schedule (PANAS) (Watson et al. 1988) and the Consumption Emotion Set (CES)(Richins 1997), Profile of Mood States (POMS) and Multiple Affect Adjective Checklist (MAACL).

The PANAS (Fig. 1) is one of the shortest and most frequently used of these emotion questionnaires; it also balances positive and negative emotions with 10 of each. However it has received criticism for its choice of words (e.g., see Diener et al. 2009). Nevertheless, it has been shown to be valid (i.e., representing two dimensions of affect) and reliable with no major differences among demographic subgroups (Crawford and Henry 2004). The PANAS is available in the 20-item original format or the enlarged 60 item PANAS-X (Watson and Clark 1994). The PANAS has been translated into many languages (see the Watson website?). Other traditional emotion questionnaires are the Profile of Mood States with 65 terms (POMS, McNair et al. 1971) and the Mood Affective Adjective Check List (MAACL) with 70 or 132 terms published by Zuckerman and Lubin in 1965 and the revised MAACL-R (Zuckerman and Lubin 1985). The POMS and MAACL have been used more in clinical research than food product research.

The Consumption Emotion Set (CES)(Richins 1997) provides a longer questionnaire; people can use the whole 47 item questionnaire or can select the terms they want to use for a specific food category or product. There are examples of the CES used in food and drink research; for example Edwards et al. (2013) showed a reduction in emotions from before a meal to after a meal in a student cafeteria environment.

Questionnaires concerning food products are usually given during eating or shortly after eating, in order to test how the product makes you feel. Traditionally, the impact of foods and beverages was tested with hedonic questions (how much do you like this product?); emotion measurement has been used along with liking, beginning in the period 2000–2010, based on the repeated finding that liking alone does not predict commercial success very well (Jiang et al. 2014). In fact, three different methods were described to consumer researchers at the 2008 Eurosense conference, whereas no commercial emotion methods had been presented at meetings before this (see EsSense Profile, GEOS, and Conceptual Profiling method below). Since the first arrival of emotion questionnaires for product testing, there have been a number of new methods proposed. The following is a list of the methods currently being used to study foods and beverages:

1. EsSense Profile®: The EsSense Profile® was introduced at Eurosense in 2008, and the resulting paper published by King and Meiselman (2010), who include examples of distinguishing emotions for different food categories, and for different food flavors of the same food category, which suggests that emotions can be

Worksheet 3.1 The Positive and Negative Affect Schedule (PANAS; Watson et al., 1988)

PANAS Questionnaire

This scale consists of a number of words that describe different feelings and emotions. Read each item and then list the number from the scale below next to each word. **Indicate to what extent you feel this way right now, that is, at the present moment *OR* indicate the extent you have felt this way over the past week (circle the instructions you followed when taking this measure)**

1	2	3	4	5
Very Slightly or Not at All	A Little	Moderately	Quite a Bit	Extremely

___________ 1. Interested	___________ 11. Irritable
___________ 2. Distressed	___________ 12. Alert
___________ 3. Excited	___________ 13. Ashamed
___________ 4. Upset	___________ 14. Inspired
___________ 5. Strong	___________ 15. Nervous
___________ 6. Guilty	___________ 16. Determined
___________ 7. Scared	___________ 17. Attentive
___________ 8. Hostile	___________ 18. Jittery
___________ 9. Enthusiastic	___________ 19. Active
___________ 10. Proud	___________ 20. Afraid

Fig. 1 (continued)

tied to product ingredients. Further research on the method was published by King, Meiselman and Carr in 2013 and King in 2016. The EsSense Profile® was designed at McCormick Co. Inc. (an international spice company) for general use with foods, with the advice to modify EsSense for application to specific food categories or food products. EsSense contains mainly positive emotion terms (39 terms, 4 negative) in line with the hedonic asymmetry (greater use of positive emotions vs negative emotions) reported by Desmet and Schifferstein (2008). The emotion terms are scaled on a 5-point scale. The issue of using more positive or negative terms is discussed below. A reduced form of the EsSense (EsSense25)

Scoring Instructions:
Positive Affect Score: Add the scores on items 1, 3, 5, 9, 10, 12, 14, 16, 17, and 19. Scores can range from 10 – 50, with higher scores representing higher levels of positive affect. Mean Scores: Momentary = 29.7 (*SD* = 7.9); Weekly = 33.3 (*SD = 7.2)*

Negative Affect Score: Add the scores on items 2, 4, 6, 7, 8, 11, 13, 15, 18, and 20. Scores can range from 10 – 50, with lower scores representing lower levels of negative affect. Mean Score: Momentary = 14.8 (*SD* = 5.4); Weekly = 17.4 (*SD* = 6.2)

Fig. 1 The Positive and Negative Affect Schedule (PANAS)

has been published (Nestrud et al. 2016 – see Fig. 2). The EsSense Profile® has probably been the most widely used emotion food questionnaire, but it has received criticism on several issues including the issue that emotions should be studied on specific food categories rather than with a general scale.

2. GEOS/ScentMove/UniGEOS: The GEOS and ultimately the more global UniGEOS were designed at Firmenich Company for use with odorous products including both perfumes and foods. The emphasis in development and testing was not on food products. GEOS (36 emotion terms) was presented at the same 2008 Eurosense meeting and published in 2009 (Chrea et al. 2009); ScentMove TM (18 emotions terms) in 2010 and UniGEOS (25 emotion terms) was published in 2013. These scales were reviewed by Porcherot et al. (2016) (Table 4).
3. Conceptual Profiling: Thomson and colleagues (from MMR) proposed the method of conceptual profiling for measuring emotions, emphasizing that questionnaires assume that the emotion experience is conscious and can be reported. Thus, Thomson proposed a way of determining emotions by looking for conceptual associations during the exposure to a food product. Thomson presented his approach at the same 2008 Eurosense meeting, and published his method in 2010 (Thomson 2010; Thomson et al. 2010). MMR's method of conceptual profiling (Thomson 2016) involves two main steps: first, the development of a specific lexicon (list of affective terms) for a product category, and then scaling of those terms using best-worst scaling. Best worst scaling takes more time that direct scaling, and that has been one criticism of the method. Developing a separate lexicon for each application for the method would also take time. Thomson has also provided a more general lexicon based on four European languages

EsSense profile	EsSense25	EsSense profile	EsSense25
Active	Active	Loving	Loving
Adventurous	Adventurous	Merry	
Affectionate		Mild	Mild
Aggressive	Aggressive	Nostalgic	Nostalgic
Bored	Bored	Peaceful	
Calm	Calm	Pleasant	Pleasant
Daring		Pleased	
Disgusted	Disgusted	Polite	
Eager	Enthusiastic	Quiet	
Energetic		Satisfied	Satisfied
Enthusiastic		Secure	Secure
Free	Free	Steady	
Friendly		Tame	Tame
Glad		Tender	
Good	Good	Understanding	Understanding
Good natured	Good natured	Warm	Warm
Guilty	Guilty	Whole	
Happy	Happy	Wild	Wild
Interested	Interested	Worried	Worried
Joyful	Joyful		

Fig. 2 The EsSense Profile® (with 39 items) and the EsSense25 (with 25 items)

(Thomson and Crocker 2013). Ng et al. (2013) use conceptual profiling to demonstrate that intrinsic product characteristics are more related to emotions (and to liking), while extrinsic product characteristics such as packaging are more related to functional attributes.

4. Spinelli et al. (2014) developed a different questionnaire method, called EmoSemio, for measuring emotions emphasizing choosing words for a specific product category, and using full sentences rather than single emotion words. The EmoSemio list contained 23 items – lists for other product categories might have more or less. Spinelli et al. also emphasized that their questionnaire was developed in Italian for Italians and thus worked better than translating from another language which might use different words or use the same words differently. Sentences in EmoSemio can be simple (instead of the word "happy," EmoSemio says "It makes me happy."), or more complex (instead of the word "relaxed," EmoSemio says "It relaxes me, and makes me carefree."). The use of simple words ("happy") might be more clear or less clear; the complex sentences (like "It relaxes me, and makes me carefree.") might introduce different affective terms (are relaxed and carefree the same?). EmoSemio has contributed to the emotion questionnaire discussion by raising the issue of language and translation, and by proposing the use of phrases or sentences rather than words,

Table 4 Proposed universal Emotion and Odor Scale (UniGEOS) with nine affective categories and 25 affective terms in four languages. N is the number of geographic areas (out of the seven studied) in which the term appears

English	French	Chinese	Portuguese
1. Unpleasant feelings			
Disgusted ($N = 7$)	Dégoûté	厌恶的	Enojado
Irritated ($N = 6$)	Irrité	恼怒的	Irritado
Unpleasantly surprised ($N = 6$)	Désagréablement surpris	不愉快的意外惊喜	Desagradavelmente surpreso
2. Happiness/delight			
Happy ($N = 6$)	Heureux	幸福的	Feliz
Pleasantly surprised ($N = 5$)	Agréablement surpris	惊喜的	Agradavelmente surpreso
Well-being ($N = 3$)	Bien-être	安宁	Bem-estar
3. Sensuality/desire			
Desire ($N = 7$)	Désir	渴望	Desejo
Romantic ($N = 7$)	Romantique	浪漫的	Romântico
Sensual ($N = 6$)	Sensuel	肉欲的	Sensual
4. Energy			
Refreshed ($N = 7$)	Rafraîchi	恢复精神的	Refrescado
Energetic ($N = 6$)	Énergique	精力充沛的	Energético
Revitalized ($N = 5$)	Revitalisé	恢复生机的	Revitalizado
5. Soothing/peacefulness			
Relaxed ($N = 7$)	Relaxé	得到安宁的	Relaxado
Comforted ($N = 5$)	Réconforté	宽慰的	Confortado
Soothed ($N = 4$)	Apaisé	受安慰的	Sossegado
6. Hunger/thirst			
Mouth-watering ($N = 5$)	Salivant	令人垂涎欲滴的	Com água na boca
Thirsty ($N = 3$)	Assoiffé	口渴的	Sedento
Famished ($N = 2$)	Affamé	极饥饿的	Faminto
7. Interest			
Amusement ($N = 3$)	Amusement	娱乐	Diversão
Interesting ($N = 2$)	Captivant	有趣的	Interessante
Impressed ($N = 1$)	Impressionné	印象深刻的	Impressionado
8. Nostalgia			
Sad ($N = 3$)	Triste	伤心的	Triste
Melancholic ($N = 1$)	Mélancolique	忧郁的	Melancólico
Nostalgic ($N = 3$)	Nostalgique	怀旧的	Nostálgico
9. Spirituality			
Spiritual feeling ($N = 1$)	Sentiment spirituel	精神感觉	Sentimento espiritual

5. Since many product researchers also collect sensory and hedonic data in addition to emotion data, Schouteten et al. (2015) developed the EmoSensory®Wheel (also see Schouteten et al. 2017). The method uses product specific terms and a rate all that apply scaling approach. The Wheel is presented with a separate

9-point hedonic scale; the EsSense Profile TM is usually presented with a hedonic scale as well.

One of the key questions in emotion questionnaires is whether the emotion terms should be mainly positive, or equally positive and negative. Do negative emotions lead the respondent to use more negative emotions? Do more positive emotions do the same thing? Hwang and Matsumoto (2016) report many more negative facial expressions to products than with questionnaires.

Clinical research on eating disorders has tended to focus on negative emotions (Macht 2008; Leehr et al. 2015; Sultson et al. 2017). For example, in the recent development of the Positive-Negative Emotional Eating Scale, Sultson et al. used 7 positive emotion items and 12 negative emotion items. Evers et al. (2018) report from their meta-analysis of the literature that only restrained eaters exhibit increased eating following negative emotions (Evers et al. also present other recent meta-analyses of these data.). In their meta-analysis, Evers include 52 studies where negative emotions were induced drawn from 49 papers, and 13 studies where positive emotions were induced drawn from 12 papers – one can see that negative emotions dominate this clinical literature on emotions and eating. The authors conclude: “Compared to negative emotions, however, positive emotions have hardly been investigated in relation to its impact on eating behavior” (p. 204). Positive emotions are reported to produce a small increase in eating.

Another question in emotion questionnaires is whether the emotion terms are general or product category specific or product specific. There appears to be a place for both more general and more specific approaches; the more general approaches will probably have less discrimination between similar products but will be useful across a broad range of products, reducing research cost and time. The more specific approaches will probably produce sharper product differences, but will take more time and hence greater cost. Commercially, larger international companies often invest in their own methods, while smaller companies often use existing methods.

Yet another issue in questionnaires is their cross- cultural application and validity. This subject has received attention for some time, but the awareness of the challenges of applying emotions from one culture into another culture is increasing (Chentsova-Dutton and Lyons 2016). The typical problem is that emotion research is often conducted in the West, most often in the English language. Then researchers try to export that language to another country using a simple translation of the emotion terms. This has proved to be inadequate. Two questions have been raised: do the emotions from the first (English speaking) country exist in the target country? And if the emotions exist, are the same words appropriate for that feeling? Ogarkova (2016) has written about the problems of translation of emotion words. In addition, van Zyl (2016) provides evidence that culture does not mean the same as language. Comparing European and American Spanish speaking countries and Portuguese speaking countries, van Zyl and Meiselman observed greater similarity in use of emotion words between European countries than countries speaking the same language in Europe and America. In other words, Brazil was more similar to Mexico than to Portugal, and Spain was more similar to Portugal than to Mexico. The best advice seems to be that conducting emotion research cross culturally requires the use of a multilanguage team of language experts and emotion experts. Simple translation is usually not adequate.

An alternative to questionnaires to assess emotions is sentiment analysis (Mohammad 2016) which is aimed at any text including social media messages. Thus, this avoids many of the possible biases of emotion questionnaires, but it can only be applied to food names, not to actual food products. One can search for a product name (chocolate chip cookie) or a category (chocolate) or a brand and examine the valence of the affective words used. This has the disadvantage of not including a list of different emotions. It will be interesting to see how sentiment analysis develops in the years ahead, as an alternative to questionnaires for the study of food names. People might raise ethical questions about conducting research without consent.

Finally, those using a substitute stimulus for an actual product, for example a product name, must keep in mind that people often respond differently to a name and to an actual product (Cardello et al. 2012). This is probably based in the tendency to optimize the product when using a name; that is, consumers think of a good example of the name, not an average or even poor version.

Body Measures of Emotions

Body measures of emotion include the following: skeletal muscle movements, especially facial, vocalizations, postures, physiological responses mainly autonomic. Body measures of emotion are often called intrinsic measures, while self-reports are called extrinsic measures, and researchers sometimes express concerns with one or the other type of measure (e.g., see Koster and Mojet 2015).

For some time there has been a serious search for alternatives to self-reports of emotion, and many of these alternatives to self-reports have been body measures (Jiang et al. 2014). The attraction is obvious: self-reports are plagued with real biases, or the fear of biases. Body measures appear to be the bias-free alternatives; objective measures of emotion. But what if self-reports and body measures do not agree – which is valid?

While emotions displayed on the face have received a lot of the attention in body responses of emotions, Aviezer et al. (2012) demonstrated that body posture communicates emotion valence better than the face. There should be more work on body posture as a signal for emotion.

The evidence supporting vocalizations as a measure of emotion is weak at best; simple models linking speech frequency or intensity have not shown much promise, although research has examined more complex speech variables (Yang and Lugger 2010) as well as speech patterns of individuals. Yang and Lugger emphasize the implicit aspects of speech in trying to connect speech and emotions, rather than the linguistic content of the explicit aspects.

Facial Measurement: Both facial measurement and autonomic physiological activity have been used to measure emotions. Facial measurement has been used as a measure of emotion for some time (Hwang and Matsumoto 2016); facial measurement is achieved through observer judgments or through equipment which senses the facial muscles. Observer trained facial measurement is time-consuming and requires highly trained observers, which also takes time (can be 6 months of training).

Direct measurement of facial muscle activity can use the Facial Action Coding System (FACS) which measures 44 facial muscles. A faster version more specifically aimed at emotions is EMFACS. Hwang and Matsumoto emphasize that measuring facial muscle activity is not theory based, and can be used to measure facial muscle movement in any situation (conversation, eating, etc). They claim that seven emotions can be clearly recognized from facial muscles: anger, contempt, disgust, fear, happiness, sadness and surprise. Note that only one of these is positive, happiness. Hwang and Matsumoto argue that the relatively small number of emotions that can be coded is actually larger if one views these emotions as categories of emotion rather than specific emotions. For example, anger might include mad, enraged, annoyed and so on. However, some would argue that there are subtle differences among these words that might be of interest in some measurement situations. Hwang and Matsumoto (2016) present data from studies of personal and homecare products (not food) and found incongruence between self-reports and facial measures which often showed negative emotions. This leads one to question whether self-reports and facial measures are measuring the same thing – do they both measure emotion? Self-reports are direct reports of an experience; facial measures are observer reports of muscle movement, without reference to the experience.

Freitas-Magalhaes (2012) presents an interesting historical review of facial measurement, and lists the many methods which are available in addition to FACS:

Freitas-Magalhaes concludes that facial measurement of emotion faces two challenges: whether facial-emotion links are universal and whether they are culturally dependent. These arguments have been going on a long time (e.g., see Russell 1994) and a quick resolution is not likely.

One of the popular commercial systems for measuring facial muscles is FaceReader™. FaceReader™ automatically measures the following emotions: happy, sad, scared, disgusted, surprised, angry, neutral, contempt. Again notice that happy is the only positive emotion. FaceReader™ has been used in studies of foods. Danner et al. (2014) used a variety of measures of emotion in response to different juices. For FaceReader™, they observed that negative facial expression was stronger for disliked juices, but positive facial expression was not stronger for liked juices. This confirms other research that facial expression is a better measure for negative emotions than positive emotions, and for disliked products rather than liked products. De Wijk et al. (2012) used FaceReader ™ with children and young adults, and found that facial expressions only occurred to disliked foods., and they occurred very quickly, and might be easily missed. Wei He, working in deWijk's laboratory (He et al. 2014) studied pleasant and unpleasant food odors, and measured facial expressions and ANS responses. Unpleasant fish odor produced fewer neutral facial expressions and more disgusted and angry expressions. Interestingly the response time for the emotion "happy" was much longer than for the negative facial expressions. The results of these studies are a challenge in food research where most food products are liked by most people (hedonic asymmetry), thus limiting the applicability of facial measurement. Another practical implicit problem with facial measurement is the challenge of using it while eating and drinking when a fork or drinking glass might be in the way.

Autonomic Nervous System Measures

There is an obvious appeal to measuring emotions without asking leading questions, and without the person's knowledge of what you are trying to ascertain. Monitoring autonomic responses like heart rate holds the promise of measuring emotions without these complications. And researchers in affective behavior and physiology have been measuring autonomic responses for some time.

Kreibig (2010) provided a summary of 134 papers on autonomic recording for emotion research, noting that 34 were cardiovascular measures, 22 were respiratory measures, and 6 were electrodermal measures. This tells us what types of autonomic measures are being used in such research. Kreibig's review shows that increasing emotion does not always lead to increasing autonomic indicator – for example, contentment and happiness, both positive emotions, do not have the same physiological response. Further there are often different results among the studies. Kreibig notes that both liked stimuli and disliked stimuli might increase hear rate, as well as a number of other emotions (surprise, disgust etc).

De Wijk et al. (2012) found significant differences in finger temperature and in skin conductance for liked and disliked foods, but did not find significant differences for heart rate, the most commonly used autonomic measure. De Wijk et al. did not ask for emotional responses. Danner et al. (2014) also found differentiation of liked and disliked products with skin conductance and pulse amplitude, but not heart rate. In the study by He et al. (2014) on facial expressions and ANS responses to pleasant and unpleasant food odors, unpleasant fish odor produced higher heart rates and skin conductance responses, and lower skin temperature. Heart rate differentiated between odors after 400 ms, much faster than skin conductance and skin temperature (Table 5).

Summary

Emotion measurement has been applied to eating and drinking for some time, first from a clinical perspective and more recently from a commercial, product development perspective. This work has grappled with several problems in the emotion measurement area: the definition of emotions, the relative importance of positive and negative emotions, the use of self-report or bodily measures, and the cross-cultural differences which might exist. The field is now seeing a great deal of research and application, and there will probably be some progress on these issues over the next decade.

Table 5. Associations between ANK patterns and specific emotions based on Kreibig (2010) (From de Wijk et al. 2012)

	Anger	Anxiety	Disgust contamination	Disgust mutilation	Embarrassment	Fear	Fear imminent throat	Sadness crying	Sadness non – crying	Sadness Anticipatory	Sadness acute	Affection	Amusement	Contentment	Happiness	Joy	Anticipated pleasure visual	Anticipated pleasure imagery	Pride	Relieve	Surprise	Suspense
Heartrate	↑	↑	↑–	↓	↑	↑	↓	↑	↓	↑	↓	↓	↓ ↑	↓	↑	↑	↓	↑	↓ ↑	↑ –	↑	(↓)
Fingertemp	↓	↓	↓ ↑	↓ ↑		↓		↓	↓	↓ ↑	↓		C		↑		(↑)				↓ ↑	
SCR	↑	↑	↑	↑		↑	↑				↓		↑	–			↑			↓		

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Part V

The Developmental Perspective

Infant Appetite: From Cries to Cues and Responsive Feeding

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Contents

Abstract

Infants are adept at communicating hunger, appetite, and satiation. While one cannot really "know" what infants are attempting to communicate, it can be assumed that crying after some hours of food deprivation relates to hunger, that decreased interest in feeding relates to satiation, and that aversive facial expressions in response to a new food reflect dislike. So at the very least, it can be said that infants express fundamental needs as well as their likes and dislikes of specific foods. For infant communication to be effective, caregivers should be able to understand infant cues, and for this to happen reliably, communication cues should be easily discernible, replicable, and responsive to changes in need state (Hetherington, Physiol Behav 176:117–124, 2017). For example, appetite signals should decline as the meal progresses, and expressions of liking and wanting should depend, in part, on the foods offered. For responsive feeding to take place then, caregivers must be able to recognize and respond to infant appetite cues and so provide appropriate nourishment

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and care to their infants. In this chapter progression from milk to solid food feeding and the infant's ability to self-regulate energy intake will be considered. The facial expressions and overt behaviors infants use to communicate with caregivers about their interest and willingness to eat will be characterized. Finally, sensitivity to the ways in which infants communicate hunger, appetite, and satiation will be discussed.

Keywords

Appetite · Food intake · Facial expression · Gesture · Vocalization · Gaze · Responsive feeding · Infancy · Development

Costly and Cute: The Helpless Newborn Human

Human newborns are uniquely helpless after birth, compared to other primates. They are entirely dependent on caregivers and require an inordinate amount of attention. The human neonate has been described as "costly and cute" (Trevathen and Rosenberg 2016); the costs refer to the dedicated labor and financial burden involved in raising a child. Fortunately costs are balanced by the attractiveness of the newborn and their capacity to captivate the attention of carers. The early dependency of babies favors processes of learning and socialization and reinforces the central importance of parenting in supporting healthy development.

The newborn is proficient at signalling hunger to their mothers via the hunger cry (Gilbert and Robb 1996; Zeskind et al. 1985). The hunger cry is the culmination of a series of behaviors from agitation, mouthing, and discomfort to a distress call. Research on infant cries indicates that adults listening to cries are able to distinguish the hunger cry from the pain cry through perceived and physical acoustic differences (Zeskind et al. 1985). Over the first year of life, the hunger cry changes in acoustic characteristics with an increase in fundamental frequency which signals the transition from reflexive to intentional crying (Gilbert and Robb 1996). As motor skills develop, infants become more adept at communicating hunger, appetite, and satiation in diverse ways. To be effective, however, communication between the infant and the caregiver is dependent upon the sensitivity of the receiver to recognize, interpret, and respond to these signals (Hetherington 2017). The World Health Organization defines responsive parenting as "prompt, contingent and appropriate interaction with the child," and responsiveness is associated with better health outcomes and psychosocial and cognitive development (WHO 2006). Therefore, how infants communicate their energy needs and the ways in which parents respond to them are key to healthy growth and well-being.

Before Mother's Milk

Babies are born as "univores" securing all their nutrient and energy needs from a single source, namely, milk. At around 6 m of age, infants are introduced to solid foods as energy, and nutrient requirements can no longer be met by exclusive breastfeeding (WHO https://www.who.int/maternal_child_adolescent/documents/9241593431/en/). The solid foods "complement" nutrition and energy provided by milk, thus the term "complementary feeding" rather than weaning, since infants can be fed breast milk long after 6 m. The transition from univore to omnivore has been described as the omnivore's dilemma (Rozin 1976). The dilemma arises from the potential hazards faced by the human infant when accepting novel foods. It is at once necessary, but potentially challenging. Given that milk is sweet to taste, it is said that infants are "hard-wired" to prefer sweet substances as an adaptive mechanism to secure a safe source of energy. To accept foods with different basic tastes, the infant must experience novel odors, tastes, and textures. This transition is enabled by both innate preferences and the capacity to learn, through mere exposure and learned safety which foods are acceptable.

Interestingly, and long before this transition, babies experience flavor in utero. Studies with animal and human participants demonstrate the role of fetal learning in odor and taste preference acquisition. Fetal learning occurs when flavors derived from the maternal diet are experienced via amniotic fluid. For example, Hepper (1988) demonstrated fetal learning in an animal model by feeding pregnant rats garlic or no garlic during pregnancy and then presenting garlic or onion in petri dishes to their 12-day-old pups. As a measure of preference, the time spent by the pups over each stimulus was recorded as well as the total amount of time spent on each side of the cage containing the stimulus. Pups born to dams fed garlic preferred garlic over onion and offspring of the control group showed no preference for either stimulus. This finding was replicated in cross-fostered pups. Therefore, odor learning occurs in utero suggesting a biologically adaptive behavior which favors positive associations with components of the maternal diet, perhaps to enhance kin recognition (Hepper 1996) and possibly to guide the developing pup to a safe, familiar food source.

In the human equivalent of these studies, head and mouth movements are used to indicate preference for odors in babies. For example, Soussignan et al. (1997) investigated the response of 3-day-old babies to artificial (vanillin, butyric acid, formula milks) and biological (breast milk, amniotic fluid) odors using recordings of behavioral (facial and oral movements) and autonomic (respiration, differential skin temperature) events. In these studies nose wrinkling and the "grimace" facial expression were interpreted as disgust for an aversive odor (butyric acid) relative to a positive odor (vanillin). These responses may reflect biological utility in guiding babies away from odors that may indicate that a food is rancid (butyric acid) and potentially harmful (Soussignan et al. 1997).

Marlier and Schaal (2005) video-recorded babies' responses to breast milk or formula using mouthing and head orientation in a choice paradigm. Human milk produced more frequent mouthing and greater head orientation than formula even in babies who had been formula fed. Evidently, the attractiveness of human milk containing many different aromatic compounds familiar to infants via in utero experience was preferred over formula which tends to be bland and of uniform flavor.

Overall, these studies indicate that during the early postnatal period, young animals, including humans, can express preference toward familiar odors (experienced in utero). The ways in which likes and dislikes are communicated in early life are through a series of behaviors including oral activation like mouthing, orientation or place preference, and facial expressions.

A Shared Love of Sweetness and Dislike of Bitterness

Facial expressions in response to different basic tastes have been well characterized in newborn babies in the elegant studies conducted by Steiner (1977). In these studies, likes and dislikes to pure tastants were recorded following delivery of the substance via pipette to newborns. The subsequent, specific facial response to water, sweet, sour, and bitter tastes were assessed to determine affective quality of the tastes. Steiner observed distinctive tongue protrusions and "smile" responses to sweet, lip pursing to sour, and the characteristic "gape" to bitter tastes. These facial responses have been observed in nonhuman primates, and a collaboration between Kent Berridge and Jacob Steiner resulted in mapping "sensory typical" and affective responses to basic tastes across different mammalian species (Steiner et al. 2001). These authors proposed that human hedonic and aversive reactions are directly related to the taste reactivity patterns of other animals. For example, in both the rat and primate, there is a shared tongue protrusion in response to sucrose in solution (representing the sweet taste) and shared "gape" in response to quinine in solution (representing the bitter taste). These responses are thought to be functional, in that the tongue protrusion extends exposure time and coverage over the tongue of the sweet solution which is liked and the gape allows ejection of the disliked, bitter-tasting fluid from the mouth. Sweetness generally signals a safe source of energy, and bitterness signals potential toxicity, and so neonatal affective responses are adaptive.

In addition to facial expressions in response to foods which signal likes and dislikes, human infants also have a diverse repertoire of more obvious and overt acceptance and rejection behaviors which occur in advance of the substance being tasted. For example, an obvious set of "approach/acceptance" behaviors indicating appetite and "wanting" is the extent to which the infant gazes at the food in anticipation of eating, leans forward to accept food when offered, and then opens their mouth in readiness to eat. Then the avidity with which solids or liquids are consumed provides further evidence of appetite. Once the food has been consumed, the infant may then begin to show a slowed rate of eating and a series of overt avoidance/rejection behaviors such as looking away from the food, gazing at other objects in the environment, closing the mouth, arching the back, or turning the head away (see Hetherington et al. 2016; Nekitsing et al. 2016; McNally et al. 2019).

In summary, infants signal their preference for sweetness and dislike of bitterness through facial expressions. Beyond these basic responses which appear to be hard-wired and phylogenetically old (shared with other species), human infants signal acceptance and rejection as they experience new foods during their transition from univore to omnivore, from consuming sweet-tasting milk to a broad range of complex solid foods.

Self-Regulation

Infants who are exclusively breastfed have already experienced a wide variety of flavors from the maternal diet and are therefore more willing to accept novel foods such as vegetables during complementary feeding (Sullivan and Birch 1994). Breastfed babies regulate energy intake to match energy requirements, showing self-regulation. For example, in a well-controlled, prospective study of exclusively breastfed babies in a developed country, energy intakes from breast milk matched energy requirements producing normal growth trajectories (Nielsen et al. 2011). In this study, volume of milk ingested, energy intake, and milk energy content were measured using the doubly labelled water method. This technique of providing mothers with a dose of doubly labelled water then sampling urine is the gold standard method for assessing energy requirements. In this study, when infants were re-tested, between 15 weeks and 25 weeks, milk intake increased significantly and matched energy requirement to sustain normal growth.

In another study where breastfed babies were randomized to complementary feeding at 4 months or exclusive breastfeeding for 6 months, the researchers found no difference in total energy intakes or body composition at 6 m (Wells et al. 2012). Here, the stable isotope method was again used to determine precisely how much energy requirement was achieved through milk, and then energy intake from solid foods was determined using weighed intakes. The infants randomly assigned to complementary foods at age 4 m consumed significantly less breast milk at age 6 m compared to the babies exclusively breastfed. Both groups showed the same rate of growth and had similar energy intakes. Therefore, these studies provide evidence of self-regulation during the first 6 m of life in breastfed babies.

In formula-fed babies, the capacity to regulate energy intake has also been studied, and given that the content of formula can be manipulated, this permits investigation of self-regulation related to systematic changes in energy density and macronutrient content on total energy and nutrient intakes.

Fomon and colleagues (1971) gave one group of infants a lower energy density (ED) formula (54 kcal/100 ml) or higher energy density formula (100 kcal/100 ml). The babies assigned to the lower ED version consumed significantly more formula but did not manage to match the energy intake of the higher ED formula group, so gained less weight. More recently, Timby et al. (2014) randomized infants to receive a lower protein, lower ED experimental formula (60 kcal/100 ml), or standard formula (66 kcal/100 ml). Infants receiving the experimental formula consumed a significantly greater volume to match the energy intake of the standard formula.

In a study of energy compensation, Brugaillères et al. (2019) provided carrot puree with or without added oil to increase energy density of the puree to 11-month-old infants; then they repeated the study at 15 m. They found that at 11 m infants compensated at a test meal offered 25 min after the puree by 52%, but by 15 m this depreciated to −14%. These data suggest that self-regulation may decline with age and that infants need to have multiple exposures to low energy density foods with added energy in order to learn about their postingestive consequences. This study illustrates the potential role of learning in infant feeding.

In summary, both breastfed and formula-fed babies show evidence of self-regulation. However, with complementary feeding and the introduction of energy dense, complex foods, infants appear to compensate for energy loads less well with maturity. Therefore, there is a significant role for learning in the early years as infants associate the sensory characteristics of different foods with their post-ingestive consequences.

Nutritional Wisdom and the Role of Learning

As infants move away from milk as their only source of nourishment, they are offered a range of solid foods to ensure appropriate nutrition. As mentioned, infants have a positive, unlearned acceptance of sweetness, but they have an aversive, innate rejection response to bitterness. This implies that infants must acquire a liking for bitter tastes through experience, if they are to accept bitter tastes. The role of learning, therefore, is crucial in the transition from univore to omnivore. In the classic observations made by Dr. Clara Davis in the late 1920s and 1930s, she demonstrated the capacity of infants to select a diet from an array of raw and cooked foods to sustain healthy growth (Davis 1928, 1939). The small number of infants she followed generated a huge data set as all meals were recorded for up to 6 years (Strauss 2006). The infants were given solid foods on a tray, and they could select whatever they wanted. Nurses who were present to ensure the safety of the infant were instructed not to guide the infant's choice. Overall, the infants selected a range of around ten foods per day and achieved a balanced diet, which ensured their health and well-being. One infant reversed symptoms of early-stage vitamin D deficiency (rickets) through selection of cod liver oil. The meal patterns of these infants during complementary feeding provide evidence of "nutritional wisdom," namely, when offered a variety of wholesome foods, infants choose well – they did not simply select their preferred sweet foods but consumed a number of foods, and in some cases the infant preferentially consumed more of the cooked version of the food compared to the uncooked (see Table 1). Although infants have an innate preference

Table 1 An example of food intake in an 18-month-old infant from Dr. Clara Davis (1939) and her study of "nutritional wisdom"; note the difference in the weight of raw and cooked apple and oats, indicating that the cooked versions were preferred

7 a.m. breakfast	5 p.m. supper
60 cc milk	230 cc milk (Grade A)
26 g raw apple	50 g fish
62 g cooked apple	1 cooked egg
100 cc orange juice	20 g raw tomatoes
0 67 g cooked wheat	150 g banana
0 15 g cooked barley	100 g orange segments
0 16 g cooked liver	**10 g raw oats**
0 50 g cooked sweetbreads	**56 g cooked oats**

for sweet, they nonetheless acquire a liking for a variety of foods covering all the basic tastes in order to attain adequate nutrient intakes, and sufficient energy to match requirements. Of course, this “experiment” demonstrates nutritional wisdom under very constrained circumstances, and it is not clear given the modern food environment of highly palatable, energy dense, nutrient-poor foods that infants would also select as wisely. These early studies by Davis reinforce the importance of learning that the infant’s appetite is influenced by the food environment presented and that given a range of foods, infants select well and not only their most preferred item.

Vegetables as a First Food

At the time of complementary feeding, when infants make the transition from univore to omnivore, they are uniquely willing to try new flavors (Harris 2008). A number of researchers have used vegetables as a first food during complementary feeding. In part this is because intakes of vegetables tend to be below recommendations globally and establishing liking for these foods in early life may provide the foundation for preferences later on (Barends et al. 2013; Hetherington et al. 2015; Remy et al. 2013). To test whether early exposure to vegetables as a first food enhances acceptance of vegetables, infants were randomly assigned to a control group receiving no prior vegetable experience or an intervention involving a step-by-step introduction of novel vegetable purees over 24 days. In the first 12 days of complementary feeding, vegetables were added to milk and then to cereal for the next 12 days (Hetherington et al. 2015). Acceptance was measured using intake, ratings of liking by mothers and researchers, as well as filmed facial and behavioral responses to pureed vegetables offered on days 25 and 26 (carrot on d25 and green bean in d26). Video recordings were coded using the Feeding Infants: Behaviour and Facial Expression Coding System (FIBFECS; Hetherington et al. 2016) with six acceptance/rejection behaviors (turns head away, arches back, crying/fussing, pushes spoon away, leans forward, and rate of acceptance; see Fig. 1) and seven facial expression items (brow lowered, inner brow raised, squinting, nose wrinkling, lip corners down, upper lip raised, and gaping). Examples used in the training from the coding system are provided in Fig. 1.

In this same study, infants were offered nine consecutive spoonfuls of vegetable puree, and behaviors and facial expressions were assessed per spoonful. When offered vegetable puree, the infants from the intervention group showed a greater duration, pace, and consumption of each vegetable than the infants from the control group. Investigator ratings (but not maternal ratings) of liking were sensitive to group assignment with higher ratings for vegetables in the intervention compared to the control group. Overt acceptance and rejection behaviors (reflecting wanting) differed by group assignment. Infants with prior vegetable exposure showed fewer rejection behaviors and more acceptance behaviors than those in the control group. Facial expressions related to aversion did not differ by group

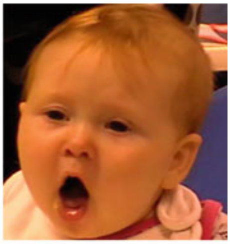
Cue	Baseline	Response
Gape		
Turn head away (THA)		
Pushes spoon away (PSA)		
Leans forward (LF) ready to eat		
Opens mouth in anticipation of food acceptance		

Fig. 1 Facial expressions and overt behaviours filmed at baseline and in response to vegetables offered during weaning

but did differ by vegetable. Thus, more frequent aversive facial reactions were observed in response to the green bean than to carrot. This may reflect the natural sweetness of the carrot which is accepted more easily than the green bean which is less sweet.

In summary, vegetables offered as a first food tend to be well accepted, and there has been a consensus statement promoting vegetables as a food to offer during complementary feeding in order to encourage preference development for vegetables (Chambers et al. 2016). Infants exposed to vegetables at complementary feeding added to milk then to cereal show evidence of liking and wanting for these foods as a function of learning. Mothers may misattribute facial expressions as disgust or dislike, but these may simply be surprise, and it may take many exposures (between five and ten) before children accept bitter-tasting, green vegetables.

Recognizing Infant Appetite Cues in the Transition to Solids

So far, we know that infants are capable of signalling appetite, that they acquire liking for foods through experience, and that they are capable of self-regulation to meet energy needs. How then do infants signal interest in food, readiness to progress to solid foods, and sensations of hunger, appetite, and satiety? The types of cues which infants use at various stages of development are summarized in Table 2 (adapted from Pérez-Escamilla et al. 2017).

Mothers have been interviewed to investigate how they know when to introduce solid foods (e.g., Anderson et al. 2001). In this study, readiness was signalled in terms of visual interest in foods eaten by family members. Hunger cues were described in relation to babies' characteristics (e.g., age, weight), their overt behavior (e.g., rapid rate of milk consumption, agitation, "chewing" their hands), and external factors such as time of day and time since last feed. Mothers reported being able to identify a "hungry cry," and they reported satiation cues in terms of expressions of contentment, especially infants appearing more settled after a feed.

Hodges et al. (2008) investigated cues which prompted mothers to initiate and end feeding. Like Anderson et al. (2001), the authors found mothers used both infant behaviors and external cues (e.g., time) to identify hunger. Typical hunger cues in this study were crying, fussing, and licking the lips, and these were reported across several age groups (3, 6, and 12 months). Common satiation cues included pulling away, spitting food out, and refusing food. The prominence, intensity, and specificity of infant cues guided decisions about initiating and ending feeds, and mothers found cues easier to interpret with increasing infant age.

Hodges et al. (2013) went on to develop a tool to characterize and code responsive feeding called The Responsiveness to Child Feeding Cues Scale (RCFCS). This tool has 20 types of hunger cue and 28 types of satiation cue which can be recorded during meals. Hunger and satiation cues are further categorized as "early" (e.g., increased alertness), "active" (e.g., excitatory movements), and "late" (e.g., fussing and crying) in order to reflect changes in cue intensity. The authors found that mothers were typically more responsive to hunger than satiation cues. However, better responsiveness to satiation was predicted by maternal characteristics such as healthy BMI, longer breastfeeding duration, and higher educational level.

In their study of the changes in feeding cues expressed over time, Hodges et al. (2016) observed mother-infant pairs during mealtimes at infant ages 3, 6, 9, 12, and

Table 2 Hunger, Appetite, and Satiation cues by approximate stage of development; adapted from the Feeding Guidelines for Infants and Toddlers, Perez-Escamilla et al (2017)

Age	Hunger	Appetite	Satiation
0–6 months	Agitation, mouthing, sucks on fist, fussing, distress cry	Orienting/mouthing, rapid sucking, then slows down	Rate of sucking slows and stops, seals lips together, ejects nipple, sleeps
4–6 months	Fussing, crying, agitation, shows excited arm and hand gestures	Visual interest in foods offered, licking lips, opens mouth in readiness to eat, leans forward to receive food, feeds avidly then slows down	Rate of sucking slows, rate of food acceptance slows then stops, gaze aversion
5–9 months	Reaches for food, points to food	Visual interest in food offered, leans forward to accept food, eats avidly then slows	Eating slows, pushes food away, turns head away, twists body away, gaze aversion, increased exploratory gaze, plays with food or utensils
8–11 months	Reaches for food, points to food, gets excited in the presence of food	Gazes at food, interest in food offered, self-feeds, eats avidly then slows	Eating slows, pushes food away, turns head away, twists body away, gaze aversion, increase in exploratory gaze, plays with food or utensils, gets restless to leave table
10–12 months	Uses sounds and language to verbalize interest in eating	Gazes at food, self-feeds, gestures for more food, eating rate initially rapid then slows	Eating slows, shakes head to indicate "no more," gets restless to leave table
12–24 months	Combines gesture and vocalization to express need to eat	Gazes at food, self-feeds, eating rate initially rapid then slows	Uses specific utterances such as "all done" and "get down," plays with food or utensils

18 months in the home. They used RCFCS at each time point and noticed that fullness cues became more diverse and less subtle over time. For instance, in the first two observations (3 m and 6 m), disinterest, falling asleep, and decreased muscle tone and activity signalled fullness, but during the later observations, pushing or pulling away and communicating "no" verbally became more apparent. In relation to appetite, postural attention and reaching for food increased after 6 months. As the infant develops, their motor and language skills enable them to assert interest or disinterest in eating.

Similarly, a study by Skinner et al. (1998) used pictures of hunger cues, and mothers were asked at what age these were displayed by their baby. The authors reported that cues of readiness to eat (e.g., opening the mouth as the spoon approached) appeared at a younger age than satiation behaviors (e.g., closing the mouth to reject food) (4.4–5.7 months vs. 5.8–7.5, respectively). Food dislikes were communicated via facial expressions and by body movements, such as turning the head or the body away from food or throwing food away. These signals of food dislike appeared by 8 m of age, and strong indications of food likes and dislikes increased in frequency with age. Overall, mothers reported that their infant's ability to communicate improved in scale and scope over time in tandem with the mother's improved skill in interpreting this communication (Skinner et al. 1998).

Visual interest in food items during a meal followed by disinterest has been noted in a number of studies as an indicator of appetite and satiation. For example, gaze aversion, when infants look away from the caregiver as food is offered, is identified as a potent disengagement cue (Sumner and Spitz 1994), and visual attentiveness to the caregiver at the start of a meal is regarded as an indicator of infant feeding responsiveness (Hodges et al. 2013).

Recent evidence from the Leeds laboratory has demonstrated that shifts in gaze may reflect changes in interest in food during a meal (McNally et al. 2019). In this study, 20 mother-infant pairs were filmed consuming a solid meal on two separate occasions. Infants were aged between 6 m and 18 m (mean age 11.7 months $\pm$3.40). All infants had been breastfed at birth for at least a few days, average breastfeeding duration was 24 weeks, and solids had been introduced at around 22 weeks. Gazing at food was most frequent during the initiation of eating and then declined during the first course. At the same time, exploratory gaze involving intent gazing at feeding utensils, food remnants, or other objects while touching or manipulating them increased during the first course. Interestingly, when a second course was presented to the infants, gazing at food resumed in the early stage of intake and then declined over time, perhaps signalling sensory-specific satiety (McNally et al. 2019).

Mothers' perceptions of infant feeding cues in the first 2 years of life generally reveal that hunger cues are easier to perceive than satiation cues and that feeding cues are easier to interpret as children grow older (McNally et al. 2016). It is likely that with developmental maturity, infants become more adept at communicating hunger, appetite, and satiation. However, caregivers must also learn to recognize and respond to these cues over time.

In summary, during milk feeding, the first form of communication about hunger status is through hand to mouth, agitation, orienting toward the breast/bottle, and culminating in the "hunger" cry. As infants develop, infants signal interest in solid foods through visual interest in family foods, fussing, agitation, and licking their lips. Appetite is signalled by mouth opening in response to food, eagerness to accept foods offered, the rate at which food is accepted, and gazing at food. Satiation is initially signalled through disinterest and sleep and later signalled through avoidance cues such as slower rate of acceptance of food offered, gaze aversion, turning the head away, pushing food or spoon away, and twisting the body away from food offered. As children progress to solid foods, the approach and avoidance behaviors develop further in scale and scope. With maturity, infants begin to use language to signal enjoyment of food and to indicate likes/dislikes. The urgency and survival value of communicating hunger is simple, strong, and dramatic, taking precedence over other needs. Cues to signal fullness appear later than hunger cues and responsiveness to these may depend on characteristics of the mother including breastfeeding duration, BMI, and education. Gazing at food appears to reflect interest in eating (appetite), and this wanes during the course of a meal. Therefore, there are a number of cues used by infants to signal their underlying need state which change as the infant is fed; and it is up to caregivers to notice these subtle changes in cue communication.

Responsive Feeding: Cue Recognition and the Role of Feeding Method

The extent to which mothers and other carers identify, recognize, and respond to infant feeding cues will determine whether infants are fed *responsively*. The ways in which parents feed their children and their understanding of their infant's appetite cues influence the early entrainment of appetite control (Disantis et al. 2011; Hurley et al. 2011). For example, DiSantis et al. (2011) proposed that "responsive" mothers are sensitive to hunger and satiation cues and respond appropriately, while discordant responses to infant cues such as pressuring to eat or overriding the cues of satiation might increase overfeeding and risk of obesity. Similarly, Worobey et al. (2009) found that mothers with lower sensitivity to feeding cues at 6 months had infants who gained more weight between 6 and 12 months than mothers with a higher level of sensitivity. Also, restrictive and indulgent feeding practices were associated with a high BMI in infants and young children (Hurley et al. 2011), and the use of assertive prompts to eat and intrusiveness during the meal predicted higher adiposity in toddlers (Lumeng et al. 2012). Taken together this evidence indicates that parents may override infant signals of hunger, appetite, and satiation and superimpose their own expectations about when eating begins, how much to feed, and when eating ends.

Mothers who breastfeed might be more responsive to infant feeding cues than mothers who formula feed assuming that mothers who breastfeed situate control of the timing and volume of milk feeds with their baby. When mothers feed formula or breast milk via a bottle, they are more able to judge the volume consumed, and the temptation to encourage babies to finish the bottle is possible. It has been found that more intensive bottle feeding (breast milk or formula) results in a greater risk of overconsumption (Li et al. 2008, 2010) and, therefore, it is not merely the source of the milk supply but also the delivery method which matters for weight regulation. Feeding from a bottle (breast milk or formula) is also associated with a lower ability to self-regulate intake than feeding directly from the breast (Arenz et al. 2004).

In order to understand better the potential differences in mealtime interactions based on prior milk feeding experience, we conducted a series of investigations in the UK and Israel on the same cohort of infants from the milk feeding stage to solid food introduction to 24 m (Shloim et al. 2014, 2015, 2017, 2018). Milk feeding was filmed in 27 mothers (13 breastfeeding; 14 formula feeding), and infant appetite cues were recorded when the infants were aged between 3 and 22 weeks. Engagement (interest in the feed) and disengagement (signalling disinterest) cues during the feed were recorded at the beginning, middle, and end of the meal. Examples of engagement cues included sucking sounds, mutual gaze, and opening the mouth in readiness to feed, whereas examples of disengagement cues included pushing away or back arching. Over time, engagement cues tended to decrease, and disengagement cues tended to increase, reflecting the transition from interest in milk to disinterest and satiation. Breastfed infants tended to display both types of cue more frequently than formula-fed babies, and they opened their mouth indicating readiness to eat at the beginning of the feed compared to formula-fed infants (Shloim et al. 2017). This suggests that breastfed babies were more active participants in the feed and signalled more to the mother their appetite and satiation status.

Mothers from the same cohort were then filmed during mealtimes on four further occasions postpartum (2–6 m, 8–12 m, 14–18 m, and 20–24 m). Feeding behaviors were coded using the Simple Feeding Element Scale (Shloim et al. 2015). In the first measurement postpartum, mealtime interactions indicated that women who breastfed (rather than bottle fed or fed solids) presented fewer distractions during the meal, provided a more ideal feeding environment and fed more responsively (Shloim et al. 2017). In the subsequent measurements, infants were more likely to communicate potent engagement cues such as babbling, mutual gaze, and looking at mother with developmental maturity, whereas disengagement cues remained stable over time. Interestingly, disengagement cues such as fussing and tray pounding were most likely to occur at the end of the meal signalling disinterest in eating (Shloim et al. 2018).

Interventions to encourage more responsive feeding in bottle-fed babies have been conducted by Ventura and her colleagues (Ventura and Golen 2015; Ventura and Hernandez 2018). In these studies, mothers were given clear bottles or opaque, weighted bottles from which to feed their infants. The opaque, weighted bottles resulted in mothers feeding infants less formula, feeding them at a slower rate, and displaying more sensitivity to the infant's satiation cues compared to using the standard, clear bottle (Ventura and Hernandez 2018). This simple manipulation appeared to direct mothers away from crude volume control toward reading their infants better. Crucially, there was a strong moderating effect of the clarity with which infants expressed satiation cues. Thus, infants who were rated as displaying more obvious satiation cues were fed less in the opaque condition than the clear condition, whereas lower clarity of cues resulted in equivalent amounts of milk fed to babies in each bottle condition. This illustrates the importance of infant proficiency in expressing cues as well as maternal sensitivity to these cues.

In summary, developmental maturity ensures that infants express more diverse and assertive means of communicating hunger, appetite, and satiation; however, responsiveness to these cues may be influenced by features of the mother such as her BMI and the ways in which she feeds her baby (via breast or bottle). There is evidence that breastfeeding mothers are more responsive to their infants, and in part, this could be due to the communication proficiency shown by breastfed babies (Shloim et al. 2017). Finally, the bidirectional nature of the mealtime interaction means that more proficient communication of appetite and satiation by the infant may also result in more responsive feeding by mothers, and responsive feeding in turn encourages greater proficiency in expressing appetite and satiation cues.

Conclusions

Infants make the transition from univore to omnivore and, in so doing, demonstrate a diverse range of ways to communicate to caregivers their needs. They become more adept at conveying appetite, interest in food, liking, wanting, and satiation through a range of behaviors. Babies are capable of self-regulation demonstrated during milk and early solid food feeding, but the ability to compensate for additional energy in the short-term declines with age. Therefore, caregiver responsivity to infant communication is central to facilitating self-regulation. A number of research tools have been developed and tested to identify the communication cues used by infants. Some coding systems can be applied to detect liking and wanting first foods offered around the time of complementary feeding (Hetherington et al. 2016; Nekitsing et al. 2016). Other tools such as the RCFCS permit a sensitive analysis of the ways caregivers recognize and respond to child feeding cues (Hodges et al. 2013). Mealtime interactions reveal the bidirectional and reciprocal nature of communication between infants and their caregivers, and targeted interventions designed to promote responsive feeding have shown that parents' ability to respond to their infant is modifiable. In summary, human infants are highly dependent on their caregiver to provide sufficient energy for survival; they are capable of self-regulation but need the caregiver to respond promptly and appropriately. Recording mealtime interactions offers the researcher a means to identify the bidirectional nature of responsive feeding which is based on caregivers being able to recognize and respond to infant communication. Characterizing infant cues and encouraging caregivers to engage in responsive feeding may provide an opportunity to intervene to promote self-regulation, healthy eating, and growth. However, infants also vary in their proficiency to communicate energy needs and eating traits such as fussiness may contribute to difficult mealtime interactions. Understanding both the caregiver's ability to recognize cues and the infant's ability to convey their needs is crucial to effective communication of hunger, appetite, and satiation.

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Eating and Drinking in Childhood

20

Sophie Nicklaus

Contents

Abstract

This chapter describes the development of eating and drinking in typically developing children up to the end of school age. Together with physiological and cognitive development, children's eating behavior undergoes major evolutions. During the early period when eating is essential to sustain growth, children eat easily and at the onset of complementary feeding discover the foods of their future diet which are marked by distinct tastes, flavors, and textures from the milk they had received before. Then they undergo a period when they may become picky and/or neophobic, which may last until school age. For this reason, eating and drinking will first be described in infancy, before the onset of food neophobia (from birth to 2–3 years), during the preschool years (from 2–3 years to 6 years), and right after this period, in school-aged children (from 7 years until 11 years). The mysteries of (pre)adolescent eating and drinking will not be covered in this chapter. Then, within each section, the following aspects will be covered: sensory capacities, likes and dislikes, attitudes and thinking, and role of the environment, including the family environment.

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Children · Eating · Drinking · Healthy foods · Unhealthy foods · Taste · Smell · Texture · Pleasure · Cognition · Parental feeding practices

Introduction

How to cover such a complex topic as eating in childhood in one chapter? It is a challenge, because eating and drinking in childhood are nearly as complex as in adulthood, if not more, given the developmental aspect specific to childhood! Infants are born with sucking abilities and within a year from birth will transition from their mother's breast to the family table. What a journey through eating and drinking! First, concerning childhood, it may be relevant to refer to "drinking and eating" rather than to "eating and drinking," because children start their journey through the consumption of foods and drinks by first consuming a unique liquid substance, (breast) milk. It is only by about the first half of the first year that foods other than milk start being consumed. This corresponds to the recommendation of the World Health Organization regarding the ideal age for introduction to complementary foods (WHO World Health Organization 2003). This recommendation is universal because according to the WHO, human milk is the most adapted food for all newborns, but this is all the more true in parts of the world where access to potable water (which is needed for the preparation of infant formula as a substitute for breast milk) is not granted. However, because some women have working activities outside the households in many countries, a transition to other foods than breast milk may be necessary before the age of 6 months, which may have led pediatric societies throughout the world to suggest the introduction to complementary foods as of the age of 4 months (as observed for the European Society for Paediatric Gastroenterology, Hepatology, and Nutrition (Fewtrell et al. 2017), the Chinese Ministry of Health, and the Japanese Ministry of Health (in (Inoue and Binns 2014)), to name a few examples). The WHO recommendation is related to the protective effect of breastfeeding against infections and, as suggested more recently, to the positive (but unwanted) association between the initiation of complementary feeding before 4 months and the development of overweight and obesity (English et al. 2019). Introduction of complementary foods about the first half of the first year is also related to the developing feeding skills of the infant, which strongly evolve during the course of the first year (Fewtrell et al. 2017; Nicklaus et al. 2015). When the oral cavity increases in size, when lips and the tongue are able to retain food in the mouth, when coordinated lateral then rotatory movements of the jaws are developing, only then is the infant able to process foods other than liquids in the mouth (Nicklaus et al. 2015). These tremendous developmental features happen in a relatively short period, which constitute a "window of opportunity" to learn about food (Nicklaus 2016b). Therefore, during childhood, "eating and drinking" first mean drinking and progressively mean eating at the family table where children will ultimately eat like their parents, if they are provided with the opportunity to learn about "adult" foods.

"Eating and drinking" in childhood must also be considered in relation to the various functions of eating and drinking. In childhood as later during adulthood, "drinking and eating" first serve the primary function of covering nutritional needs for maintaining body functions, with the specific nutritional need to cover healthy growth. Second, "drinking and eating" deliver pleasure, through the presence of the mother (importance of her physical contact as shown in skin-to-skin practice, of her body warmth, of her voice, her smell, etc.) (Schaal 1988), through the positive reinforcement related to the cessation of the painful feelings related to hunger, to the satisfaction related to satiation and the ingestion of calories, and through the pleasurable sensory properties of foods that are either immediately pleasant to the child or learned through experience with foods. Third, "drinking and eating" contribute to socialization; and for children it is essential to learn to eat like their siblings, in order to develop social competencies that will enable their integration to social activities encompassing eating, such as schooling. Finally, because drinking and eating are so embedded into our daily lives, they also contribute to define one's identity, and the food choices that we make daily carry important symbolic values toward others. This is true also in children, and many of children's reactions to parental feeding strategies can also be interpreted in relation to defining their own identity.

In order to describe the main features of eating and drinking in childhood, this chapter is organized in different sections related to the main stages related to eating in this particular age range. One important dimension to account for regarding eating in children is the development of a phase during which children exhibit strong neophobic reactions (i.e., reluctance to eat and try new foods) and may come to reject foods that were previously eaten. This phase generally starts by the end of the second year, when marked signs of food neophobia/fussiness/pickiness become the norm (and may concern at least three children out of four), and fades away by about 8 years of age (Dovey et al. 2008; Nicklaus and Monnery-Patris 2018; Rioux in press; Taylor et al. 2015). For this reason, eating and drinking will first be described in infancy, before the onset of food neophobia (from birth to 2–3 years), during the preschool years (from 2–3 years to 6 years), and right after this period, in school-aged children (from 7 years until 11 years). The mysteries of (pre)adolescent eating and drinking will not be covered in this chapter. Then, within each section, several aspects related to eating will be described. First, sensory capacities will be exposed, because at an early stage in life, sensory-motor inputs play a particularly important role in determining food choice decision-making. Then, likes and dislikes will be explained, which develop in relation to dietary experience. Third, attitudes and thinking abilities will be described, since cognitive abilities strongly evolve across childhood. Finally the role of the environment in shaping eating and drinking will be explained, focusing in particular on the role of the social environment (including family environment), which changes drastically across development.

This chapter focuses on the development of eating behavior of typically developing children and does not cover the potential specific needs of children with atypical development, whether it stems from physiological or psychological impairment. Furthermore, most of the studies used to document this chapter were conducted in

Western Europe or in the USA. While one may reasonably assume that these pieces of evidence relate to fundamental learning mechanisms, in relation to physiological and psychosocial factors, it may be questioned whether the phenomena described in this chapter hold true in all parts of the world. More specifically, many factors that strongly relate to the development of eating and drinking are so variable across the globe (food availability (in relation to climate variations), cooking habits, culture and prejudices about infant and child feeding, socioeconomic development, parental feeding practices, parental feeding and parenting style, exposure to food commercial, etc.) that their independent or combined influences on all aspects of children's development of eating and drinking are not known with precision. Whenever possible, examples from non-Western countries will be exposed.

Infancy: Drinking and Eating Before the Onset of Food Neophobia: The Golden Age

Sensory abilities. Infants are born with the capacity to taste and smell drinks and foods (Lipchock et al. 2011). While it is difficult, if not impossible, to compare infants and adults sensitivities to tastes and smells in line with strong differences in applicable methods, several studies indicate that infants display finely tuned abilities to differentiate flavors of foods and drinks, which can be inferred from their preferences. For instance, they can distinguish the smell of milk from that of water, the smell of breast milk from that of formula milk, and the smell of their mother's milk from the smell of another lactating woman (Marlier et al. 1998). They can also demonstrate a preference for an odor that was experienced in utero, which also reveals the transnatal continuity in terms of food flavor learning (Schaal 2005). They can differentiate and prefer the odor of vanilla compared to the odor of butyric acid (Soussignan et al. 1997). Concerning taste perceptions, newborns are able to display a variety of facial expressions and behavioral responses when they are exposed to the different primary tastes (sweet, salty, sour, bitter, and umami) (Lipchock et al. 2011). Later in development during infancy, infants still show contrasted preferences across the primary tastes, but preference for all tastes do not evolve in the same way: for instance, the preference for salty taste increases sharply during the first year (Schwartz et al. 2017). Regarding manipulation of food textures, infants are born with very limited oral skills that only enable sucking during the first months (Nicklaus et al. 2015). However, they can develop control over sucking during the first months and can refrain from drinking a formula milk that they do not like, as was shown in the case of hydrolyzed protein formula (generally prescribed in case of allergy to cow milk proteins). Such formulas have a strong flavor (bitter, sour, in relation to the hydrolysis of the formula into smaller peptides), which children start rejecting around the age of 3.5 months (Trabulsi and Mennella 2012). Their abilities to develop more sophisticated oral control over food gradually evolve during the first years of life, but it is only when final denture is in place that chewing efficiency of children reaches adult maturity (Nicklaus et al. 2015). This happens during preadolescence.

Food likes and dislikes. In relation with these finely tuned and developing sensory abilities, infants exhibit a marked development in terms of food likes and dislikes. From birth on, their preferences are strongly dependent upon their food and flavor experience (Nicklaus 2016a; Schaal 2016; Trabulsi and Mennella 2012). This may be interpreted as an adaptation mechanism to enable the chemosensory guidance toward foods that are safe to eat within a given environment. This conclusion may appear as very broad, but several pieces of evidence can support it. At birth, preference for an odor can be guided by prenatal exposure to the same odor present in a food consumed by mother: this was shown concerning the consumption of food containing the anise flavor (Schaal et al. 2000). At the start of complementary feeding, children's preference for food flavor can be related to prior learning, during pregnancy as shown regarding exposure to carrot flavor (Mennella et al. 2001) or to green vegetable flavor (Wagner et al. 2019) or to prior learning during lactation as shown regarding exposure to carrot flavor (Mennella et al. 2001), to caraway flavor (Hausner et al. 2010; Wagner et al. 2019), or to green vegetable flavor (Wagner et al. 2019). The exposure to the flavor of garlic during pregnancy was even shown to influence children's preference for garlic flavor in a potato gratin up to adolescence (Hepper et al. 2013). The exposure to vanilla flavor in the context of milk feeding was shown to influence adult's preference for vanilla flavor in a ketchup (Haller et al. 1999), revealing the long-term influence of such an early sensory imprinting on food preference. Epidemiological studies also point to the association between breastfeeding and further acceptance of fruit and vegetables (Burnier et al. 2011; de Lauzon-Guillain et al. 2013; Skinner et al. 2002).

Preferences for foods at the onset of complementary feeding can be modulated by milk feeding experience, in relation to the milk composition independently from the maternal food consumption, in the context of breast milk (Schwartz et al. 2013) or formula feeding (Beauchamp and Mennella 2011). After the initiation of complementary feeding (introduction of foods other than milk to the child's diet), children can process foods which have a soft texture (like infant cereals or purees foods) but are still limited in their ability to process hard/chewy foods (Demonteil et al. 2019), but in terms of flavors, they tend to accept a wide variety of foods (Lange et al. 2013). Notably, the liking of a food (judged from parental reports) can differ as a function of food taste, and infants may like more foods that have a saltier taste (Schwartz et al. 2011), in relation with the development of salt taste preference (Schwartz et al. 2017). This is not a good news because the consumption of sodium is advised against at this stage of life, in relation to kidney immature functioning.

The beginning of complementary feeding itself is fundamental period for children for learning about foods. Many experiments conducted during this period show that repeated exposures help children to like a variety of foods (Sullivan and Birch 1994), even foods they did not like right away (Maier et al. 2007). The diversity or variety of foods fed during this period is also strongly supporting the development of likes for unknown foods. Studies in this area showed that the introduction of three different types of vegetables (or fruits) at the very beginning of complementary feeding instead of one type only is associated with a higher acceptance of a new food right after this period (Gerrish and Mennella 2001; Maier et al. 2008; Mallan et al. 2016;

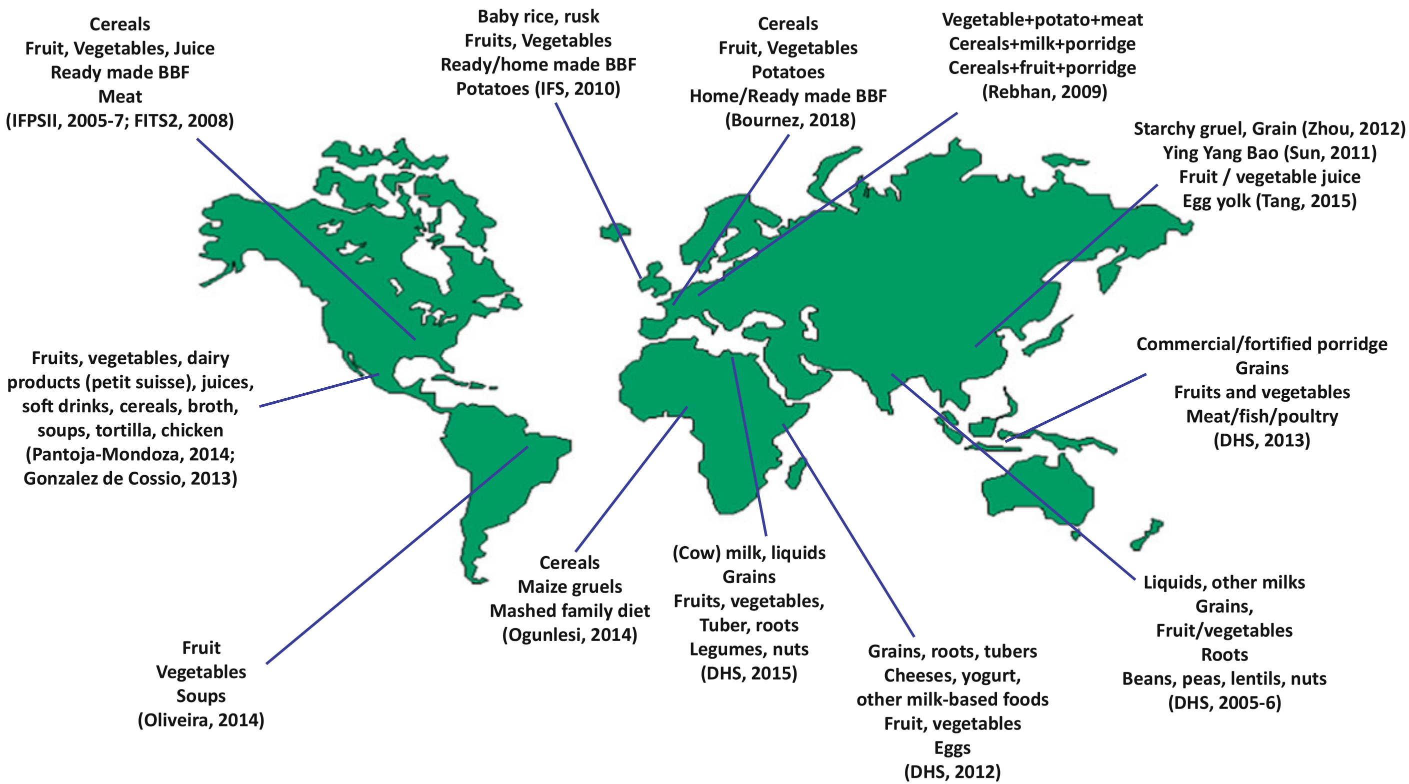

Fig. 1 Mapping of the first foods offered across the world. BBF: ready-prepared baby foods. (Sources: the USA (Grummer-Strawn et al. 2008; Siega-Riz et al. 2010), the UK (McAndrew et al. 2012), France (Bournez et al. 2018), Germany (Rebhan et al. 2009), China (Sun et al. 2011; Tang et al. 2015; Zhou et al. 2012),

Mennella et al. 2008), which demonstrated lasting effects on intake of familiar or novel vegetables up until the age of 6 years (Maier-Nöth et al. 2016). The effect of the introduction of a variety of foods on the development of food preference may depend on the age of children: a study conducted in the UK showed an effect of the introduction to a variety of vegetables on acceptance of a new vegetable in infants introduced to complementary foods after 6 months, but not before 6 months (Coulthard et al. 2014). A study conducted in three cultural contexts (the UK, Greece, and Portugal) where feeding practices are different (high vegetable variety at the beginning of complementary feeding in Portugal but low in Greece and the UK) showed that the effect of an imposed pattern of vegetable variety introduction has more effect on children's acceptance of a new vegetable in countries where parents were not culturally inclined to provide a high variety of vegetables (e.g., in the UK and Greece) than in a country where an introduction of a high variety of vegetables is the norm (e.g., in Portugal) (Fildes et al. 2015).

Having a look about the first complementary foods that are fed around the world is useful to understand how early feeding practices relate to cultural eating habits, as represented in Fig. 1. The types of foods fed in a given culture are generally related to the food availability in this country, to the existence of core foods in the diet (e.g., tortilla in Mexico, legumes and nuts in India, tuber and roots in Egypt). Some regularities can also be observed, like the use of local or commercial cereals or grains and the introduction of vegetal products, like fruit, vegetable, roots, and tuber, while the diet is still rich in milk.

Altogether, this period appears as fundamental for learning about food likes. Beyond the repeated exposure mechanism for learning (or mere exposure), forms of Pavlovian conditioning may also modify children's behavior toward foods (as far as intake or liking are concerned). Preference for an unknown flavor (the conditioned stimulus) may be conditioned by a liked flavor (the unconditioned stimulus, e.g., the sweet taste) in the case of flavor-flavor learning or by the presence of nutrients (the unconditioned stimulus being calories) in the case of flavor-nutrient learning. This has been studied in infants, but the actual contributions of these mechanisms are still controversial (Yeomans 2012). Flavor-flavor learning (with sugar as the unconditioned stimulus) does not produce significant effect on learning to like a new vegetable, but the association of the flavor of a food to calories from lipids may in fact be associated with conditioned satiation (Caton et al. 2014; Remy et al. 2013), revealing the importance of energy density in conditioning food intake. More studies are needed to better understand learning mechanisms for a range of foods with a range of flavor additions, or of energy densities, in order to understand which flavor intensity and which energy density would be associated with the highest increase in liking an intake, especially for foods which are not liked right away by children such as vegetables.

Fig. 1 (continued) Indonesia (Statistics Indonesia (Badan Pusat Statistik-BPS) et al. 2013), India (International Institute for Population Sciences (IIPS), Macro International, & 2007 2007), Ethiopia (Central Statistical Agency [Ethiopia] and ICF International 2012), Egypt (Ministry of Health and Population [Egypt] et al. 2015), Nigeria (Ogunlesi et al. 2014), Brazil (Oliveira et al. 2014), Mexico (Gonzalez de Cossio et al. 2013; Pantoja-Mendoza et al. 2014))

Attitudes and thinking. Although children are mostly in a preverbal stage during this early period before the onset of food neophobia, they start developing representations about foods, either related to whether foods are edible or not (Fallon et al. 1984) or whether foods "smell good or bad" (Wagner et al. 2013). By the beginning of the second year of life, when infants watch people eating different foods, they expect agreement in food likes, revealing a social agreement model, in which infants expect a generalization of food preferences among people eating the same foods, especially if they share the same language (Liberman et al. 2016).

Role of the environment. The previous observation drives to underline the power of the social environment in the shaping of children's eating behavior (Savage et al. 2007). The younger the children, the less autonomous they are in terms of drinking and eating; meaning, they need to receive social support to drink and eat properly. This is strongly shaping what and how much children eat (Shutts et al. 2013). For instance, research has shown that infants aged between 7 and 14 weeks drink more formula in the presence of social interactions, revealing the power of social reinforcement at a very early stage (Lumeng et al. 2007). The mechanisms behind social eating are multiple: when infants are old enough, eating together enables sharing the same foods, which provides an opportunity for the repeated exposures learning mechanism to take place. Moreover, this provides a context for visual imitation. Eating together is also accompanied by conversations at the meal table, which may have the power to define likes and dislikes even at a very early stage of food discoveries (Wiggins 2019). Altogether, social eating in early childhood is a context for "emotional pervasion": language may help develop knowledge and social norms about what is "good for children" to eat which could sustain the pleasure from eating specific foods related to their sensory properties (i.e., children's perceptions of whether the food is "good to them" to eat). During this very early stage in life (as also later in life!), pleasure from eating is partly constructed by interactions with others and socially produced (Marty et al. 2018a).

The Preschool Age: A Neophobic Phase, Source of Family Tensions

Sensory capacities and cognitive development. At around the end of the second year of life, children start demonstrating strong neophobic reactions, when presented with unknown foods (Dovey et al. 2008; Nicklaus and Monnery-Patris 2018; Taylor et al. 2015). They may also demonstrate rejection reactions when offered foods they previously ate without problem. This type of neophobic behavior is a source of questioning for parents and researchers alike. Very often, this neophobic temperament is associated with a low consumption of fruit and vegetables. Some researchers suggested that this type of eating behavior could be related to a specific sensitivity to flavors, as measured by a psychometric scale evaluating "sensory sensitivity" through parental report in children aged 2–5 years old (Coulthard and Blissett 2009). Further work helped to refine this observation based on children's behavioral observations while tasting or smelling actual food tastants or odorants, showing that a higher reactivity to food smells but not to food tastes was associated with a higher neophobia score (Monnery-Patris et al. 2015). Beyond this sensory-based interpretation of the development of neophobic behavior in children, other aspects of cognitive development could account for this evolution. It has been proposed that neophobic behaviors could be adaptive to prevent the child from ingesting noxious foods once the child becomes autonomous and mobile enough to reach for foods (or objects) from the environment, without the supervision of parents or caregivers (Nicklaus and Monnery-Patris 2018). Cognitively speaking, food neophobia also seems to parallel the development of categorization abilities in children (Lafraire et al. 2016). The use of the "no" frequently associated with neophobic reactions (or rejection of some food items) can also be interpreted in relation to the emerging awareness by children of their distinction from their parents (especially their mother). They are learning during this phase to manipulate a new power, which has strong consequences on their social environment.

Food likes and dislikes. Studies conducted right at the beginning of the neophobic period show that by 2 or 3 years of age, children have established firms likes and dislikes (Nicklaus et al. 2005b) and start making less varied food choices despite the increase in their absolute nutritional needs probably in relation to their likes and dislikes (Nicklaus et al. 2005c), and their patterns of likes/dislikes are quite stable throughout childhood and adolescence (Nicklaus et al. 2004, 2005a). For instance, these studies show that the children who chose vegetables most frequently at 2–3 years were also those who consumed a higher variety of vegetables up to the age of 22 years. Thus, most likes and dislikes could be formed at an early stage during childhood and could be relatively stable through childhood. This does not preclude learning at all ages during childhood, as shown in many studies with older children, or even adults. Given the high plasticity of the affective system controlling the food system, food preferences may also find their origin in early dietary exposure. For instance, preschool-aged children may prefer more sour beverages if they had been exposed to a specific formula milk with distinct taste properties, such as extensively hydrolyzed cow milk protein formula, which may taste bitter or sour (Mennella and Beauchamp 2002). Thus, variations in flavor preferences during the preschool period may find their origin in early dietary exposures during the first years of life.

The immediate consequence of food neophobia is the fact that food or beverage likes and dislikes during this period are strongly influenced by the degree of familiarity of the child with the food or beverage. Repeated exposures may help overcome neophobic reactions, if foods are actually tasted and not only visually exposed to children (Birch et al. 1987), but the effect of repeated exposures seems to attenuate as children grow in age (Caton et al. 2014). In this study, repeated exposures to a new vegetable (artichoke) were associated with a high food consumption and to a high increase in consumption after exposure in children in their first year, but these effects were attenuated in children in their second or third year. This suggests a lower flexibility in terms of learning to like a new food as children grow into preschool age. Because of repeated exposures which still appear as a robust mechanism for learning, children learn to like the specific features of a food they are exposed to. For instance, children who had been exposed to salty or sweet tofu learn to prefer the version they had been exposed to, but not the other versions (Sullivan and Birch 1990). Although the repeated exposure mechanism is theoretically well described, reviews on its effects show small effect sizes when looking at the evolution of specific food acceptance, such as vegetables (Appleton et al. 2018). Other strategies to enhance children's vegetable acceptance, such as parental education, are not more successful (Hodder et al. 2018).

Attitudes and thinking. During the preschool stage, children start developing an abstract reasoning about foods (Michela and Contento 1986; Roedder 1999); executive functions develop, as well as brand representations (McAlister and Cornwell 2010). The emergence of more developed mental representations about foods may also be associated with side effects: for instance, children learn to associate "good for health" with "bad taste," for instance, when they are asked to eat vegetables, which taste bad to them, because "they are good for them." This may create unwanted expectations in such a way that a given product (a sweet beverage, in this study) labeled as "good for health" is less liked by children than when it has no label (Wardle and Huon 2000). Similarly, foods that are said by caregivers to "make you strong" are less eaten than foods with no label (Maimaran and Fishbach 2014). Would such unwanted expectations about the relationship between "good for you" and "bad taste" be observed in non-Western cultures? This is, to the best of our knowledge, not documented; but it is likely that any type of contradiction between information provided related to a food and individual preference is likely to produce a decrease in liking, as shown also in adults. So at this early stage in life, it appears clearly that health-oriented arguments are not a good strategy to encourage the consumption of a given food. Indeed in many studies, applying such strategies in the family context to encourage the consumption of foods is generally associated with a lower willingness to taste such foods, but in such studies it is difficult to tear apart cause and consequences. It may very well be that parents use more bribing strategies to make children taste a food when they know that their child has previously shown rejection reactions to this food and/or when they consider that this food has a specific nutritional interest (e.g., vegetable). But if these foods with specific interest are also foods which generally taste bad to children (e.g., vegetable), the application to bribing strategies may be critical in generating negative expectations about the food, resulting in a negative spiral likely to create (unwanted) educational tensions at the family table.

Role of the environment including parental feeding practices. As suggested above, another important consequence of the emergence of a peak of neophobic reactions in children is the feeding strategies adopted by parents to encourage their children to eat the rejected foods. Because neophobic reactions are often observed in reaction to the presentation of foods such as vegetables and fruit, and because most parents are aware of the health values and of the importance of consumption of such foods to maintain a healthy status, often the strategies employed by parents are applied to the same types of foods (Savage et al. 2007). (Of note, this observation cannot be generalized across the full socioeconomic gradient, since some research studies have clearly shown that in families with a lower socioeconomic status, the foods preferentially fed to children are unhealthy, indulgent foods that are perceived to be the only affordable option by parents (Fielding-Singh and Wang 2017).) Research has long shown that such strategies, such as coercion, bribing, or forcing, can have counterproductive effect by generating a negative context around eating, which acts as an unconditioned stimulus to condition rejection of the food (Savage et al. 2007). In some circumstances, rewarding the consumption of a target food with a small, nonfood reward could have a positive effect (Cooke et al. 2011). However, it is now considered that repeated exposures alone, without reward, should be the best way to promote the development of liking for a given food, even if its effects are of small amplitude (Appleton et al. 2018; Hodder et al. 2018). On the contrary, parents may also wish to restrict access for foods which are either specifically liked by children or considered "unhealthy." In this case again, the application of restriction may increase the desire to eat the "forbidden" food (Fisher and Birch 1999; Jansen et al. 2008).

During the preschool period, children start attending daycare, or preschool, depending on each country's schooling organization. This creates the condition for socialization effects to take place, and research indeed shows that social modeling has a strong effect on willingness to taste unknown foods. For instance, children are more willing to taste unfamiliar foods if adults are also eating the food (Addessi et al. 2005; Harper and Sanders 1975), if peers declare that they like the food (Greenhalgh et al. 2009; Hendy 2002), and if peers may even be more influential than adults (Frazier et al. 2012; Hendy and Raudenbush 2000). Research also showed the influence of the presence of other children on the level of food consumption: preschool children ate more pizza in groups of nine than in groups of three individuals (Lumeng and Hillman 2007). At this age children become sensitive to portion size, meaning that they eat more when larger food portions are presented to them (Reale et al. 2019).

School Age: A Curious, Autonomous Eater Still Framed by Parental Practices

When approaching school age, reasoning and reading abilities increase which facilitate the conduct of studies with children; hence many studies have focused on this age range.

Sensory capacities. While it becomes easier to study sensory perceptions as children grow older (Nicklaus 2015), the most relevant knowledge related to development of sensory aspects of eating relates to sensory preferences in children, not to perceptions. Studies show that children aged 6–12 years old find sweeter variants of beverages less sweet than teenagers or adults but prefer them (Zandstra and de Graaf 1998) and that preadolescents have a more marked preference for very sweet solutions than adults (Desor et al. 1975). When the kids were followed up to early adulthood, their preferred level of sweet taste was lower than when they were preteens, revealing a change in affective tone for very sweet products (Desor and Beauchamp 1987). Rejection of bitterness of common substances (urea, caffeine, tetralone) is observed in school-age children and is indeed applied in practice by the addition of bitter substances (tetralone or Bitrex©) to home care products to deter their consumption by children (Mennella et al. 2003). The taste of a food may influence how much children can like it. For instance, children can get to like a sweet orangeade after eight exposures, but not a sour orangeade (Liem and de Graaf 2004). Sensitivity to bitterness may strongly influence liking for bitter foods: children who are more sensitive to PROP or 6-*n*-propylthiouracyl more frequently refuse vegetables, which may taste bitter, than nonsensitive children. This was confirmed for spinach (Turnbull and Matisoo-Smith 2002) and broccoli (Keller et al. 2002), but the association is not systematically observed (Anliker et al. 1991). Similarly, children who like sourness (boys, in that study) may also like sour fruits more than children who don't like sourness (Liem et al. 2006). Saltiness may also influence how much children like and consume foods but has a minor influence compared to level of hunger, which is the n° 1 factor to explain level of food intake (Bouhlal et al. 2013).

Likes and dislikes. The influence of hunger on food choices leads to considering the importance of energy density in driving children food preferences and energy intake control. It was indeed shown, in sweet-flavored beverages which were caloric or not (based on use of sucrose or sucralose, a nonnutritive sweetener), that energy density seems to condition more stable flavor preferences than sweetness alone (Remy et al. 2014). Furthermore, this study shows that energy density is not detected on the short term after consumption (i.e., within 1 hour post consumption of a new beverage) but is learned through repeated exposures. This suggests the importance of providing foods with a constant flavor-energy density association, in order to facilitate appropriate food intake control in children and adaptive flavor preference learning. However, it is very likely that by school age, children have already developed their main food repertoire and developed marked food likes and dislikes which may strongly influence their food choices. They have extensive knowledge about meal structure, type of foods likely to be offered at a given meal (Birch et al. 1984). This implicit knowledge can guide children in making choices to optimize liking level through a competitive range of foods which may vary in terms of healthiness (Marty et al. 2018b).

Attitudes and thinking. As underlined previously, cognitive abilities evolve strongly with age, and this has been especially studied in the context of understanding the effect of cognitive cues on food decision-making, for instance, in the context of food advertisement and marketing (Story and French 2004). Credence cues as those used in (food) advertisement are likely to influence choice behavior. Before the age of 7/8 years, children tend to view ads as entertaining and informative, which makes them very vulnerable to ads (McAlister and Cornwell 2010; Michela and Contento 1986; Roedder 1999). After this age, children begin to understand the persuasive intent of ads but can still be persuaded by the emotive message of ads. Credence cues from representations and expectations, which are likely to modulate experiences pleasure (Fernqvist and Ekelund 2014). In children as in adults, brands have a positive effect on liking, which may be modulated by socioeconomic status (Sosa and Hough 2006). Thus, the presence of licensed characters has a positive effect on liking, as revealed also in preschool children (Roberto et al. 2010). The use of such characters may be more influential than the application of cognitive information about nutritional content to alter children's evaluations of foods, which may be effective in health-concerned children only (Engell et al. 1998).

The emergence of mental representations about foods makes it possible to consider the manipulation of these representations to modify food choices, if one admits the connection between intentions and actions. In other words, it may be possible to orientate children's food choices by making choice option more or less salient in children's mind, by manipulating cues in the environment that are likely to "prime" mental representation of these foods (Chambaron et al. 2015; Gaillet et al. 2013). Following on this idea, one study attempted to prime mental representations of healthy versus unhealthy foods in children by using olfactory primes (respectively, a pear odor to prime "healthy foods" and a pound cake odor to prime "unhealthy foods") and evaluated whether the presence of these olfactory primes would be associated with different choices for healthy versus unhealthy foods and whether the effect of the olfactory primes on food choices would be different in children with or without overweight (Marty et al. 2017a). In children with obesity, the fruity odor increased the likelihood of a fruit to be chosen compared to the no-odor condition, while the fatty-sweet odor had no effect on food choice. In children without obesity, both the fruity and the fatty-sweet odors decreased the likelihood to choose a fruit compared to the no-odor condition. The different patterns of results obtained in both groups of children suggest differences in the mental representations activated by non-attentively perceived olfactory cues based on weight status. This suggests important differences in attitudes toward eating associated with weight status, which were either pre-existing the development of overweight or resulting from the overweight status. Thus, the development of obesity with age is not only associated with physiological and psychological adverse effects but also to modifications of mental representation of foods which are likely to alter food choices in everyday situation.

Attitudes toward eating can also evolve because of the development of individual relationships with foods and eating (independently from weight status). Affective attitudes toward foods develop in parallel to cognitive attitudes and could be influential in determining food choices. For instance, children's attitudes were defined as nutritionally oriented versus hedonically oriented and evaluated with a direct task or an indirect task (Monnery-Patris et al. 2016). With development, the direct task (food categorization) showed a significant increase in nutrition-driven categorizations with school level, but the indirect task showed an increase in hedonically oriented attitudes, in relation to the children learning culinary scripts in his/her environment. This reveals that with development, children increase their nutrition knowledge (and are able to report so accordingly) but when asked less directly also reveal an increasing dominance of affective-based relationship to food. To note, a complementary study looking at food choices and their associations with affective or cognitive attitudes showed that children with high nutritionally oriented attitudes (whether they were studied directly or indirectly) made a *lower* number of healthy food choices when they were offered the possibility to choose among snack foods of differing healthiness values (Marty et al. 2017c). This observation that nutritionally oriented attitudes were not associated with a higher choice of healthy foods may suggest that on the contrary, hedonically orientated attitudes could help children make healthy food choices when healthy versus unhealthy choices are equally likely or in other words that pleasure of eating could be favorable to healthier choices in some circumstances.

This method to study attitudes also revealed differences among children according to weight status (Marty et al. 2017b). There was no difference in nutritionally oriented attitudes with the indirect task, but with the direct task, children with overweight or obesity revealed more nutritionally oriented attitudes than normal-weight children. This could be related to the tentative management of their overweight by their caregivers, which could drive them to declare more attention toward the nutritional aspect of eating.

Role of the environment. These few examples illustrate how children's representation about foods can be modified with development, in relation to the immersion in the social milieu in which children live. As noted by P. Fielding-Singh, "whereas low-SES parents use food to buffer against deprivation, high-SES parents provision foods to fulfill classed values around health and parenting" (Fielding-Singh 2017). Children incorporate social norms about which foods are relevant to eat in which situation, and they can adjust the food choices they make to various social situations (Marty et al. 2018b). Clearly, even at this early age, food choice decisions increase in complexity as they can be influenced by pleasure, interactions with parents, sibling, social norms, marketing messages, etc. (Lapierre et al. 2017). Mapping the role of the environment in this context becomes more difficult because it becomes almost as complex as in adults. In children as in adults, the environment in which choices are made can influence food choice. This aspect of the choice environment was explored to evaluate the effect of nudging strategies on food choices. Nudges (e.g., "any aspect of the choice architecture that alters people's behavior in a predictable way (1) without forbidding any options or (2) significantly changing their economic incentives" Thaler & Sunstein 2008, in (Cadario and Chandon 2019)) intend to make foods more or less salient, in order to facilitate or hinder food choice. Nudges applied to encourage healthy eating have proven as successful to increase healthy food choices in children as in adults (Cadario and Chandon 2019). However, modification of the food offer is not always sufficient to promote healthy eating. Providing more choice between different types of vegetables to children was seen as a means to increase their consumption and liking, because this could increase self-efficacy and feelings of autonomy (Zeinstra et al. 2010). However, in this study, the provision of more choice options was appreciated by children but did not result in an increase in vegetable liking or consumption.

Other nudging studies prime the social norms around the food consumption in order to encourage healthy eating. One study, for instance, delivered information to children suggesting that other children had eaten a large amount of carrots, no carrots, or control information (Sharps and Robinson 2015). Children ate more carrots when they believed that other children had eaten a large amount of carrots, compared to all other conditions. This example shows that perceived social norms can influence healthy eating in children. This is not always pushing children toward healthier food choices. For instance, when children are asked to choose foods for a birthday party among a selection of healthy versus unhealthy foods, they are much more likely to choose unhealthy options than when make food choice for a nutrition class (Marty et al. 2018b)!

During school age, children are given more and more autonomy regarding food purchasing, and their buying strategy develop (Hartmann et al. 2017). They buy the brand they like rather than the brands they know, and they become price-sensitive. This may open ways to encourage healthy eating by applying price increase for energy-dense, unhealthy foods. However, the long-term consequences of such strategies on mental representations of healthy versus unhealthy foods are unknown. Clearly, more research is needed to understand the effect of the environment (including social media) on twenty-first century's children's eating and drinking behavior and the conditions under which healthy and sustainable food choices are made.

Conclusions

In conclusion, drinking and eating in childhood bear a special significance considering that eating behavior is learned and that most of this learning process takes place during the early years, forming enduring memories, for the best or for the worst. Thus, early drinking and eating experience may program both food preferences and the health status of the adult. However, in relation to the importance of sensory inputs for children, and of pleasure from eating, childhood is also a period when pleasure plays a prominent role in orienting food choices. When growing into school age, children's food choices can be modulated by attitudes and social norms and start to recompose because of the internalization of social norms related to eating and drinking.

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Food Neophobia in Childhood

21

Camille Rioux

Contents

Abstract

Food neophobia is defined as the reluctance to eat new foods. It has been presented as one of the main obstacles to improving children's intake of fruits and vegetables. Hence, it is essential to uncover the factors that influence the development or expression of food neophobia in childhood, in order to promote the adoption of healthy eating behaviors early in life. To date, research on neophobia has revealed a large range of factors influencing this disposition:

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both individual factors (e.g., genetic influences and temperament traits) and environmental factors (e.g., early food experiences and feeding practices). Various strategies can efficiently decrease children's food neophobia expression, such as taste and visual exposure to new foods. Further studies could systematically evaluate the effectiveness of such interventions, as well as investigate the mechanisms behind positive effects.

Introduction

Children's low consumption of fruits and vegetables is a common source of concern for parents who are worried about their child's dietary diversity and quality (DeCosta et al. 2017). Food neophobia, defined as the reluctance to eat new foods, has been presented as one of the main obstacles to improving children's intake of fruits and vegetables (Cole et al. 2017; Dovey et al. 2008; Lafraire et al. 2016). The impact of food neophobia extends well beyond childhood, since dietary habits acquired during childhood largely determine dietary patterns in adulthood (Nicklaus et al. 2005). It is therefore essential to understand the mechanisms underpinning food neophobia in childhood, in order to promote the adoption of healthy eating behaviors early in life. This chapter aims to examine the question of food neophobia in typically developing children (adults and those children who have been diagnosed with a pediatric disorder such as avoidant/restrictive food intake disorder(ARFID) are out of the scope of the present chapter). The chapter starts by discussing how to characterize food neophobia and a general approach to its measurement. The second part provides an overview of the factors influencing food neophobia. Then, an evaluation of the effectiveness of different interventions aimed at reducing food neophobia is presented, highlighting on interventions based on food exposure, and further opportunities for research and interventions are explored.

Characterization and Measurement of Food Neophobia

Definition

Food neophobia is defined as the reluctance to eat new foods or the fear of new foods (Pliner and Hobden 1992). Food neophobia can be considered as a true phobia (Maratos and Sharpe 2018): it is associated with typical physiological fear responses, such as galvanic skin response (i.e., changes in sweat skin activity) and an increase in pulse or respiration rhythm. Additionally, food neophobia in children is often associated with an increased anxiety or even disgust over new foods, as well as with attentional biases toward new foods. All three components (anxiety, disgust, or attentional biases) are often found in phobias (see Maratos and Sharpe 2018 for a review of food neophobia as a true phobia). This fear of new food is assumed to serve a protective function for omnivorous species (i.e., species that do not eat just one type of food) in potentially hostile food environments (Pliner and Hobden 1992; Rozin 1979). Rozin (1979) described food neophobia as an efficient adaptive strategy for children to avoid the risk of ingesting new (and thus potentially poisonous) food items, once they are mobile enough to reach for, and consume food available in their proximal environment. Some authors have suggested that this view explains why plant-based foods such as fruits and vegetables are the privileged targets of food neophobia as plants often contain secondary compounds that can be toxic to human and no visual features reliably signal which plants may contain these toxic compounds (Cashdan 1998; Wertz and Wynn 2014; Włodarczyk et al. 2018).

The notion of *novelty* plays a central role in the definition of food neophobia. This notion has to be broad since a rejected new food can be (i) a food item the child has never encountered before or (ii) a food that has been encountered before but, due to variations in color, shape, preparation, etc., is not currently recognized by the child. This means that *new* foods can include items previously accepted by the child, well known from the caregivers' perspective, and frequently consumed in the cultural area the child belongs to (e.g., a tomato for most European children). In other words, it is from the child's perspective that the notion of novelty has to be analyzed. A new food item can be *genuinely new* (e.g., a dragon fruit for most European children) or *perceived as new* (e.g., a tomato cut into cubes instead of slices). Some authors have suggested that this view also explains why fruits and vegetables are the privileged targets of food neophobia as they are more likely to exhibit changes in color, shape, or preparation between servings than other foods (e.g., starchy foods) and therefore can be more easily perceived as new by children, even though they have been encountered in other forms before (Harris 2018).

In both cases (genuinely new food or food perceived as new) the presented food is not subsumed under a known category (e.g., the category *tomato*), and properties of the food cannot be inferred (such as the property *edible* if the presented food would be categorized as a tomato). Categorization is a fundamental cognitive process that allows us to organize objects into groups that share common characteristics (Murphy 2002). One main use of categories is to make predictions about new items (e.g., tomatoes are edible; therefore if a new item is categorized as a tomato, one can infer that this new item is edible) (Murphy 2002). Accordingly, some researchers suggest that food neophobia is closely intertwined with the development of categorization abilities in the food domain, abilities that largely improve around 2–3 years of age as children become more mobile (Harris 2018; Lafraire et al. 2016; Nicklaus and Monnery-Patris 2018; Rioux et al. 2016; Rioux et al. 2017b). More precisely, Rioux and colleagues recently found a robust association between food neophobia and food categorization abilities in 2- to 6-year-old children (Rioux et al. 2016; Rioux et al. 2017b). Categorical judgments are mainly made based on visual cues as neophobic reaction results in new foods being rejected on mere sight, even before being tasted or swallowed (Cashdan 1998; Harris 2018; Dovey et al. 2008; Lafraire et al. 2016). Vision is indeed the main sensory component predicting whether a child would try a new food (Nicklaus and Monnery-Patris 2018).

Trait Neophobia Versus State Neophobia

Food neophobia is most often conceptualized as a personality trait, a continuum along which children (and more generally individuals) can be located in terms of their stable and persistent propensity to avoid new foods (Alley 2018; Dovey et al. 2008; Pliner and Hobden 1992). Indeed, as listed below, food neophobia exhibits most of the characteristics known as supporting the definition of a personality trait:

(a) *Heritability*. For instance, comparing food neophobia between monozygotic twins (sharing all their genes) and dizygotic twins (sharing on average half their genes), researchers found that food neophobia is highly heritable (see section "Genetic Influences" below).
(b) *Linked to biological mechanisms (*e.g., *neurochemical*, *neuroanatomical)*. A handful of studies have revealed implication of neural mechanisms in food neophobia (Klarer et al. 2014).
(c) *Early ontogenetic appearance*. Food neophobia appears in the first few years of life and is fully expressed by preschool age (see section "Developmental Trend and Gender Differences" below).
(d) *Counterparts exist in nonhuman primates as well as in certain other social mammals*. Neophobic behaviors are commonly observed among omnivorous species, such as capuchin monkeys or rats (Rozin 1979).
(e) *Generation of important individual differences*. Pliner and Hobden (1992) developed a scale to assess the level of individual food neophobia and found a great inter-individual variation in respondents' answers: some respondents obtained low scores and could be defined as neophilic, while others obtained high scores and could be defined as neophobic.

Nevertheless, food neophobia does not seem to exhibit one important characteristic of a personality trait: to be relatively enduring and predictive of conceptually coherent outcomes. Indeed, while neophobia is thought to be relatively stable during early childhood, most researchers agree that, in late childhood, the expression of food neophobia decreases (see section "Developmental Trend and Gender Differences" below). Additionally, food neophobia is only partially predictive of coherent behavioral outcomes, since most studies found only medium correlations between neophobia and willingness to try new foods. A recent review of instruments developed to measure food neophobia (Damsbo-Svendsen et al. 2017) revealed that the highest correlation between neophobia and willingness to try new foods found in the literature was 0.47. The lowest correlation was 0.11 (correlation coefficients range from −1 to 1. These two end points mean that two constructs are perfectly negatively/positively correlated, while a coefficient of 0 means that the two constructs are not at all correlated). This led some authors to rather address neophobia as a state (Alley 2018), a transitory negative emotion (in the case of neophobia, fear), elicited by the idea of ingesting a specific food, in a specific context. In this view, the expression of food neophobia can be unstable, age-dependent, and modulated by context modalities such as food properties, individual's mood, or social modeling (Alley 2018).

To reconcile the distinction between food neophobia as a trait or as a state, the concept of disposition is enlightening (Mumford 1998). Dispositions are seen as genuine and functional properties ascribed to objects, kind, or persons (e.g., the disposition *fragile* for a glass). To each dispositional property corresponds a typical manifestation (e.g., *shatter when struck* for a fragile glass), explained by a physical/biological state or mechanism (possibly unknown). Importantly, to possess a disposition is not to be in a particular state but to be liable to be in a particular state when certain circumstances are met (e.g., *if* the fragile glass is struck, it shatters). Neophobia could then be viewed as a disposition. Only when neophobic children are presented with new foods, they will present rejection behaviors. The circumstances are met when a food is genuinely new or perceived as new. As children develop and get older, fewer things are new for them, thus the circumstances that trigger food rejection behaviors occur more and more rarely, potentially explaining the non-stability of neophobia during the lifespan.

Measurement of Food Neophobia in Childhood

Questionnaires

Methodologically speaking, it appears that when neophobia is conceptualized as a trait, questionnaires are used (Alley 2018). This is due in large part to ease and rapidity of administering such measures (Alley 2018). The first researchers to develop a food neophobia scale were Pliner and Hobden (1992), who designed the Food Neophobia Scale (FNS). This questionnaire asks adult participants to indicate the extent to which they agree, or not, with statements about consumption of new foods, such as "If I don't know what is in a food, I won't try it" (see Fig. 1). Originally devised to score adults' neophobia, the FNS was rapidly adapted to measure children's neophobia (e.g., "If my child does not know what is in a food, she/he won't try it," Children Food Neophobia Scale (CFNS); Pliner 1994). This scale has been widely used to measure food neophobia in childhood and successfully

Fig. 1 Items of the original Food Neophobia Scale. (Retrieved from Pliner 1994)

I am constantly sampling new and different foods
I don't trust new foods.
If I don't know what is in a food, I won't try it.
I like foods from different countries.
Ethnic food looks too weird to eat.
At dinner parties, I will try a new food.
I am afraid to eat things I have never had before.
I am very particular about the foods I will eat.
I will eat almost anything.
I like to try new ethnic restaurants.

adapted (e.g., the Fruits and Vegetables Neophobia Instrument (FVNI), the Food Neophobia Test Tool (FNTT), the Questionnaire pour Enfant de Neophobie Alimentaire (QENA); see Damsbo-Svendsen et al. 2017 for a recent review on tools to measure food neophobia). It has also been translated into several languages, for instance, French, Spanish, Chinese, Swedish, and Italian (Damsbo-Svendsen et al. 2017).

Both auto-assessment scales (i.e., children respond for themselves) and hetero-assessment scales (i.e., caregivers respond for their children) are used. Hetero-assessment scales are commonly used with children younger than 5–6 year olds (Alley 2018). It is important to have in mind that hetero-assessment scales give only approximation of children's own food behaviors. There are potential social desirability biases (i.e., parents may present a better image of their children or themselves), or parents may sometimes project their own behaviors onto those of their children (Alley 2018). In fact, caregivers' reports of their children's neophobia only moderately correlate with children's reports of their own neophobia (e.g., $r = 0.3$ in Pliner 1994). Both auto-assessment scales and hetero-assessment scales also have the potential pitfall of memory errors (Alley 2018). Additionally, recent reviews (Alley 2018; Damsbo-Svendsen et al. 2017; de Lauzon-Guillain et al. 2012) pointed out that several existing scales measuring children's food neophobia are not completely reliable, potentially leading to deceptive conclusions. For instance, the widely used FNS/CFNS failed to validate construct validity and/or temporal reliability (de Lauzon-Guillain et al. 2012). This means that they can measure something else than neophobia (failure to validate construct validity) and provide different outcomes if completed several times (failure to validate temporal reliability). This urges caution of the choice of the scale selected to measure food neophobia in children.

Willingness to Try New Food Tasks

Rather than asking people about consumption of new food in general, one can attempt to determine actual consumption of specific new foods (Alley 2018). There are some clear advantages to using direct consumption measures. When faced with a request to actually select or eat new food items, young children might provide better information on the attractiveness of particular new food items, than when expected to deal with a purely verbally based assessment, as the actual presence of food is believed to trigger the emotional response. This strategy is actually often used when food neophobia is considered as a state. However, there are a multitude of factors that shape an individual's food choices and vary across time and situation (such as hunger level) and make it difficult to create a test that purely reflects variation in food neophobia (Alley 2018). These measures of food neophobia are thus better treated as a mean to test the construct validity of questionnaires (Alley 2018; Damsbo-Svendsen et al. 2017).

The most common task used is the "Willingness to Try New Food" task (WTNF), in which children are presented with new foods and are asked to try them. The first WTNF task was developed by Pliner and Hobden (1992). It consists of participants ranking six a priori new foods from five categories (salads, dips, crackers, vegetables, and snacks) in order of their willingness to taste them (in a fictitious subsequent tasting session). Pliner and Hobden's food task has been widely used and largely adapted (Alley 2018; Damsbo-Svendsen et al. 2017). Some authors use pictures of foods instead of actual foods, while others use real foods. Some authors add familiar foods to the task and compare the number of familiar foods tasted to the number of new foods tasted. Further, in some WTNF, children have to taste the foods, while on the original task, they just had to indicate which foods they were willing to taste (see Damsbo-Svendsen et al. 2017 for a review of WTNF tasks). Usually, the willingness to try new foods is moderately to highly correlated with scores on food neophobia scales.

Developmental Trend and Gender Differences

Most researchers agree that neophobic behaviors appear at around 2 years of age, when children become more mobile and could find themselves outside parental guidance (see Dovey et al. (2008) and Lafraire et al. (2016) for reviews on the developmental pattern of food neophobia). A few recent studies have also discovered precursors of food neophobia in infancy, though after weaning (Harris 2018; Moding and Stifter 2018). There is however a contention in the literature as to whether neophobic behaviors increase progressively thereafter or remain stable during early childhood. On the one hand, some authors found that 5-year-old children tend to be more neophobic than their younger counterparts. On the other hand, other authors did not find any correlation between food neophobia and age within the 2- to 6-year-old age range (see Lafraire et al. 2016 for a review; see Table 1). Longitudinal studies on food neophobia are scarce and are needed to investigate further its developmental trend. Nevertheless, there is a relative consensus that in late childhood/beginning of adolescence, the expression of food neophobia decreases, until it reaches a relatively stable expression in adulthood (Dovey et al. 2008). Actually, the mere fact that fewer things are new for an adult or an adolescent than for a child automatically reduces the expression of food neophobia (Cooke and Wardle 2005).

Concerning potential gender differences, most studies investigating food neophobia during childhood did not find gender differences (see Dovey et al. 2008 for a review). Though some studies have found differences in both directions (i.e., girls being more neophobic than boys and vice versa, see Dovey et al. 2008), however, overall there is still limited evidence for a robust association between food neophobia and gender (Dovey et al. 2008).

Food Neophobia and Its Association with Diet Quality and Weight Status

Food neophobia has been shown to affect children's diet and food preferences. The food items that are rejected the most are certainly fruits and vegetables (see Kral

Table 1 Summary of studies relating food neophobia to age during early childhood

Publication	Population	Measurement instrument	Correlation with age
Addessi et al. (2005)	2–5 years, the USA	WTNF task	No association
Barends et al. (2014)	12–23 months, the Netherlands	WTNF task	Positive
Cashdan (1994)	1–10 years, the USA	Questions on reaction to novel food	Positive
Cooke et al. (2003)	2–6 years, the UK	CFNS	No association
Koivisto-Hurti & Sjoden Koivisto-Hursti and Sjöden (1996)	2–9 years, Sweden	CFNS	No association
Monnery-Patris et al. (2015)	20–22 months	Children's Eating Difficulties Questionnaire (Rigal et al. 2012)	No association

(2018), Cole et al. (2017), and Nicklaus and Monnery-Patris (2018) for reviews on food neophobia and its association with diet quality and weight status). Numerous studies have indeed uncovered negative associations between food neophobia and intake of fruits and vegetables (Cole et al. 2017; Nicklaus and Monnery-Patris 2018, see Table 2). This often goes along with a negative association between food neophobia and liking for these food products (Henriques et al. 2009; Laureati et al. 2015). Besides fruits and vegetables, the intake of other food groups such as meat and protein are also negatively impacted by food neophobia (Kral 2018). Therefore, food neophobia in children is associated with decreased dietary variety and quality (Kral 2018) along with a possible lack of essential micronutrients and fibers that are necessary for a normal and healthy child development (Dovey et al. 2008; Lafraire et al. 2016).

Regarding weight status, studies that have systematically examined the relationship between food neophobia and BMI scores are scarce and have produced mixed results. Some studies found no association between BMI and food neophobia, but others found that neophobic children tend to be overweight, as they seem to eat few fruits and vegetables and high quantities of discretionary foods (Cole et al. 2017). Overall there is limited evidence to date for a robust association between food neophobia and BMI scores in children and adolescents (Kral 2018).

Food Neophobia and Its Relationship with Food Pickiness

Food neophobia is often associated with food pickiness, another type of food rejection (neophobic children are often also picky and vice versa) (Dovey et al. 2008). While food neophobia is well defined, the definition of food pickiness is more imprecise and a matter of contention. Generally, it is defined as the rejection of new

Table 2 Summary of studies relating food neophobia to dietary intake outcomes. (Adapted from Nicklaus and Monnery-Patris, 2018)

Publication	Population	Measurement instrument	Dietary intake outcomes in neophobic children
Cooke et al. (2003)	2–6 years, the UK	CFNS (only six items)	Lower consumption of fruits, vegetables, meat, and egg
Cooke et al. (2006)	4–5 years, the UK	CFNS (only six items)	Lower consumption of fruits, vegetables, meat, and egg
Galloway et al. (2003)	7 years, the USA	CFNS	Lower consumption of vegetables
Helland et al. (2017)	2–3 years, Finland	CFNS	Lower consumption of fruits, vegetables, and fish
Maiz and Balluerka (2016)	8–16 years	CFNS	Lower consumption of fruits, vegetables, and fish. Higher consumption of sweets and candy
Nicklaus et al. (2005)	4–22 years	CFNS	Lower consumption of all food groups
Perry et al. (2015)	24 months	CFNS	Lower consumption of fruits and vegetables. Higher consumption of discretionary foods

and previously accepted foods, along with the rejection of certain textures that are rejected after the tasting step (i.e., foods are tasted but not swallowed) (Dovey et al. 2008; Lafraire et al. 2016; Rioux et al. 2017a). Rioux and colleagues have recently suggested that theoretically speaking, food neophobia and pickiness may capture a similar kind of fear for new and potentially toxic foods. Indeed, as with food neophobia, pickiness presents at least one signature feature of a phobia, that is to say an increased disgust over food items in general (Rioux et al. 2017a). Moreover, texture rejection, an important component of food pickiness, can prevent children from the ingestion of decayed foods that can potentially become toxic foods (as texture can inform of the decay of a food). Additionally, the authors suggested that what is thought to be rejection of familiar foods is probably rejection of foods perceived as new for children (see section "Definition"). Nevertheless, neophobia and pickiness appear to be two behaviorally distinct kinds of food rejection (Dovey et al. 2008; Lafraire et al. 2016; Rioux et al. 2017a). Although the motivation for rejection may be the same, caregivers appear to distinguish food neophobia from pickiness: distinguishing rejection due to texture (pickiness) from rejection due to sight (neophobia) and rejection after the tasting step (pickiness) from rejection before the tasting step (neophobia).

Typology of Factors Influencing Food Neophobia

Extensive research on food neophobia has revealed a large range of factors influencing this disposition in childhood. They can be broadly divided into two categories reviewed below: intrinsic/individual factors and extrinsic/social or environmental factors (see Fig. 2).

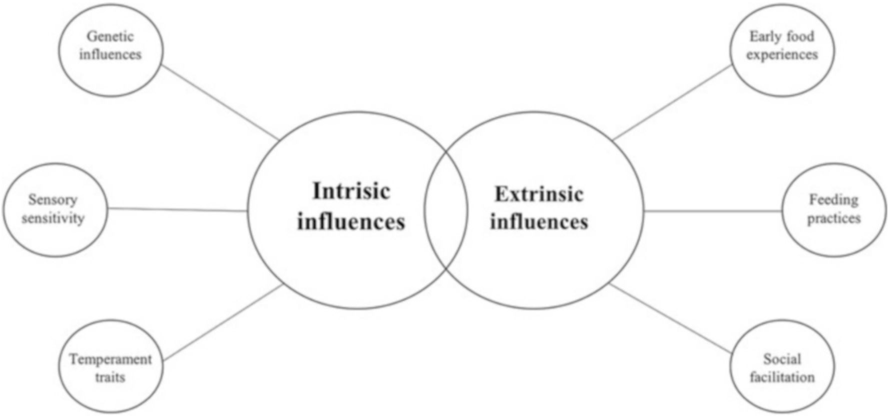

Fig. 2 Typology of factors influencing food neophobia (Adapted from Lafraire et al. 2016)

Intrinsic Influences on Food Neophobia

Genetic Influences

There is evidence that points to genetic influences underlying food neophobia. Studies to establish the contribution of genetic factors to food neophobia are of one main type: twin studies (see Cooke 2018 for a review). Twin studies compare similarity between monozygotic twins who share 100% of their genes and dizygotic twins who share 50% of their genes. These studies produce robust estimates of the contribution of genes on food neophobia (e.g., Cooke et al. 2007) and generally revealed that food neophobia is highly heritable (from 58% to 78% of the variance of food neophobia could be explain by genetic factors; Cooke 2018).

The Role of Sensory Sensitivity

The anticipated sensory characteristics of foods (e.g., smell, texture, etc.) are recognized as a key determinant of decisions about whether to accept or reject a food (Farrow and Coulthard 2018; Wadhera and Capaldi-Phillips 2014), and evidence suggests that there is individual variety in how children perceive and evaluate sensory information, influencing food neophobia. Indeed, it has been shown that sensorily hypersensitive children are more likely to be more neophobic – hypersensitive children are more able to identify subtle changes in the sensory properties of stimuli, such as changes in smell, for instance (Blissett and Fogel 2013; Farrow and Coulthard 2018). Monnery-Patris et al. (2015) have explored smell and taste sensitivity in children by asking them to taste different solutions representing basic tastes, such as sweet or salty, and sniff different solutions representing pleasant or unpleasant odors and found that food neophobia in toddlers was correlated with smell sensitivity, but not taste sensitivity. It has also been shown that neophobic children sniff new food from a further distance compared to their non-neophobic counterparts (Farrow and Coulthard 2018). Other studies have also revealed an association between tactile sensitivity and food neophobia (Smith et al. 2005). For instance, it has been shown that tactile defensiveness (overreactions to the experiences of touch or withdrawal responses to some typically inoffensive tactile stimuli perceived as offensive) is associated with high food neophobia (Smith et al. 2005). Together these findings indicate that neophobic children may experience exaggerated reactivity to olfactory and tactile food cues. It is interesting to note that these cues can be perceived before the food stimuli is tasted or swallowed, which is consistent with the claim that food neophobia serves a protective function (Rozin 1979).

Relationship Between Food Neophobia and Temperament Traits

Temperament traits are defined as individual differences in emotional and behavioral reactivity that are relatively stable (Nicklaus and Monnery-Patris 2018). Several temperament traits have been found to be associated with food neophobia (see Lafraire et al. 2016 and Nicklaus and Monnery-Patris 2018 for reviews). It is assumed, for instance, that food neophobia is associated with increased anxiety in children (Lafraire et al. 2016; Nicklaus and Monnery-Patris 2018). More precisely, it has been shown that girls with food neophobia are more anxious than their non-neophobic counterparts. Sensation-seeking has also been found to be negatively associated with food neophobia (Nicklaus and Monnery-Patris 2018). Children who are greater sensation-seekers, that is to say, requiring a lot of stimulation to reach the appropriate level of awakening, tend to be less neophobic. Some researchers have also proposed that food neophobia could be a direct consequence of one specific dimension of temperament: approach/withdrawal (Moding and Stifter 2018). This dimension characterizes individual differences in responses to new stimuli, such as toys, people, or situations. Children who are low in approach tend to show negative affect toward new stimuli and withdraw from them (Moding and Stifter 2018). In their longitudinal study, Moding and Stifter (2018) showed that children with low approach tendencies at 18 months had higher levels of food neophobia at 4.5 years of age. This set of studies raises the question of the selectivity of neophobia and suggests that food neophobic children are likely to present neophobic behavior in other domains as well (as revealed, for instance, in Moding and Stifter 2018).

Extrinsic Influences on Food Neophobia

Early Food Experiences and Feeding Practices

Several studies have proposed that children’s immediate environment is important in shaping their food neophobia (prenatal food experiences and feeding practices). Regarding prenatal and early experiences, evidence suggests that children are more willing to taste new flavors if they have experienced them through amniotic fluid (Cooke 2018; Mennella et al. 2001). Indeed, infants show less negative facial expressions to carrots when introduced to the diet if their mother had drunk carrot juice during the third trimester of pregnancy (Mennella et al. 2001). Regarding the influence of children’s post-birth environment, certain feeding practices significantly affect food neophobia expression (Cooke 2018; Lafraire et al. 2016). For instance, commonly used parental feeding strategies such as food rewards, or pressure to eat, increase the expression of children's food neophobia (DeCosta et al. 2017; Nicklaus and Monnery-Patris 2018; Lafraire et al. 2016). On the other hand, breast-feeding and offering children a high variety of vegetables at weaning seem to have a positive impact on food neophobia (Cooke 2018; Nicklaus and Monnery-Patris 2018). It is nevertheless important to note that most studies on food neophobia are not longitudinal (children are not followed during several months or years and are instead seen only once); therefore it is difficult to know the causality of the effects (is it because a child is neophobic that caregivers use more negative feeding practices or the inverse?).

Social Facilitation

Another far and wide studied extrinsic factor influencing food neophobia is social facilitation (Lafraire et al. 2016; Nicklaus and Monnery-Patris 2018), defined as an increase in the probability of performing a class of behavior in the presence of conspecifics performing the same class of behavior at the same time (see Herman 2015 and ▶ Chap. 14, "Social Influences on Eating" by Higgs this volume, for a review of the food social facilitation effect). Put differently, social facilitation means that when a child eats in the presence of others eating food, her behavior is socially facilitated toward food intake. It has been shown, for instance, that toddlers are more willing to taste a new food if they see an adult eat it first (Addessi et al. 2005). Adults can serve as models for food acceptance, e.g., an encouraging teacher or a friendly visitor in a classroom can foster food acceptance in young children. However social facilitation with peers (i.e., other children) seems more effective (Lafraire et al. 2016). Social facilitation is enhanced when models are familiar to children (Harper and Sanders 1975) and are "prosocial" (i.e., nice and helping) (Hamlin and Wynn 2012). Nevertheless, questions remain on what aspects of modeling are actually effective on children's food acceptance: the act of consuming the food, facial expressions or verbal messages that are associated with parental or peer consumption, or a combination of these factors (Blissett and Fogel 2013).

Interventions to Overcome Food Neophobia

Various reviews of existing interventions show that certain strategies efficiently decrease children's food neophobia (Appleton et al. 2016; DeCosta et al. 2017; Keller 2014; Knai et al. 2006). These interventions can generally be divided into two main types: interventions focusing on the eating context and interventions focusing on the food itself (see Appleton et al. (2016) and DeCosta et al. (2017) for reviews). The interventions focusing on the eating context usually manipulate extrinsic factors known to influence neophobia, mentioned in the section above (see, for instance, Laureati et al. 2014, for an intervention in schools using peer social facilitation to decrease neophobia). Therefore, these interventions will not be further developed in this chapter (see DeCosta et al. (2017), for a review of the interventions focusing on the eating context).

Regarding the interventions based on the food itself, three types of interventions are widely used to decrease food neophobia: flavor-flavor learning, flavor-nutrient learning, and mere exposure (Appleton et al. 2016). Ninety percent of the interventions based on the food adopted at least one of these methods (Appleton et al. 2016). Flavor-flavor learning (FFL) and flavor-nutrient learning (FNL) are two strategies based on conditioning: an association between a neutral conditioned stimulus and a positive unconditioned one will trigger a positive attitude toward the conditioned stimulus, even when the unconditioned stimulus is latter removed. The principle of FFL is that the pairing of a target food (often a new vegetable), with a taste that is already liked (e.g., a sweet or salty taste), should trigger positive attitude toward the target food. The principle of FNL is that the pairing of a target food, with a food with high-energy density (e.g., enriched in fat), should trigger positive attitude toward the target food. Both FFL and FNL have been shown to positively enhance new fruit or vegetable acceptance in children (Appleton et al. 2016; Caton et al. 2013; Nicklaus and Monnery-Patris 2018). For instance, Caton et al. (2013) found that infants accepted more plain artichoke puree at posttest, compared to baseline, when they had been offered ten times artichoke puree enriched in fat (FNL strategy). The third type of strategies used is mere exposure (also named repeated exposure). According to the mere exposure theory (ME), the exposure to one instance of a given food stimulus is sufficient to trigger a more positive attitude toward a subsequent instance of that particular stimulus, because it increases its familiarity (Zajonc 1968). There is considerable support for the success of such ME on food acceptance in controlled experimental settings, as well as in more ecological settings like home or school environments (see Cooke 2007 for a review). For instance, some researchers asked caregivers to expose their 5- to 7-year-old children to bell peppers (an a priori new vegetable) for eight consecutive days and found that, compared to a control group, children in the exposure group ate significantly more bell peppers at posttest than at baseline (Cooke 2007).

Despite the apparent efficiency of these three strategies (FFL, FNL, ME), it has been argued that conditions within studies are often confounded and that, in many studies that purported to measure conditioning effects (FFL and FNL interventions), exposure was actually not controlled for (Appleton et al. 2016). In fact, studies comparing directly these three strategies often found no advantage of conditioning (FFL and FNL) over mere exposure (ME) (Caton et al. 2013; Nicklaus and Monnery-Patris 2018). For instance, Caton et al. (2013) found that infants who had been exposed to plain artichoke puree (ME condition) accepted plain artichoke puree as easily at posttest, as children who had been exposed to sweetened puree (FFL condition) or puree enriched in fat (FNL condition). As mere exposure interventions are easier to implement and seem to be as effective as FFL/FNL interventions, ME appears to be the simplest choice to enhance positive attitude toward fruits and vegetables and to decrease food neophobia (Appleton et al. 2016). It is nevertheless important to note that many exposure studies have failed to adopt an appropriate control group against which to compare the intervention group's changes in food attitudes (Appleton et al. 2016; Dazeley et al. 2012). For future investigations of ME, it is important that control groups are closely matched to experimental groups in terms of demographics but also in terms of the food tested at baseline and posttest (equivalence in familiarity, liking, energy density, food category, etc.).

Taste Exposure

In the food domain, an exposure can occur in different modalities (taste, sight, smell, etc.). The majority of studies on ME have only investigated whether taste exposure will be efficient to decrease food neophobia (see Cooke (2007) and Dazeley et al. (2012) for reviews). This central interest in taste exposure may be due to the seminal study of Birch et al. (1987). The authors directly compared the effect of visual and taste exposure on preschoolers liking for new fruits. They found that visual exposure led to an increase in liking for the appearance of the new fruits, while taste exposure led to an increase in liking for both the appearance and taste of the new fruits (Birch et al. 1987). Subsequent research on ME focused on taste exposure as it was thought to be necessary to enhance consumption of new foods like fruits and vegetables. Nevertheless, it could be argued that visual exposure would not likely directly influence taste preferences but can influence instead willingness to taste exposed foods (Dazeley et al. 2012).

While the benefits of repeated taste exposure are evident (Cooke 2007), these strategies may be difficult to implement outside the laboratory since 10–15 taste exposures to a new food item may be needed for its successful acceptance in preschool-aged children (Cooke 2007). This is a number greater than most parents are willing or able to provide (Dazeley et al. 2012). This number may even increase for highly neophobic children (de Wild et al. 2017) that yet need the most this kind of intervention.

Visual Exposure

Because neophobic reactions result in foods being rejected on mere sight, before being tasted (Cashdan 1998; Dovey et al. 2008; Lafraire et al. 2016), it is reasonable to suppose that *visual* exposure could be as efficient to reduce food rejections than *taste* exposure. Indeed, according to some authors, a child will taste a food (e.g., a tomato) only if it visually matches him/her prototypical food representations in mind (e.g., the red and round tomato) (Dovey et al. 2008; Lafraire et al. 2016). Additionally, while after weaning infants are normally familiarized with the taste of several vegetables (through pureed baby foods), they often are not familiarized with the visual aspect of the whole vegetables. Furthermore, interventions seeking to enhance positive attitudes toward fruits and vegetables through taste exposure also increase the visual familiarity of the target. In studies that offer children repeated taste exposures, the food is both seen and tasted at each session, and it is difficult to isolate the effect of taste exposure alone (Dazeley et al. 2012). It is therefore plausible that the effectiveness of taste exposure interventions is partly due to a greater visual familiarity with the target food (Dazeley et al. 2012). Finally, from a practical point of view, it could also be less effort for caregivers to provide visual exposures to food (e.g., through picture books), especially if it occurs outside mealtimes that carry the stress associated with ensuring that the child is consuming a healthy diet (Dazeley et al. 2012).

There is actually an encouraging body of evidence to support research into the impact of visual exposure on children food neophobia (see Dazeley et al. 2012 for a review). For example, some authors provided 2- to 6-year-old children with picture books about leeks or carrots. They showed that toddlers consumed more of the vegetable they had seen in their picture book (carrot or leek), compared to a matched control vegetable. Importantly, some authors found similar changes in new vegetable acceptance for highly neophobic children and non-neophobic children (Rioux et al. 2018). This suggests that visual exposure might be employed successfully with children for whom taste exposure has been showed to be less efficient (de Wild et al. 2017). Furthermore, Osborne and Forestell (2012), one of the few authors which directly compared visual and taste exposure since Birch et al. (1987), found that visual exposure was as efficient as taste exposure to enhance willingness to taste new fruits in 4- to 8-year-old children. Interventions that use a more direct contact with unfamiliar food and enable children to play with it (so as children are not just passively exposed to pictures) also show promising results (Coulthard and Ahmed 2017; *Sapere Method*, Nicklaus and Monnery-Patris 2018). For instance, Coulthard and Ahmed (2017) found that children who played a game of bingo with real fruits and vegetables consume more of a new fruit than children who played the same game with picture stimuli. Additionally, they found that children who played the bingo game with pictures ate more of a new fruit after the session than children who simply viewed and sorted the same pictures (Coulthard and Ahmed 2017). The potential for visual exposure to enhance children's willingness to taste new foods therefore deserves further exploration, especially to investigate whether it produces long-term effects. Indeed, there is a dearth of research evidence supporting long-term changes in children's diets after taking part in exposure interventions (Appleton et al. 2016; Knai et al. 2006).

The Mechanisms Behind Mere Exposure

While a large body of research has investigated the potential effect of mere exposure, there is no consensus on its mechanistic explanation. It is yet important to understand the mechanisms behind such a strategy if we want to create the most possible effective interventions to decrease neophobia. One of the mechanisms by which exposure is assumed to engender a positive attitude toward a stimulus is thought to be "learned safety" (Cooke 2007): repeated ingestion of an unfamiliar food without negative post-ingestion consequences (e.g., nausea, illness) will lead to increased acceptance of this food (Cooke 2007). Nevertheless, the recent evidence that mere visual exposure could also enhance the acceptance of unfamiliar food items casts doubt on whether the "learned safety" hypothesis entirely explains the positive effect of exposure. There is an alternative explanation, which embodies a cognitive approach to the mere exposure effect (Aldridge et al. 2009; Lafraire et al. 2016). By increasing the amount of experience an individual has with any stimulus, repeated exposure increases the ease and speed with which the stimulus is categorized (Aldridge et al. 2009): when a food item is first presented to a child, it is organized into categories relating to its characteristics (Murphy 2002). Knowledge gained through this first encounter allows for easier and faster categorization, when subsequently presented with the same or a similar food item (Aldridge et al. 2009). This gained ease in categorization is then hypothesized to lead to a positive attitude toward the stimulus. A recent study partly supports this hypothesis. Using a sorting task involving pictures of fruits and vegetables to assess categorization performances, Rioux et al. (2018) showed that categorization performance was associated with food neophobia disposition. Moreover, in the same study, the authors found that a visual exposure intervention (table mats with pictures of new vegetables were displayed on school canteen tables for several days) was more efficient for those children with good categorization performance (Rioux et al. 2018). Efficiency of the intervention was measured via Willingness to Try New Vegetable tasks proposed at baseline and after the intervention (see section "Willingness to Try New Food Tasks"). Therefore, it seems that an ease in categorization indeed leads to more positive attitude toward exposed stimuli. Nevertheless, it remains to be seen if visual exposure intervention actually increases food categorization performances. There are few hints to think it could be the case. For instance, it has been recently shown that a short exposure to few animals through a class trip to a zoo enhances animal category-based induction performances (Badger and Shapiro 2019).

Summary and Further Directions

Children moving into the second year of life have to make quite complex decisions about the foods they will eat and accept. Food neophobia, reviewed in the present chapter, is one of the strategies infants and children employ to deal with this complex problem of food selection. There has been considerable research on the topic, but some questions remain. First, there is a lack of cross-cultural studies to investigate the influence of culture on children's food neophobia. Most studies on the topic have been conducted in Western and rich countries (Nicklaus and Monnery-Patris 2018). It will be valuable to investigate whether food neophobia is universally observed and especially investigate children's neophobia in rural communities practicing more traditional subsistence. This investigation will first require to have tools to measure neophobia validated in several cultures (not merely translated), which is rarely done. Second, longitudinal studies on food neophobia are scarce and are much needed if we want to have a clear picture of its developmental pattern. The evidence provided by the rare longitudinal studies reveals that precursors of food neophobia are already present in infancy and contrasts with the common picture that neophobia arises as toddler become mobile (Dovey et al. 2008). Third, further studies could systematically evaluate the effectiveness of interventions aimed at decreasing food neophobia, investigate the mechanisms behind positive effects, and test for long-term effects (Appleton et al. 2016). Systematic comparison between interventions can prove difficult because a wide variety of outcome measures are used to assess efficacy (e.g., trait neophobia, willingness to try exposed foods, food consumption in grams) but is of interest to identify those of greatest benefit.

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Eating in the Elderly

22

Claire Sulmont-Rossé

Contents

Abstract

Although having a good diet is recognized to be important for successful aging, malnutrition is one of the highest threats to the health, autonomy, and well-being of older adults. Several medical associations and public policies have proposed dietary guidelines directed at elderly people to ensure a healthy nutritional status and prevent the onset of disease. However, several studies have demonstrated the inadequacy of food intake in the elderly population. A decline in energy and protein intake is frequently observed with aging, in particular for the very old and/ or dependent people. The aging process, even when it takes place normally, is associated with several changes likely to have an impact on food intake and the nutritional status of the elderly people such as impairment in appetite regulation, oral health, and chemosensory perception. Beyond these changes, the life of an

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elderly individual is marked by “breaking points” which may have a social origin (e.g., retirement, widowhood, fall in income) or a medical origin (e.g., onset of a disease, dementia). These breaking points are likely to disrupt their lifestyle habits and in particular their eating habits, leading to new eating habits, which are sometimes inappropriate and at the origin of unbalanced diet. In the context of an aging population, it is therefore crucial to combine meal interventions and food development with nutritional strategies to stimulate appetite and sustain food intake in the older individuals, in order to support active and healthy aging.

Introduction

Aging is a universal, natural, and physiological mechanism which is imposed upon somebody without choice. During this period, a healthy human being is affected by impairments which can weaken him. Functional deficiencies and cognitive capacities progressively decrease during aging, inducing a vulnerable status which increases the risk of disease and dependence. But at what age does one become an “elderly” people? For the professionals in marketing, the consumer becomes a senior at the age of 50 years old, while for the public authorities, the person is considered a senior between 60 and 65 years old (the access age to certain social financial supports) (Ogereau 2019). In the labor market, the average age of retirement is 64 for the men and 61 for the women (OECD 2017). Finally, for health professionals, the old age begins over 70 with the onset of chronic diseases (Jaul and Barron 2017).

All over the world, the proportion of elderly people in the population is growing quickly. According to data form World Population Prospects, the number of persons aged 65 or over is expected to more than double by 2050, rising from 612 million in 2015 to 1.5 billion in 2050 (United Nation 2017). In 2018, there are an estimated 681 million people aged 65 or over in the world, comprising 9% of the global population. Currently, Europe has the greatest percentage of population aged 65 or over (18%), but rapid aging will occur in other parts of the world as well, so that by 2050, all regions of the world except Africa will have nearly a fifth or more of their population at age 65 and above (28% in Europe; 23% in Northern America; 19% in Latin America; 18% in Asia and Oceania; 6% in Africa). Increase in life expectancy also leads to an increase of the “very old,” namely, people aged 80 or over. The number of 80 and over is expected to increase from 126 million in 2015 to 202 million in 2030 and 425 million in 2050. These “very old” people are also the ones who present the poorest health and accumulate the severest disabilities.

In the context of an aging population, one of the major societal concerns of countries is to allow everyone to “age successfully.” Allowing people to “age successfully” means enabling people to carry through their projects at every phase of their lives by coming to terms with physical and social changes. It means allowing people to maintain their self-esteem and to adapt to their environment (including food-related) with regard to their preserved abilities. Successful aging also means allowing the elderly person to benefit from relevant support when difficulties arise with accomplishing certain activities (including food purchasing, meal cooking, and feeding one's self). Although having a "good diet" is recognized to be important for successful aging, malnutrition is one of the highest threats to the health, autonomy, and well-being of older adults (di Francesco et al. 2007; Leslie 2011). Malnutrition corresponds to a deficiency in nutritional intake, in terms of calories and/or nutrients, and is associated with numerous adverse outcomes: it increases the incidence of falls, fractures, disease, and hospitalization, it causes or worsens a state of frailty and disability, and it affects the quality of life of elderly people (Corti et al. 1994; Wallace et al. 1995; Rasheed and Woods 2013). Poor nutrition is not simply a result of disease states but often precedes and predisposes elderly people to disease (Ferry et al. 2007).

Several medical guidelines and public policies specify the nutritional needs of elderly people and make nutritional recommendations to allow elderly people to achieve a healthy nutritional status (World Health Organization (WHO) and Tufts University School of Nutrition and Policy 2002). There are also nutritional recommendations aimed at preventing specific diseases (Bauer et al. 2013; Rizzoli et al. 2014; Mohajeri et al. 2015). However, several studies have demonstrated the inadequacy of nutrient intake in the elderly population (Roman-Vinas et al. 2011; Mensink et al. 2013). Consequently, the present chapter will first describe the impact of aging on food intake, both from a qualitative (i.e., dietary pattern) and quantitative (i.e., nutrient intake). In a second section, the determinants of eating behavior in the elderly people will be reviewed. Finally, some possible levers to improve elderly people's compliance with dietary recommendations will be discussed.

Impact of Aging on Eating Behavior

Qualitative Aspects: Aging and Dietary Pattern

Most of the food dietary guidelines directed to elderly people are close to those intended for an adult population: emphasizing the consumption of fruits, vegetables, and whole grains while reducing the consumption of sodium, saturated fat, and added sugar. However, the guidelines published by the World Health Organization also included recommendations to answer specific changes observed in the older people (World Health Organization (WHO) and Tufts University School of Nutrition and Policy 2002). Two recommendations may be linked to a decline in food intake and diet variety in old age: "Select nutrient-dense foods such as fish, lean meat, liver, eggs, soy products" and "Eat several (5–6) small non-fatty meals. This pattern appears to be associated with greater food variety and lower body fat and blood glucose and lipid levels, especially if larger meals are eaten early in the day." One recommendation echoes the decline in thirst regulation with aging, "Avoid dehydration by regularly consuming, especially in warm climates, fluids and foods with a high water content," and one recommendation is related to the suggestion that diet high in long-chain polyunsaturated fatty acids may protect people from cognitive decline and dementia (Sydenham et al. 2012): "Where refined fats are necessary for cooking, select from a variety of liquid oils, including those high in ω-3 and ω-9 fats." Interestingly, some recommendations included in the WHO's dietary guidelines are related to meal commensality: "Transfer as much as possible of one's food culture, health knowledge and related skills to one's children, grandchildren and the wider community"; "Enjoy food and eating in the company of others."

Comparison of young* versus *old people. Three large cross-sectional studies have observed a tendency for higher consumption for healthy foods and lower consumption for unhealthy foods in the older respondents compared to the young ones. In the USA, the National Health and Nutrition Examination Survey (NHANES III) showed that older adults tended to consume more vegetables and fruits but less sweet and fat foods than younger adults (1988–1991, $n = 8696$, 16 to +80 years old, 24-h recall; Drewnowski and Shultz 2001). In the French INCA 3 study, a higher consumption rate of fruit, vegetables, meat, and fish was observed for people aged 65–79 compared to people aged 18–44. Conversely, a higher consumption rate of sweet foods was observed for the former compared to the latter (2014–2015, $n = 2121$, 18–79 years old, 24-h recall; ANSES 2017). Finally, in the French Nutrinet-Santé cohort study, it was observed that consumption frequency for cooked vegetables, raw fruits, and fish increased with age, while it decreased for meat and sweet desserts (2016, $n = 32{,}696$; 20–79 years old, food frequency questionnaire; Sulmont-Rossé et al. 2017). In a longitudinal study, Plessz et al. (2015) explore the evolution of vegetable consumption over 20 years among a sample of 15,681 French participants aged 40–49 years at the beginning of the follow-up. The authors observed that the probability of consuming vegetable everyday increased with aging, both for women and men.

Aging* versus *cohort effect. However, one should be cautious before concluding that aging is accompanied by an increase in healthy eating. Indeed, the studies mentioned above are all but one cross-sectional and thus do not allow for deciphering between a true aging effect or a cohort effect. In France, the BDF survey ("Enquête des ménages") was conducted every 5 years from 1979 to 2000 in a representative sample of the French population by the French National Institute of Statistics and Economic Studies (INSEE). Data were analyzed by the CREDOC (Centre de Recherche pour l'Etude et l'Observation des Conditions de Vie). In data analysis, people were stratified by age cohort (e.g., people born from 1956 to 1947). The compilation of data collected from 1979 to 2000 shows that overall, the old cohorts (people born from 1936 to 1917) purchase on average more fresh fruits and vegetables than the young cohorts (people born from 1976 to 1957). However, results show an increase of fruit and vegetable purchase in the young cohorts from 1979 to 2000 but a decrease in the old cohorts (Fig. 1). In other words, young people increased their fruit and vegetable purchase from 1979 to 2000, while old people decreased it, but overall, young people tended to purchase less vegetables and fruits than old people (in 2000, the purchase rate of the cohort [1976–1967] was still lower than the one of the cohort [1916–1907]) (Recours et al. 2005; Hébel and Recours 2007).

Dietary patterns in the elderly population. Some studies have explored the evolution of food choice in an elderly sample and have reported a trend toward fewer healthy food choices in the "older elderly" subjects compared to the "young

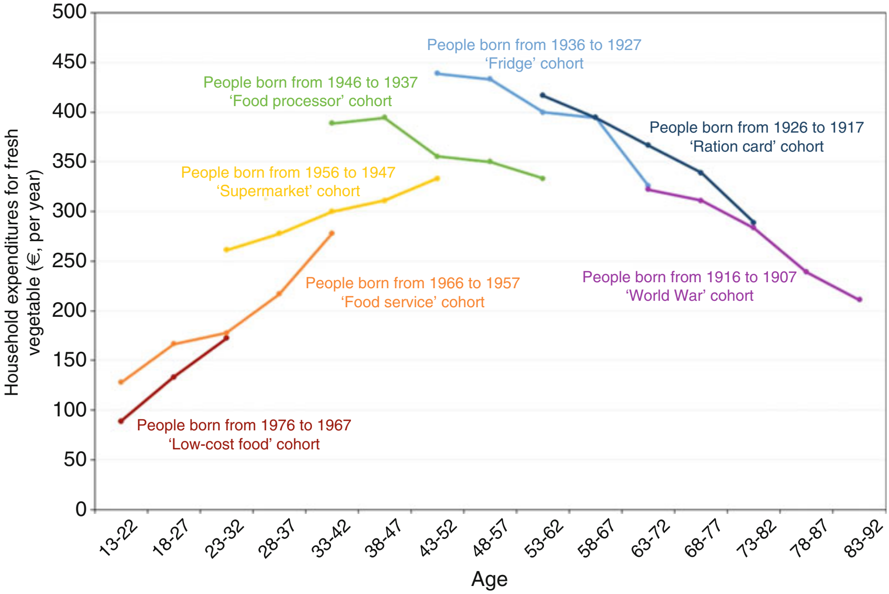

Fig. 1 Impact of age and cohort on the household expenditures for fresh vegetables in France. (From Recours et al. 2005; data source: survey BDF 1979, 1984, 1989, 1995, 2000, INSEE)

elderly" subjects. For instance, in a sub-population of elderly subjects, older subjects ate meat, fish, cereals, raw vegetables, and pulses less regularly ($n = 9250$ community-dwelling aged 65 years and over in France; Larrieu et al. (2004)). Barnia et al. (2005) and Power et al. (2014) reported that older elderly subjects consumed more sweet and fat foods than younger elderly subjects (64–74 years) ($n = 99{,}744$ French adults aged 60 years and over for Barnia et al.; $n = 208$ community-dwelling Irish adults aged over 64 for Power et al). However, Appleton et al. (2009) observed that a higher consumption of vegetables was associated with higher age in adults aged 65 or over. These discrepancies between the studies may be linked to the fact that food choices are characterized by a large inter-individual variability within the elderly population. Several studies have highlighted various dietary patterns in the older age, including "healthy" pattern (fruit, vegetable, fish), "western" pattern (meat, pastry), "traditional" pattern (bread, potatoes, milk, vegetable, butter, stock), or "snacking" pattern (frequent snacks, crackers, biscuits) (Schroll et al. 1996; Corrêa-Leite et al. 2003; Samieri et al. 2008; Bedard et al. 2015; Andreeva et al. 2016; Gazan et al. 2016; Thortpe et al. 2016).

It should be noted that all the studies mentioned in these sections were conducted in Western countries (USA, Europe, Australia). There is a crucial need to explored change with ageing in other parts of the world that will also be affected by aging population (Asia, Latin America). Furthermore, these studies mainly recruited "community-dwelling" elderly, namely, elderly people living at home, and some have included health variables in their survey (e.g., Samieri et al. 2008; Andreeva et al. 2016). However, the living status (at home versus in institution) and the health status are not always specified in these publications (e.g., Bedard et al. 2015; Thorpe et al. 2016). Consequently, there is a need for a better characterization of elderly samples in future studies (age mean, age range, living status, health status, dependency grade, frailty, etc.) in order to better decipher between changes in healthy aging versus changes occurring with the onset of frailty, disease, or dependence.

Quantitative Aspects: Aging and Nutritional Intake

Contrary to common beliefs, nutritional needs decrease little with age and are sometimes even higher than the needs of younger subjects. With regard to caloric intake, a joint report from the Food and Agriculture Organization and the World Health Organization recommend a daily allowance of 2450 kcal/day for men and 2000 kcal/day for women (FAO and WHO 2001). The European Food Safety Authority (EFSA 2013) recommends a daily allowance of 2000–2600 kcal for people aged 30–39, from 2000 to 2500 kcal for people aged 50–59, and from 1800 to 2300 kcal for people aged 70–79. With regard to protein intake, recent works carried out by the consortium PROT-AGE (Bauer et al. 2013) and by EPSEN (Deutz et al. 2014) show that older people need to ingest more protein than younger people to stay healthy, to maintain their abilities and to fight infections. Among others, it was demonstrated that a higher amino-acid bolus is required to stimulate muscle protein synthesis in the elderly compared to younger individuals (Cuthbertson et al. 2005; Walrand et al. 2011). As a result, the daily protein intake should be 1–1.2 g protein per kg of body weight per day for a healthy person over 60 versus 0.8–1 g per kg of body weight in younger subjects.

Comparison of young* versus *old people. Despite these recommendations, several studies have reported lower energy, macro- and micro-nutrient intake in the elderly compared to younger population. In the USA, the NHANES III survey showed that energy intake for men ranged from a high of 3100 kcal/day at age 20–29 year to 1900 kcal/day at age 70–79 years. For women, the corresponding range was 1900–1400 kcal/day (Briefel et al. 1995). A French survey (Etude Nationale Nutrition Santé – IVS 2006) revealed that energy intake declined from 2400 at age 18–29 years to 2000 kcal/day at 55–74 years for men and from 1700 to 1500 kcal/day for women. In the French INCA 3 study, the energy intake was equal to 2196 kcal/day for people aged 18–44, 2108 kcal/day for people aged 45–64, and 1913 kcal/day for people aged 65–79 (ANSES 2017). Similarly, lower protein intake in the elderly was observed compared to young adults (Campbell et al. 1994; Rousset et al. 2003). Lower food intake is also associated with decline in the intake of most micronutrients. Age is associated with declining consumption of calcium, iron, zinc, B vitamins, and E vitamins with some variations between men and women (Drewnowski and Shultz 2001). According to the IVS survey, 68% of men and 88% of women aged 55–74 years did not meet the recommended dietary allowances for calcium (IVS 2006).

The small old eater. In addition to the dietary patterns described previously, several authors observed a "small eater" pattern in their elderly samples (Schroll et al. 1996; Corrêa-Leite et al. 2003; Samieri et al. 2008; Gazan et al. 2016; Thortpe et al. 2016). These patterns were characterized by a low consumption for most food items and were associated with a caloric intake below the recommendations (~ 1380 kcal/day for women and ~ 1800 kcal/day form men). Across these studies, the prevalence of small eaters in the elderly population is far from being negligible, ranging from 23% (Gazan et al. 2016) to 55% (Thortpe et al. 2016). A meta-analysis conducted by Ter Borg et al. (2015) on 46 studies revealed that 10–12% of community-dwelling older adults do not meet the daily allowance for protein. The situation worsens in old age and dependent seniors. In the longitudinal Survey in Europe on Nutrition and the Elderly: a Concerted Action (SENECA), 247 Danish and Dutch people aged 70–75 were first surveyed in 1988/1989 and re-examined 4–5 years later, in 1993. Results showed a significant decline in energy intake for both genders over the 4 years of follow-up (Schroll 1997). Lesser et al. (2008) reported that energy intake was considerably lower than recommended in very old seniors in the Eastern/Baltic European country. Recently, Sulmont-Rossé and Van Wymelbeke (2019) weighed all foods and beverages consumed by 88 French elderly people living in geriatric long-term care facilities for 24 h. The results showed that the average caloric intake was 1693 kcal/day for men and 1364 kcal/day for women, below recommended daily allowance. With regard to proteins, the average intake was 63 g/day for an average weight of 74 kg in men and 55 g/day for an average weight of 61 kg in women. Based on these results, only 13% and 20% of the participants met their caloric requirements and protein, respectively. Furthermore, 60% and 40% of participants consumed respectively less than 2/3 of their caloric and protein needs.

To sum-up this first section, seniors tend to make healthier food choice than cohorts of younger adults. However, a decline in energy and protein intake was observed with aging which may weaken the nutritional status of the elderly and predispose them to associated pathologies (sarcopenia, malnutrition). This drop in food intake worsens with the increase in age and the onset of dependence, which requires us to pay particular attention to the food diet of very old, frail, or institutionalized elderly people.

Determinants of Eating Behavior in the Elderly

In the elderly population as in younger populations, eating is a complex behavior driven by many determinants and their interaction (Köster 2009; Brug et al. 2017). In the present chapter, a choice was made to focus on determinants specific to old age. However, this list should not be considered as exhaustive, and for several determinants, the scientific literature is scarce and inconclusive. In fact, eating behavior in the elderly has received much less attention than eating behavior in children for instance (in Google©, the research "children eating behavior∗r" raised 256 million results compared to 44 million for elderly; June 2019). It is expected that this chapter will evolved in the future with growing interest in the elderly because of an aging population.

Determinants Related to Aging Process

The aging process, even when it takes place normally, is associated with many changes likely to have an impact on food intake and the nutritional status of the elderly (Morley 2001).

Hunger and satiety. From a physiological point of view, aging is accompanied by gastro-intestinal changes such as a slowdown in gastric emptying, an increase in baseline levels of anorexigenic hormones which induce satiety, and a decrease in levels of orexigenic hormones with stimulate appetite (Clarkston et al. 1997; Hays and Roberts 2006). These modifications may contribute to dysregulation of hunger and thirst in the elderly (Rolls 1993; Hetherington 1998). Roberts et al. (1994) reported that following 21 days of food deprivation, younger subjects increased their food intake to compensate for underfeeding whereas the older subjects did not. Conversely, younger subjects decreased their food intake following overfeeding, whereas the older subjects did not. Similarly, Phillips et al. (1984) reported that after a 24-h water deprivation, elderly subjects failed to rehydrate, whereas young subjects did so successfully. A meta-analysis conducted by Giezenaar et al. (2016) on 59 studies showed that after overnight fasting, hunger and energy intake were, respectively, 25% and 16–20% lower in older compared with younger adults. Looking at short-term regulation, it was demonstrated that after ingesting a fixed amount of a food or a drink, elderly subjects were less accurate to adjust their subsequent intake according to the energy content of the preload compared to younger subjects (Longbottom and Hetherington 1995; Rolls et al. 1995). Finally, Rolls and McDermott (1991) showed that elderly subjects did not show sensory-specific satiety, while such an effect was observed in younger age groups: elderly subjects did not show a decrease in desire to eat for the food that they have just eaten compared with uneaten foods.

Oral health. Many studies have shown that aging can be accompanied by significant changes in the oral health and one of the most obvious changes is tooth loss. According to a German National Survey (Micheelis and Schiffner 2006), the most frequently lost teeth are the molars followed by the maxillary premolar and front teeth. In this survey, young adults had 25 $\pm$ 4 remaining teeth while the elderly had 14 $\pm$ 10 remaining teeth. Despite the fact that the prevalence of edentulism has been dropping for the past decades, it remains higher in older adults than in young adults (Wu et al. 2012). Aging is also associated with a decrease in muscle mass (Melton et al. 2000) and in occlusal strength (Bakke et al. 1990). However, while older people adapt relatively well to decline in muscle strength by increasing chewing time, masticatory efficiency significantly decreases with tooth loss (Kohyama et al. 2003; Ikebe et al. 2011). According to Steele et al. (1997), the conservation of at least 21 natural teeth well distributed in the mouth is necessary to maintain a proper masticatory function. The systematic literature review of

Kiesswetter et al. (2018) highlighted a significant impact of dental status on eating behavior in the elderly, with lower intake of hard-to-chew foods (e.g., raw fruit and vegetable, meat, nuts) in elderly people (65+ years) suffering from dental impairments compared to those with a good dental status. In parallel, aging is often accompanied by a decrease in salivary flow: Vandenberghe-Descamps et al. (2016) observed a 38% reduction of salivary flow in individuals aged 70 and over compared to individuals aged 20–55 years. In some studies, hyposalivation was associated with a lack of appetite in hospitalized and independently living elderly people and a reduction in the consumption of vegetable, fish, and shellfish. However, the impact of hyposalivation on eating behavior remains too little explored in the scientific literature to draw definitive conclusions (see Muñoz-González et al. 2018 for a review).

Chemosensory perception. It is also well-known that aging is accompanied by a deterioration in the acuity of taste and smell perception. For olfaction, the literature showed an increase of odor detection thresholds in older people, a decrease in perceived odor intensity of supra-threshold concentration and a decrease in the ability to distinguish between odors (see Sulmont-Rossé et al. 2015 for a review). For gustation, the literature review of Methven et al. (2012) showed that older adults display higher detection thresholds in more than 70% of the studies. Perceived taste intensity at supra-threshold levels was found to be significantly lower for older adults in 64% of studies (see also Mojet et al. 2001, 2003). Some authors have observed that a decrease in chemosensory capacity was associated with a lower appetite (de Jong et al. 1999), a lower interest in food-related activities (e.g., enjoying cooking; Duffy et al. 1995), or a lower diet variety (Kremer et al. 2014). However, the role of chemosensory function on food intake in the elderly remains unclear and poorly documented compared to masticatory function (Kiesswetter et al. 2018).

Determinants Related to Aging Trajectory

Beyond changes related to the aging process, the life of elderly people is marked by “breaking points” likely to disrupt their lifestyle habits and in particular their eating habits (Falk et al. 1996; Cardon 2010). These breaking points may have a social origin (e.g., retirement, widowhood, fall in income) or a medical origin (e.g., onset of a disease, dementia). These changes are progressively crystallized in the form of new eating habits, which are sometimes inappropriate and at the origin of unbalanced diet (Ferry et al. 2005; Huffman 2002; Caradec 2008).

Social ruptures. Retirement is a major transition in the life course, and several studies showed that households substantially reduce food expenditures upon retirement (see Allais et al. 2018 for a review). Looking at the impact of retirement on eating behavior, a Finnish cross-sectional study showed an increase of healthy food habits in women from 55–60 to 60–67 years, and this increase was higher in retired employees compared to their continuously employed counterparts (Helldán et al. 2011). However, Allais et al. (2018) found a drop in quantities purchased for several food items, with positive health effects attributable to decrease in the consumption of sugary- and salty-fat foods, but also potentially negative health consequences due to lower intake of meat and fish (see also Baer et al. 2018). Widowhood is a painful but also common life event in the old age. It was shown that widowhood modifies the eating habits of the remaining person with the disappearance of homemade dishes and an increase of ready-to-eat or frozen dishes (Donkin et al. 1998; Shahar et al. 2001; Cardon 2010) as well as a decrease in diet variety (Quandt et al. 2000; Vinther et al. 2016) and in energy intake (Heuberger and Wong 2014). Rosenbloom and Whittington (1993) interviewed 50 recently widowed (within 2 years) people 60 and over and 50 married subjects of similar age. Their results indicated a decline in meal enjoyment and appetite as well as lower diet quality in the widowed subjects than in the married subjects. Vesnaver et al. (2016) attributed these changes in meal preparation and food choice to the loss of meal commensality. In fact, eating alone has been associated with lower caloric intake (Locher et al. 2005) and lower food variety (Kimura et al. 2012). Inadequate money and physical disabilities affecting food shopping or cooking are other social factors identified as affecting food choices and nutritional intake in the elderly (van der Pols-Vijlbrief et al. 2017).

Disease and drugs. Several diseases may have a negative impact on appetite and food intake and lead to an unintentional weight loss in elderly patients (e.g., cancer, depression, gastrointestinal disease, cancers, cardiovascular disease, nutritional disorders, respiratory disease, chronic infection; Berry and Marcus 2000). Furthermore, numerous drugs are known to cause appetite loss (iatrogenic anorexia; Morley 1997), to alter taste and smell perception (Schiffman 1991; Doty and Bromley 2004), or to elicit oral (mycosis, xerostomia; Ghezzi and Ship 2000) and digestive (nausea, vomiting, constipation; Carr-Lopez and Phillips 1996) troubles. These side effects take an additional toll on the physiological aging of sensory, food oral processing, and digestive functions and consequently worsen the negative impact of aging on appetite and eating behavior.

Dysphagia. Once ready to be swallowed, a food bolus is pulled toward the pharynx by the tongue movements (oral phase) and propels into the pharynx (pharyngeal phase). During the pharyngeal phase, the soft palate rises and the epiglottis lowers to block the airways. Finally, the bolus is driven by peristalsis in the esophagus to the stomach (esophageal phase). Alterations in chewing and salivation may result in large food particles and a poorly cohesive food bolus which can lead to swallowing disorders. However, aging can be accompanied by a delay in triggering the pharyngeal swallowing reflex, a decrease in peristaltic forces and a failure to close the airways or to open the upper sphincter, in particular in people with neurological pathologies or stroke (Britton 2016). Swallowing disorders can range from simple discomfort to an increasing risk of aspiration (misdirection of food bolus into the respiratory tract), which may cause aspiration pneumonia or even death by suffocation (Ebihara et al. 2016). Prevalence of dysphagia is estimated at between 8% and 15% in elderly people living at home and 30–40% in patients living in institutions (Puisieux et al. 2009). It has been reported to affect 8–80% of stroke patients and 11–81% of Parkinson patients (Takizawa et al. 2016). In order to prevent the risk of aspiration, dysphagic patients are often served with “texture-modified foods" in the form of chopped, blended, or pureed foods. Obviously, the setting-up of this specific diet has serious consequences on eating behavior. Beyond the decline in diet variety (e.g., more cooked foods and less raw fruits and vegetables), it leads to a decrease in appetite and food intake as texture-modified foods are often unattractive and unpalatable (Rofes et al. 2011). In fact, several studies have shown that dysphagia is associated with a significant increase in the risk of malnutrition (Serra-Prat et al. 2012).

Dementia. Food refusal is a common trouble in elderly people suffering from neurodegenerative troubles (see Berry and Marcus 2000 for a review). Alzheimer's disease is often associated with feeding difficulties and changes in eating behavior which may cause a decrease in food intake (Cullen et al. 1997; Wasson et al. 2001; Correia et al. 2010). Ikeda et al. (2002) observed that 58% of Alzheimer patients showed at least one symptom among the following: swallowing difficulty (e.g., coughs or chokes when swallowing, takes a long time to swallow food or liquids), change in appetite (e.g., loss or increase of appetite), change in food preference (e.g., prefers sweet foods more than before), disorders of oral behavior (e.g., tends to overfill mouth, eats non-edible foodstuffs), feeding difficulties (e.g., eats with hands, takes a long time to eat). Distraction from eating, frequent table-leaving events, and refusal to eat because of inability to recognize an object as food were other eating disorders frequently reported in Alzheimer patients living in long-term care facilities (Norberg and Athlin 1989).

Dependence. The onset of functional or cognitive disabilities may lead elderly people to require help for achieving daily tasks, including tasks related to eating (food purchase, meal cooking, and even support during mealtime). Cardon and Gojard (2009) proposed the term "culinary dependence" to describe situations in which "elderly people are unable to obtain and/or prepare food for their meals and are forced to delegate these tasks to others." There are several degrees of culinary dependence, ranging from the help provided by a family or professional helper to meals-on-wheels services and, finally, long-term care facilities. Whether voluntary or not, admission to a nursing home is a major turning event in the life of an elderly person, as it modifies his/her habits and physical and social environment. The elderly person must adapt to rules set by the establishment, notably with regard to food. In fact, multiple aspects of life in a nursing home are governed more by necessity than by personal choice (Mallon, 2004). Table placing, dinner guests, menus, and mealtimes depend less on the free choices of residents and more on organizational constraints of the nursing home. Furthermore, eating in nursing home implies a redefinition of the meal, from the point of view of the nursing staff who are subjected to specific constraints connected to hygiene and nutritional frame but also from the point of view of the residents who are subjected to the changes of practices and to the redefinition of commensality. Corbeau (2001) wrote that the symbolic dimension of a meal, a strong element in feeding behavior, is highly damaged in institution settings: "The opacity of the food sector at hospital makes hardly easy the incorporation of signs and reassuring symbols which may allow finding his cultural matrix and habits." This may disengage an elderly individual from his/her diet, which in turn may have a negative impact on appetite and food intake. Gustafsson et al. (2003)

reported that older women suffering from stroke, rheumatoid, arthritis, or Parkinson's disease "valued their independence and feared dependence when declining ability threatened performance of food-related work."

Levers to Stimulate Appetite and Sustain Food Intake in the Elderly

As discussed in the previous sections, aging is often accompanied by a decline in appetite and food intake which may predispose the elderly to nutritional risk. Beyond nutritional interventions which consist in providing the elderly with nutritional education, nutritional supplementation, or even parenteral and enteral nutrition in acute cases, some studies have tested various strategies to stimulate appetite and increase food intake in the elderly, in particular in the institutionalized elderly. These strategies can be divided among two main axes: improving meal context and improving pleasure elicited by food.

Improving Meal Context

Several authors have stressed the importance of meal context on the appetite and food intake of older adults, in particular in long-term care settings (Nijs et al. 2009; Nieuwenhuizen et al. 2010; Philpin 2011). However, as pointed out by the systematic literature review of Abbott et al. (2013), studies remain too few to provide definitive conclusions on the effectiveness of meal context to improve eating behavior in the elderly.

Looking at ***the social context of a meal***, one of the very rare studies conducted at home assessed the impact of an intervention combining dietary advice and meal commensality in community-dwelling older adults living alone (<70 years old) (McHugh et al. 2016). The intervention consisted in providing the participants with a guidebook on nutrition and culinary skills, and participants received a weekly visit from a trained volunteer who prepared and shared a meal with them. Results showed a significant improvement for food enjoyment in the intervention group compared to a control group, but no effect on energy intake. In a nursing home, Charras and Frémontier (2010) observed a positive impact on body weight of having shared mealtimes between caregivers and older people with Alzheimer-type dementia.

Looking at ***the physical context of a meal***, Gibbons and Henry (2005) observed that energy intake was 8% higher when elderly subjects ate in a training restaurant (improved environment) than in a standard environment (staff canteen). In older patients suffering from dementia, an increase of food intake was associated with the improvement of room lighting and table setting contrast (Brush et al. 2002), with the diffusion of music in the dining room (Ragneskog et al. 1996; Thomas and Smith 2009), with the diffusion of a food odor before the meal (Sulmont-Rossé and Van Wymelbeke 2019) and with the enhancement of the color contrast of tableware

(Dunne et al. 2004). However, Divert et al. (2015) failed to observe any increase in meal enjoyment or food intake when institutionalized elderly people were allowed to choose decorative objects (e.g., table cloth, table ware, flowers) to put on their dining table or to choose the music to be played during the meal.

Finally, looking at ***the service***, Shatenstein and Ferland (2000) observed that changing from a centralized food delivery system to decentralized bulk food portioning led to an increase of energy intake (+24%) in residents with dementia. However, Cluskey and Dunton (1999) and Divert et al. (2015) showed that providing institutionalized elderly people with small portions led to a decline in food intake despite older people often complaining that portion sizes are too big in nursing homes.

Finally, seven studies assessed large-scale changes which mainly aimed at shifting the dining room from an institutional appearance to more home-like setting (Table 1). Five of these studies reported that an improvement in the context of the meal could have a positive impact on food intake (Elmståhl et al. 1987; Desai et al. 2007; Nijs et al. 2006; Kremer et al. 2012) and/or body weight (Mathey et al. 2001a; Nijs et al. 2006). Kenkmann et al. (2010) observed no impact of a 1-year intervention on weight, despite a slight (but not significant) reduction in weight loss in intervention homes compared to control homes. In these studies, the context of meal in nursing homes was improved "as a whole," by improving several dimensions related to the food (e.g., choice, variety), to the service (e.g., buffet style, second helping), to the people (e.g., promoting autonomy, social interaction), to the staff (e.g., staff sits down at tables with residents), and/or to the situation (e.g., table dressing, attractive dining room). As a result, even though some of these studies showed that improving meal context had a positive effect on food intake, such "holistic" changes are difficult to implement in the field because they are difficult to reconcile with the constraints of nursing homes in terms of cost and personnel.

Improving Pleasure Elicited by Food

In order to compensate for the decline in olfactory and gustatory capacities with aging, several authors have proposed to enhance the flavor of food, namely, to deliberately add an aroma or a taste compound in the food. For instance, Bellisle et al. (1991) tested the impact of adding monosodium glutamate (compound responsible for the umami taste) in two soups, rice, and mashed potatoes. The results showed an increase in food intake for one soup (+7%) and for the mashed potatoes (+17%) compared to meals with standard foods. Similarly, Mathey et al. (2001a) enhanced the flavor of the protein dishes served to elderly people living in nursing home. After 16 weeks of intervention, the authors observed a slight increase in weight (+ 1 kg) in people eating enhanced dishes compared to residents who continued to eat standard dishes (control group). However, when Essed et al. (2007) replicated this study under the same conditions, this positive impact of flavor enhancement was no longer observed. In fact, when one is looking at the different

Table 1 Impact of improved meal context on eating behavior in institutionalized elderly people: literature review

Study	Control condition	Intervention condition	Population[a]	Design[b]	Duration	Outcome	Effects[c]
Elmstahl et al. (1987)	Trays	**Decor 40s**	Older people ($M = 80$)	Within-subject	4 months	Food intake	+
	Hospital decor	Bulk portioning service	Living in long-term care units	($n = 16$)		Body weight	**0**
		Residents could help themselves					
		Improved dining room decor					
Mathey et al. (2001b)	Trays	**Refined ambiance**	Older people ($M = 82$)	Between-subject randomized trial	1 year	Food intake	(+)
	Limited staff	Meal served in dishes on the table	Living in nursing home	Control group ($n = 10$)		Body weight	+
		Assistance by the staff		Test group ($n = 12$)		Quality of life	+
		One nurse for two patients					
		Improved table dressing, music					
Remsburg et al. (2001)	Trays	**Buffet-style dining program**	Older people ($M = 80$)	Between-subject randomized trial	3 months	Body weight	**0**
	No choice	Choice, second helping	Living in long-term care units	Control group ($n = 20$)			
		Assistance by the staff		Test group ($n = 20$)			
		Improved table dressing, music					
Desai et al. (2007)	Trays	**Home-like setting**	Older people ($M = 88$)	Between-subject	9–12 months	Food intake	+
	Institutional appearance	Bulk portioning service	Living in dementia units	Control group ($n = 23$)		Body weight	**0**
		Cafeteria style with waitress service		Test group ($n = 26$)			
		Improved dining room decor					

Nijs et al. (2006)	Trays	**Family ambiance**	Older people ($M = 77$)	Between-subject randomized trial	6 months	Food intake	+
	Choice of menu	Choice	Living in nursing home	Control group ($n = 83$)			
	15 days in advance	Meal served in dishes on the table		Test group ($n = 95$)		Body weight	+
		Personnel sat with residents				Quality of life	+
		Improved table dressing					
Kenkmann et al. (2010)	Crowed room	**Restaurant atmosphere**	Older people ($M \approx 87$)	Between-subject	1 year	Body weight	**0**
	Single sitting	Choice (more options, at mealtime)	Living in nursing home	Control group ($n = 48$)		Meal enjoyment	**0**
		Display of food		Test group ($n = 57$)			
		Fewer tables, several sittings					
		Improved table dressing					
Kremer et al. (2012)		**"Delicious green table"**	Older people ($M \approx 78.5$)	Between-subject	8 weeks	Energy intake	**0**
		Organic food, choice, appetizer	Living in nursing home	Control group ($n = 40$)		Food intake	+
		Residents could help themselves		Test group ($n = 28$)		Meal enjoyment	+
		Improved table dressing					
		Countryside decor					

[a]M: averaged age mean
[b]n: sample size
[c]0, no effect; +, significant positive effect

Table 2 Impact of flavor enhancement on food intake: literature review

Study	Food	Enhanced flavor	Population[a]	Design[b]	Duration	Effect on food intake[c]
Bellisle et al. (1991)	2 soups	Umami taste	Older people ($M = 84$)	Within-subject	3 meals	+ for one soup
	Rice		Living in nursing home	($n = 100$)		0
	Mashed potatoes					+
Schiffman and Warwick (1993)	30 various foods	Flavor	Older people ($M = 85$)	Within-subject	3 weeks	0 for 27 foods
	(Vegetable, gravies, eggs, soup, stew, etc.)		Living in nursing home	($n = 39$)		+ for 3 foods
De Jong et al. (1996)	Strawberry jam	Sweet taste	Older people ($M = 79$)	Within-subject	5 days	Non
	Strawberry yoghurt		Living in senior home	($n = 25$)		
	Orange lemonade					
Griep et al. (1997)	Tomato soup	Flavor	Older people ($M \approx 77$)	Within-subject	1 meal	0
						0
	Quorn		From an hospital geriatric unit	($n = 20$)		+
	Yoghurt					
Mathey et al. (2001a)	Protein dishes	Flavor	Older people ($M \approx 84$)	Between-subject	16 weeks	+
			Living in nursing home	Control group ($n = 31$)		
				Test group ($n = 36$)		
Essed et al. (2007)	Protein dishes	Flavor	Older people ($M = 86$)	Between-subject	16 weeks	0
		Umami taste	Living in nursing home	Control group ($n = 23$)		
				Test group ($n = 60$)		
Koskinen et al. (2003)	Yosa	Flavor	Independent living	Within-subject	3 meals	0
			Older subject ($M = 74$)	($n = 57$)		

[a]M: averaged age mean
[b]n: sample size
[c]0, no effect; +, significant positive effect

studies on this topic, it appears that flavor enhancement seldom improved food intake in the elderly (Table 2).

Some authors have studied the impact of sauces or condiments on food intake in institutions. For example, Appleton (2009) found that adding sauce to the main course increased energy intake, but this gain result from an increase in sauce intake, not in main dish intake. In contrast, Divert et al. (2015) showed that providing condiments on the meal tables (e.g., butter, tomato sauce, lemon, parsley, mayonnaise) had a positive impact on food intake in institutionalized elderly people.

Finally, Sulmont-Rossé et al. (2018a, b) tested the feasibility and effectiveness of improving the sensory quality of food according to sensory expectation and food preference of elderly people. This study focussed on three types of dishes: a ready-to-eat dish from the French familial cuisine (veal stew), a texture-modified food (pureed beef-carrot), and a fortified food (high-protein and high-energy dense vanilla custard). In a first stage, independent-living and institutionalized elderly people were asked to taste the market products and to suggest how the sensory characteristics could be improved (appearance, flavor, texture, etc.). On the basis of these results, different variants were developed for each dish. In a second step, a second panel of independent-living and institutionalized elderly people rated their liking for each variant. Finally, in a third step, a consumption test was carried out in a nursing home to compare the initial market variant and the variant that was the most appreciated in the previous step. The results showed that improving food sensory properties according to elderly people's expectations led to an increase of food intake (+6%). Furthermore, the results also showed that the variants improved on several sensory dimensions (texture, taste, aroma) were preferred to the variants improved on only one dimension. This argues in favor of a multidimensional approach when developing food for the elderly population (see also Kremer et al. 2014).

Conclusion

In view of the major challenge posed by malnutrition among the elderly population in terms of quality of life and public health, it is crucial to develop meal interventions and food products that promote appetite and sustain food intake in the older adults, in combination with nutritional strategies. However, to be effective, such research should take into account the capacities and the expectations of the elderly people. The last word comes from a man over 70 years old who has lost his sense of smell. To the question "Do you still enjoy eating, even if you have less sense of smell?" This person answered very spontaneously: "Oh yes! Oh yes, YES, YES! Eating is almost the only pleasure we have left!."

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Part VI

The Culinary Arts and Sciences

Check for updates

Influence of French Cooking Globally

23

Julia Csergo

Contents

Abstract

Gastronomy, which includes processes ranging from "farm to fork," and of which the culinary arts are but one component, has thus become, through a synthesis of the diversity of cultural heritages, one of the most emblematic representations of French culture. A model during the sixteenth and seventeenth centuries, French gastronomy triumphed in the eighteenth century, continued to exert a hegemony during the nineteenth century, and saw a weakening of its dominant position at the close of the twentieth century. In response to this more recent

French Gastronomy: Birth, Hegemony, and Survival of a Cultural Model (Sixteenth to Twenty-First Century). Translation French-English by Alexia Moyer

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change in status, France has developed strategies designed to maintain influence and preeminence. To trace this history is to trace a cultural history in which the culinary arts were constituted in France as a form of political, economic, and social government as well as diplomatic device.

Keywords

French cultural history · Gastronomy · Culinary art · Cultural model · Hegemony · Globalization · Cultural heritage · Gastrodiplomacy · Nation banding

Introduction

At the beginning of the twentieth century, while tensions in Europe intensified, began a politico-philosophical inquiry into "the psychology of the people" as it relates to the question of national belonging. Culture and collective mores were found to be at the heart of what constitutes the "consciousness of being a people" (Fouillée 1903). As French and German conceptions of nationality came to a head over the status of Alsace-Lorraine, certain German writers attempted to pinpoint what it meant to be French, or to possess a French soul, a French spirit, and French taste. In *Dieu est-il Français?* (1929), journalist Friedrich Sieburg (1991) wrote the alimentary customs, the importance placed on local specialties, on the culinary arts, on wine, and on menus as the embodiment of French culture. At the same time, novelist Ernst Robert Curtius (1932) defined what made France and what set it apart from Germany, paying particular attention to the kinds of social and intellectual democracy through which the country developed its idea of civilization and articulated its cultural identity:

> It is universal not only in the sense that it unites the nation and humanity, and that within the nation it includes all classes, but also because it covers the whole of existence (. . .) We may indeed assert that in France civilization begins with food. Gastronomy is part of civilization. (p. 39)

Gastronomy, which includes processes ranging from "farm to fork," and of which the culinary arts are but one component (Csergo 2016b), has thus become, through a synthesis of the diversity of cultural heritages, one of the most emblematic representations of French culture. A model during the sixteenth and seventeenth centuries, French gastronomy triumphed in the eighteenth century, continued to exert a hegemony during the nineteenth century, and saw a weakening of its dominant position at the close of the twentieth century. In response to this more recent change in status, France has developed strategies designed to maintain influence and preeminence. To trace this history is to trace a cultural history in which the culinary arts were constituted in France as a form of political, economic, and social government, as well as diplomatic device.

An Assertion of a *manière française* at Table

Medieval recipe books describe a culture of cooking and dining common to all European elites. Characterized by a taste for spice, acidity, and the associations of both sweet and salt and sweet and sour, cookery of Middle Ages nonetheless saw the expression of certain national tastes and the use of ingredients or cooking methods specific to each country (Rambourg 2005).

It is in the sixteenth century that the idea of "*une manière française*" at table asserted itself, this in line with the growing sense of belonging to the nation. Beginning in the Middle Ages (Beaune 1985), this construct of "belonging" was reinforced in the sixteenth century as a unifying response to the bloody territorial and religious conflicts that had divided the kingdom. It is rooted in the monarchy's pursuit of centralization: the political and cultural assimilation of the provinces by the nation. The institution of French as the administrative language by Francois I (1494–1547) is but one example. This last policy helped to foster the scholarly discovery of the provinces, their natural features, their inhabitants and their histories, and their resources, the sum of which not only generated a certain degree of local patriotism (Yardeni 2005) but also contributed to the wealth of the entire kingdom. As such, alongside landscapes, remarkable buildings, industries, and markets, a decisive place was given to agricultural production and to the way the people fed themselves, but also to the princely cultures of banquets, the pageantry of the table, and dishes prepared and served the *manière française* at table (Du Chesne 1620, pp. 409–410). Thus, distinguished from those of other peoples, the table became a site of expression of the cultural community being forged. Meanwhile, the kingdom's superiority in various domains, particularly in that of cooking and the culture of feasts, was affirmed. The expression of such a feeling of superiority can be attributed to a cultural context in which the will to express the love and pride of a nation under construction and the return to fashion of an ancient form of rhetoric, that of epideictic oratory, converged. This public statement of positive and persuasive judgment in favor of a given object had the effect of producing, and sharing, common values. Estimation, consideration, and appreciation, which in the Middle Ages had been reserved for God alone (*löenge de Dieu*), were transferred to the nation: to the genius of its soil and to the divine profligacy of its productions. The territory of France, its *terrouer* in old French, becomes the *Jardin des Délices* (Alquié, 1670), a unique place where one finds both spiritual and sensual pleasure, a "Paradise Regained." We might find in this phenomenon the origins of how *terroir* came to express in France the "nous national," or "ce qui nous unit" (Droit 2015).

The affirmation of the superiority of France's agricultural products and of its table is also very much a matter of economic design. After years of conflict and devastation, Henri IV (1553–1610) made use of the peace that followed to establish reconstruction policies, which were rooted in the dominant mercantilist theories of the period. Mercantilism is an economic practice first developed in England in the sixteenth century, which seeks the greatness of the developing state the financial means necessary for its political and war action; it consists of bringing gold into the coffers of the state by ensuring a positive trade balance. In view of augmenting a state's powers, mercantilism grants the sovereign the financial means to take political action and/or make war. In other words, a state's power is measured by the abundance of its wealth in gold and silver. In the absence of precious metal mines, this abundance can only come from a positive trade balance. Plowing and grazing were recognized as France's main riches, since they nourished its people and helped it to avoid the need for imports while favoring exports (Serres 1600). The idea of regional agricultural specialization (Montchrestien 1615) supports this point of view. Colbert, Louis XIV's minister of Finance, would take this tack. For instance, to reduce the commercial power of Holland, he favored the French production of cooked pressed cheeses, encouraging the farmers of the North to create counterfeit Netherlands cheeses whose importation he had prohibited.

Thus, praise of the nation for its agricultural and alimentary wealth as well as the *manière française* at table served mercantilism, which itself brought an economic dimension to the political and cultural connections being made for the purpose of uniting the people of France. Mercantilism was a factor in strengthening the consciousness of national unity through the protection it offered to the country and its subjects by way of the sovereign.

The defense of the language and recognition of the nation's history, its culture, and the national economy were closely associated. The culture of the table was an essential component, of which agricultural production constituted the base, the *terroir*, the values.

Birth and Codification of a French Cuisine and Table

During the seventeenth century, a French style of cooking and "art of the table" was codified for better assertion and dissemination. European elites were fascinated by it, just as they were fascinated by Versailles and the French taste that found expression there.

Under the reign of Louis XIV (1638–1715), absolutism and centralization reached their peak. The superiority and grandeur of France were now embodied in the *Gloire du Roi*, through which the process of building a national cultural identity continued. This *Gloire* is based upon a "government of minds" (Lavisse 1978), that is to say, absolutism means exercising political control over all fields of knowledge, including the arts, with the aim of promoting a French style that symbolizes the power of the state and attempting to eclipse the reigning Roman model. The academic system was at the heart of the matter: *l'Académie française* (1635), created for the purpose of perfecting and universalizing the French language, *l'Académie de peinture et de sculpture* (1648) and *l'Académie d'architecture* (1671), and the sometimes transitory académics schools of dance (1662), of opera (1671), of music (1672), of performance (1674), all of which were used to set up and support a doctrine of official taste *à la française*, now a mark of distinction. The industrial arts and crafts (tapestry, lace, glassware, mirrors) were organized around the same objective, through state-owned industries. The ornamental and leisure arts, described by Kant (1985) as satisfying only the senses but not the mind, did not benefit from institutional structures, but nonetheless experienced the same forms of academization and codification. Such is the case with the art of cooking and the art of the table.

Brought to the fore by royal command and playing a central and ceremonial part in the staging of the monarchy, these arts were not granted academic bodies, but nevertheless they were academized: they were ordered into bodies of rules and doctrines, which, as for the major arts, subscribe to an ideal of taste. As the rules of gardens *à la française* were defined, so were those of *cuisine à la française*. In 1651, La Varenne's *le Cuisinier François* identified these rules. This text marked the beginning of a revolution that became known in the eighteenth century as "new French cuisine." It broke with the medieval culinary tradition still in force in many European courts, as well as with the Italian-centered Renaissance. This "French" cuisine offered new flavor profiles and thoughtful food combinations, new skills, and the use of indigenous resources. It saw a decline in the use of spices in an attempt to preserve a food product's natural taste. It was also characterized by more precise cook times, the separation of sweet and savory, and sweet and sour, as well as the use of fat and butter (La Varenne 1983). These characteristics remain the basis of French cuisine.

La Varenne's cookbook was followed by a series of texts, all of which set out to order and to structure a French style of the table in terms of vegetable production (Bonnefons 1651), pastry (An. 1653), confectionery (An. 1650), food service and the ways of butchering and carving meat (LSR 1674), the dishes or courses served, as well as the aesthetics of the table settings and linens. All of these books, supported by illustrations, cemented this style to better teach a growing canon of living *à la française* to the trades at work in the townhouses of Paris (Gady 2008). Equipped with kitchens and reception rooms, pantries, and dining rooms (Lestienne 2017), such townhouses testify to the importance accorded by an enriched bourgeoisie – which had acquired, through the purchase of offices, the honors of serving the state and with all the social obligations this newly acquired status entailed – to the art of receiving at table.

Praise for France's prodigality, for the abundance and quality of its products, was now being extended to its cuisine. The author of *Délices de la France* (1670), Savinien d'Alquié, described France as distinguishing itself by the perfection of its cuisine ("we have the best Cooks in the world" (pp. 233–234)) and of its service *à la française*, in vogue throughout Europe (p. 147).

This culture, he wrote, was spreading throughout urban society: "profusion and profligacy reign in the refreshments and feasts that the least bourgeois, and even the least artisan, offers his friends" (pp. 233–234). This trend continued throughout the eighteenth century. Through the emergence of a bourgeois kitchen and table, itself modeled on a simplified court table (Takats 2011), came a national kitchen and table. Hence, the codes, established at Versailles, passed on to a new social layer to acquire wealth, were then diffused to the rest of the social body while also becoming a cultural reference among European elites.

A Common Culture that is the "Making of France"

The revolutionary decade, which saw the rise of the Republic, did not break with this model but rather strengthened it. In 1798, Louis-Sébastien Mercier wrote that during the horrors of the revolution, Adéphagie (the goddess of gluttony) had lost none of her empire, "within striking distance of the guillotine and the large cemeteries filled with victims" (1990, p. 455).

Aron (1975) showed how, throughout the nineteenth century, gastronomy was strengthened by the new bourgeoisie who, coming to power, identified with this mode of expression. He traced the "social requalification" of the table, carried out by gastronomes like Berchoux, Brillat-Savarin, and, above all, Grimod de la Reynière, identified as the first to transmit the aristocratic mores of the table (Grimod de la Reynière 1978). The spectacularization of food and the rituals of the table found a new home in restaurants, which began to appear as cooks and *maitre d'hotels* sought to work outside of aristocratic homes. The restaurant became the new and public space for the culinary arts. The establishment founded by Chef Beauvilliers in 1782 became one of the most elegant and reputable places in Paris.

In line with its own values, the new political regime, the Republic, continued to build upon and to transmit this culture of the table which, once again, found itself at the heart of a nation under construction and central to the national community's sense of belonging. Praise for France's culinary prowess now extended to its diverse territories and the people who lived in them, whose common past was traced through their everyday lives (Grell 2000). Indeed, when the Revolution ordered a review of France's economic and social status, it also produced a review of the nation's wealth in the form of its customs, its monuments, and its natural resources. Agricultural specialties and eating habits were viewed as proof of France's diversity as well as what tied it together, united as it was by a continuity, a past, and a future. For quite apart from other regional particularities, local food cultures were not considered a hindrance to the construction of a republican unity. In conjunction with the practices of Ile-de-France elites, these would undergo a process of "nationalization," integrated into a cultural ensemble that would become French gastronomy. As such, gastronomy is (always) an instrument of national harmony. To educate its citizens, the Republic would design "patriotic gardens" wherein each section was named after a memorable event, a historical personality, a building, or a food specialty (Deleyre 1793, pp. 25–26). A few years later, in 1807, Grimod de la Reynière evokes this educational tool and arranged for the production of a particular kind of national map:

> (...) Featuring the gourmet productions that made our cities famous (...) Thus, instead of the steeple of Amiens, we distinguish at this place a duck pie; at Nérac, a terrine of red partridges; a duck liver in Toulouse (...). (2012, p. 622)

This first food-centered map of France, published by Gassicourt (1809), presents specialties, noteworthy as much for their taste as for the memories they both carry and impart. That the Republic and its territory could be learned through its local food specialties is indicative of the status that food continued to hold in the imaginary, and in the symbolic representations, of the nation. Written into the history of the Earth (and of the people who occupy it), foods came to be seen as monuments, as reminders of a common past, constituting a group identity. Like castles and cathedrals, they were regarded as a form of cultural heritage (Csergo 2011). This pedagogy of France by way of gourmet specialty would be popular throughout the nineteenth century: children's books, popular poetry, school textbooks of the Third Republic, as well as countless vignettes and prints would form the tools that taught the nation (Csergo 1999) through the consumption of its incomparable gastronomic wealth. It would also maintain a lasting fusion of France's sensitive identity (Sansot 1985) with its political and civic identities.

Beyond the food products, it is the cuisine that, in the twentieth century, would be subject to the same process of social and regional synthesis. In an attempt to create hallmarks of the nation's new identity, the first publications on regional cuisine were published. Interestingly, these books represent areas with contestable borders: Geneva, former free republic, occupied by and annexed to France (An. 1798); Alsace, a pivotal site where French and German conceptions of nationality would meet (Spoerlin 1811); and the South, where Michelet had not yet encountered "the true France" (Durand 1830). At the end of the century, almost all regions would have their repertoires of recipes and food products but also their local stories of food customs (Csergo 1999), many of which are still in print.

The early twentieth century saw the first compilations celebrating France's culinary wealth, in all its social and regional components. *L'Art du bien manger* (Dumonteil and Richardin 1901) demonstrates this process of integrating regional cuisines into the national cuisine. This monument raised in honor of French cuisine is a synthesis of "renowned dishes of great restaurants," of "local cuisine," of "recipes from the old French kitchen," and of "the bourgeois kitchen and the housewife's kitchen" as well as "simple and easy recipes." In 1913, *Les Bons Plats de France* (Pampille, alias Marthe Allard-Daudet, 2008) was the first to associate French cuisine with the immutable identity of a *terroir*, the highest expression of the soil and the rural territory that produced it. This would also make gastronomy a touchstone for the reactionary and nationalist right. In 1933, *le Trésor gastronomique de France* (Croze and Curnonsky 1933) concludes this review of alimentary and culinary production that had begun in the eighteenth century. Cuisine has thus played a significant role in mapping out and memorializing the nation. It has been a key vector in the work of linking *petites patries*, or local homelands, to *la grande patrie*, or nation (Thiesse 1997) and has rendered the table an embodiment of France; they are both one and yet divisible. The attachment of the French to their gastronomy, whatever their social and regional origins, their religious or philosophical convictions, is a sign of this policy's success. This is what led Zeldin (1977) to describe gastronomy as a French passion.

The Hegemony of a Cultural Model for an Economic Dimension

The table, with the cultural value it had accrued and the reputation it has acquired, would contribute to France's cultural hegemony in Europe, and in the world, until the end of the twentieth century. *Gloire du Roi* having become *Gloire du peuple*, gastronomy would figure in various forms of international exchange, sustaining France's economy by way of its territories.

As an instrument of government foreign policy, gastronomy deployed the power of the nation through diplomatic action, strengthening strategic decisions abroad, helping to form alliances, managing conflicts, but also influencing public opinion, creating a "desire for France."

All sovereigns since François I gave primacy to culinary diplomacy exercised state to state in the form of official receptions and banquets. During the reign of Louis XIV, culinary diplomacy rose on an unprecedented scale. Through the pomp, refinement, ceremony, aesthetics, and general excellence of the royal table on display at Versailles, France did more than stage an absolute monarchy in all its grandeur. It also pushed foreign embassies to take on or emulate aspects of the French cultural identity, thus confirming and ensuring the nation's influence and preeminence. The reign of the French model would outlive a succession of political regimes – from a monarchy to a republic to an empire – all of which would draw from its prestige. This culinary diplomacy even fueled a national mythology. The current government still refers to the "diplomatico-gastronomic masterpieces" made during the Congress of Vienna (1814–1815), to the sumptuous receptions put on by Talleyrand, who had been made *Amphitryon* of the Napoleonic regime and to whom legend attributes the following aphorism: "a diplomat's best assistant is his cook." Indeed, it was the cooks who were the main ambassadors of the French table. The excellence of their art was practiced in all European courts and beyond. The greatest of them served kings, princes, and foreign embassies. Among them were Vincent La Chapelle, who wrote his *Modern Cook* in English (1733); Alexis Soyer, whose work held such influence in Victorian England; Antonin Carême, styled as "king of cooks and cook of kings," prodigy of culinary architecture and decoration; as well as Jules Gouffé and Urbain Dubois, held similar sway during the nineteenth century and Auguste Escoffier and Prosper Montagné in the early twentieth century, quickly translated as they were into English (Laudan 1996). All of these cooks actively participated in establishing the French model and maintaining its preeminence.

Meanwhile, the industrial revolution and the advent of liberal capitalism altered the geo-economic balance in the world, increasing competition between countries. The so-called "modernist" nations, namely, Germany and the United States, brought their industrial foods to market, which the French denounced as food "imposture." Nonetheless, their low cost rendered such products a serious threat to French food production. France thus undertook to defend its share of the export market. Beyond culinary diplomacy, France began developing a broader diplomatic project, with the aim of influencing attitudes and ensuring markets for terroir products, for cooking, for wine and spirits, and for the decorative arts of the table. That politicians and mayors of major cities, like Edouard Herriot in Lyon (Csergo 2008) or Gaston Gérard in Dijon (Laferté 2002), set out to give their respective cities a gastronomic status was both beneficial to the development of the surrounding territories as well as to France as a whole. Their gastronomic crusades were part of a patriotic mission: to defend the national economy along with the French identity.

Promotional activities were carried out at international fairs and exhibitions in view of acquiring and maintaining export markets. The main objective was to conquer the American market, then dominated by Germany. Ally and the world's largest economic power, the United States, offered a market that appealed to French ambitions given the commercial blockade imposed on Germany and Austria during the First World War. France saw an opportunity to "capture American gold." In 1915, at the height of war, France introduced the "Palais de la France" to the San Francisco International Exhibition, which boasted lavish banquets. A look at trade with the United States reveals that French food products hold a certain "seductive charm" for Americans. Their symbolic meaning, great style, and an art of living tinged with elitism and aristocracy – now become cultural and commercial brands – appealed to newly wealthy Americans with a fondness for conspicuous consumption. Beyond individual food products, trade began to move toward the pleasures of the table "*à la française*" repackaged as luxury goods, recalling a golden age of royal splendor (Csergo 2016b). Champagne, fine wines, liqueurs and spirits, cured or potted meats, haute cuisine, and tableware, with their artisanal excellence contrasted with the mass-produced goods offered by an American industry convinced only of the most functional aims of the act of eating. These distinctions would influence France's commercial export strategies.

Well before the reign of gastrodiplomacy, France sought to guarantee the long-term export of the best and most expensive products to the United States and thus launched operations intended to influence consumers, to create and maintain a desire for French gastronomy. Meals displaying French-style splendor were given in the sumptuous dining halls of luxury *Palace*-hotels and in transatlantic ships, whose kitchens were staffed by Escoffier's disciples. Further, Gastro-diplomatic delegations, composed of renowned winemakers and chefs, were sent to the United States to train the social elite and restaurateurs in the French model of the table. Banquets became showcases of products – wines, fine china, gold and silver plate, and crystal glassware – as well as savoir-faire related to cooking, eating, and drinking. Emphasis was placed on the learning of grape varietals, the temperature of consumption of different wines, and the pairing of dishes with wines, this last a notion that already fascinated Americans. This promotional work in the area of export development is indissociable from efforts to conquer the tourism market. The challenge that this growing industry set for itself was to attract tourists, among them wealthy Americans, to bring "foreign gold" into France and by extension preventing competing powers from similarly enriching themselves. The project was fueled by a theory, fashionable at the time that tourism, which consists of selling goods and services to a foreigner on, in this case French soil, is the equivalent of serving an "export market from within." The idea that France's appeal was based on its cultural resources (its history, landscapes, monuments, local traditions), all of which coalesce in the art of eating well. The following statement, attributed to paragon of American success, John D. Rockefeller, supports this understanding of what constitutes resources: “The French have a great industry but they do not realize it. It is their art of dining and their eating practices.” In Paris, in the towns and villages of France, in restaurants and inns, be they refined and reserved for the elite or more commonplace and rustic, the table, the diversity of the products that adorned it, and the hospitality that accompanied it became tourist attractions. The consumption that these practices and products generated operated as levers of economic development. It was also a matter of setting French culinary style apart from the influence of tasteless, non-specific international cuisine, which began to appeal to – and be expected by – a growing number of international tourists, to protect the treasure that is French alimentary art “in the same way that monuments are protected,” and to cultivate the charm of a provincial welcome and to make restaurant owners aware of the advantages of using local products, local wines, and recovering local dishes. During the 1920s, a culinographer, Curnonsky, evoked in this regard the *Sainte Alliance du tourisme et de la gastronomie* (Csergo 2007). Around the same time, tourist guides, newspapers, and magazines specializing in tourism and gastronomy, designed to give travelers the desire to taste France, began to multiply: inviting readers to crisscross the country by train, by bicycle, or by car, to taste the local specialties in the best way, i.e., in situ, sauerkraut in Alsace, “foie gras” in the Périgord, and lobster by the sea. Gourmet maps were produced for visitors so that they might easily locate local specialties, consuming them on the spot or taking them home. Such maps helped to shape the regional gastronomic and culinary stereotypes that would take hold.

To the iconic depictions of Versailles or Chartres, those of castles and abbeys, the beaches of Normandy and the Côte d’Azur, were then added local products and dishes and the art of living at table. National identity, made up of its regional components, thus joined the tourism project, itself an instrument of defense and promotion of what was becoming a fixed identity. This perspective on tourist-related communication continues to dominate.

Preeminence Under Threat

From the sixteenth century onward, France built a persuasive praise (*éloge*) followed by storytelling (Denning 2004) concerning the identity and excellence of its table culture. It thus ensured and maintained the hegemony of a model that would last through the 1960s, during which its dominant position would be reaffirmed by the *nouvelle* nouvelle cuisine, promoted by the great chefs and by Gault et Millau, publishers of le *Dix commandements* (1973).

However, from the 1990s onward, this preeminence began to waver. The new globalization and the financialization of gastronomy favored the emergence, if not the visibility, of other culinary models. Given the economic stakes in this sector, these models represented [serious] competition, even at a moment when Michelin-starred French chefs were opening restaurants in the United States or in Japan. As “world food” came to the fore, France denounced the option of

American-style expansion and the "miscegenation of anything and everything, where every culinary culture in the world delivers its simplest and least refined foods" (Lazareff 1998, p. 61). Fast food, ethnic restaurants, casual dining, pizza, or Tex-Mex were nonetheless popular in France, as in the rest of the world. Regrettably, Gault listed fewer French restaurants in Paris than foreign restaurants. Other threats, even more worrying, made their appearance: the increased competition with Californian, Australian, and Chilean wines; Italian cuisine surpassing French cuisine in international polls; the growing popularity of Japanese and Thai cuisines; and chefs from other countries, like Ferran Adria and Marco Pierre White, whose innovations earned Michelin stars. The crisis culminated with 3-starred chef Pierre Gagnaire's declaration of bankruptcy: with some saying that international competition had had the better of the French kitchen.

While this competition calls the French model into question, its elitist and prestigious heritage with its formalisms and rigidities, its intimidating and discriminatory doctrines, in May 1996, an appeal to "save the French cuisine threatened by globalization" was launched. Signed, notably, by Ducasse, Robuchon, Blanc and Loiseau. Against "Japanese-Californian" cuisine and "unbridled creativity," this tricolor crusade, based on the values of terroir and regional traditions, set out to defend the "French identity" in cooking. In response to this discourse described as d'*archéo or archaic.* and *pétainiste. During the German occupation, Petain set up an authoritarian regime that glorified attachment to the land, as the embodiment of an immutable national identity.* (Noce 1998). Other chefs *Bras, Chibois, Gagnaire, Lorain, Passard, Roellinger, Troisgros and Veyrat*, signed a counter appeal, inviting a rethinking of French cuisine through cultural mixing.

While this crisis led some American observers to announce the decline of the hegemony of the French model (Gopnik 1997), in 2003 a vast French-bashing offensive was launched. This followed France's condemnation – in the form of a speech at the United Nations – of the American Iraqi Freedom project. In retaliation, the United States attacked French food products: wines were dumped down in the gutter, or, along with cheeses and foie gras, they were removed from the menus of many restaurants. California then voted to ban the sale of foie gras (2004). *On January 5, 2015, the United States Court overturned this provision, saying it interfered with commercial law*; and two members of the House of Representatives sought to rename French fries, Freedom fries. But in reality, the roots of this diplomatic culinary war run deep. They reveal trade tensions that lasted several years. Indeed, in the logic that led to cultural exception (Gagné 2005), and with the intention of setting limits on the rules put in place by the World Trade Organization (WTO) that tend to favor the all-powerful American trade and the standardization of productions and goods, including cultural ones, France defended a UN strategy of cultural diversity. This would lead in 2001 to the Universal Declaration on Cultural Diversity and in 2005 the Convention on the Protection and Promotion of the Diversity of Cultural Expressions. Reproaching the Convention for its lack of clear definition as to what constitutes "cultural expressions" and denouncing the implicit protectionism of the market, the United States refused, and still refuses, to ratify it. Food markets are at the heart of the argument, as evidenced by the article published in 2005 about the position taken by

Bill Clinton's former secretary of agriculture, Dan Glickman: "All countries that negotiate Trade agreements will therefore find that there is always a cultural point of view in coffee, banana, cotton or cheese" ("La Convention sur la diversité culturelle inquiète Hollywood,", *Le Monde*, 2005.10.22, https://www.lemonde.fr/culture/article/2005/10/22/laconvention-sur-la-diversite-culturelle-inquiete-hollywood_702423_3246.html, consulted 2014.06.17).

Two years later, *Time* devoted an article to "The Death of French Culture" (Morrison 2007) and, in 2009, French cuisine, whose attachment to elitism and tradition was similarly decried. Michael Steinberger wrote, for France, "Food had always been a tool of French statecraft; now, though, it was a source of humiliation." (2009, p. 10). At the same time, an increasingly internationalized Michelin was accused of favoring French restaurants: the reign of the red guide, undisputed since the 1930s, was strongly shaken, especially when Sanderens (in 2005) and Roellinger (in 2007), each rejected their three stars. Competing ranking systems like the *San Pellegrino World's 50 Best Restaurants* began to appear, and great French establishments were ignored. Other international awards followed, and the French were, if not absent, at least ranked last or nearly. The resulting anxiety over these developments led the French government, in partnership with the daily newspaper, *Le Monde*, to launch a survey on the state of French taste in the world (Le Monde 2009). Its conclusions underline that, while French cuisine remains a reference, French chefs have lost their influence and no longer practice in the upper echelons. That is, they have ceased cooking for heads of state and other persons of influence.

There is, it must be noted, a broad and continued interest in the notion of *terroir*, over which France claimed a certain exclusivity. Following European regulations, North America also sought to recognize and regulate local products (Black 2007). And with support from UNESCO and the World Trade Organizations, came a "*terroir*isation" of the world. The food tourism market was thus flooded with competition. With the development of the cultural tourism doctrine, the UNWTO (2003) encouraged all countries to undertake heritage and tourism valuations of their local products and culinary traditions. From then on, the initiatives multiplied – the creation of wine or cheese routes, food festivals, cooking competitions and farm visits – and new culinary tourist destinations emerged, like Peru, named the "best gastronomic destination in the world" since 2013 by the World Travel Awards (Csergo 2016a).

Thus, the new globalization has changed the geopolitics of gastronomy in the world. The status quo, the influencers and influencees, and the markets have been reshuffled, and all threaten France's historical position; its preeminence as a country of good food, good products, and good wines; and its image as a gastronomic nation.

For the Survival of a Model and the Maintenance of Preeminence: Cultural Heritage and Gastrodiplomacy

It is in this context that France undertook not only to defend its cultural model of the table but also to regain a preeminence that, if not lost, was at least being disputed. To this end, the state developed a communication plan with two main components: cultural heritage and gastrodiplomacy.

The first counteroffensives were launched on the cultural heritage front, both at national and international levels. In 2006, at the national level, foie gras, the product and the feeding process it necessitates, was designated as a "cultural and gastronomic heritage of France" – this as a means of protecting a market threatened by animal rights lobbies and of illustrating the "heritage and the link to the soil that characterize the originality of the French food model (Code rural, art. L654-27-1 du 5 janvier 2006 – art. 74.)." In 2014, wines and spirits from local traditions had their turn to receive the "cultural heritage, gastronomic and protected landscapes of France" label (Code rural, art. L665–6, Loi n° 2014–1170 du 13 octobre 2014-art. 22). This recognition would allow them to bypass laws prohibiting the advertisement of foreign alcoholic beverages, to which they are subject [outside of France] (Code de la Santé publique, art. L3323-3-1, Loi n° 2016–41 du 26 janvier 2016-art. 13). Finally, the French Inventory of Intangible Cultural Heritage, launched in 2009, increased its inscriptions relating to food production "savoir-faire."

At the international level, France took advantage of the UNESCO Conventions, including inscribing the landscapes of its major wine regions among those "Cultural Landscapes" of the 1972 World Heritage Convention. To date, the Jurisdiction of Saint-Émilion is registered; the Loire Valley between Sully-sur-Loire and Chalonnes; Coteaux Houses and Champagne Cellars; Climates of the Burgundy vineyards. In 2008, the French President himself petitioned the Convention for the Safeguarding of Intangible Cultural Heritage (ICH-2003) for its recognition of French gastronomy. Justifying his position, he said: "We have the best gastronomy in the word." The project, which caught the attention of other countries wanting to position themselves accordingly, culminated in 2010 with the inscription of the "French gastronomic meal." On line: https://ich.unesco.org/en/d%C3%A9cisions/5.COM/6.14, consulted 2019.03.04. This inscription received unanimous praise in France, in particular by the French Prime Minister, as a tool for promoting the table, the cuisine, and the products that adorn it on an international scene.

Building on this recognition, the French government opened a second front, launching a vast international relations and soft power offensive (Nye 2004). Beyond the more traditional form of culinary diplomacy at work in the form of pomp and ceremony in the dining establishments of the Republic, France was now to practice "gastrodiplomacy" on the world stage. Appearing in 2002 (Food as ambassador 2002), the term "gastrodiplomacy" refers to a country's self-promotion via its kitchen, its network of chefs, entrepreneurs, and other actors in that sector that, like ambassadors, work to ensure French gastronomy's influence abroad. This tactic is supposed to attract investors and develop commercial and tourist markets (CCI 2014).

In 2012, Secretary of State Hilary Clinton launched the Diplomatic Culinary Partnership Initiative aimed at increasing the role of cuisine in American diplomacy, and in it France recognized the form of public relations that it had initiated as early as the seventeenth century. Gastronomic promotion, which had heretofore been relegated to an undersecretary in charge of trade and craft, was now within the purview of the Minister of Foreign Affairs himself, who could offer the initiative all the authority and prestige of his office.

By virtue of the new state's branding strategy, France as company was now invited to promote its cultural identity, now a trademark (Aronczyk 2008). Gastronomy, therefore, has found itself at the cross-section of a number of diplomatic, trade, and tourist-based initiatives. In 2012, the Minister inaugurated the state's commitment to the strategy during an official visit to the United States for a meeting at the United Nations headquarters; there, he launched the *Taste of France*, an operation set up to defend French gastronomic heritage, foie gras, *appellations contrôlés*, and French wines, this on American soil. Henceforth, chefs and winemakers are to accompany official delegations abroad, not only to serve at receptions but to promote business. French embassies around the world are required to carry out a campaign designed to seduce invited leaders. At his sumptuous official residence on the Quai d'Orsay, the Minister himself greets the annual arrival of the updated Michelin Guide, or the *Meilleurs Ouvriers de France*, with fanfare, receiving three-starred chefs or the best cheesemakers and bakers at his table, with an eye to, for instance, inscribing the French baguette on UNESCO's Intangible Cultural Heritage list. Beyond [the celebratory dinners], and with the aim of counteracting the loss of French gastronomic influence abroad, it is to those three-starred chefs who have acquired the status of international businessmen – particularly those with connections to the United States – that the Minister turns. He is seeking expert opinion on those public policies that might best foster France's products, its cuisine, its culture, and gastronomic heritage (Ducasse et al. 2014). To minimize the impact of ranking systems from the English-speaking world so that the French model might again recover its influence and prestige, the nation supports the production and promotion of *La Liste des listes* (the List of lists). Developed from a compilation of 200 gastronomic guides, mostly of French origin, and online review sites, this List, which has no international impact, nevertheless reassures the French gastro-diplomatic sphere by showing that French chefs are still among the best. Finally, in terms of events, Chef Alain Ducasse is entrusted with the task of overseeing *Good France-Gout de France*, offered up as a counteroffensive to French bashing and as an assertion of French dominance in the kitchen. Presented as the perfect illustration of UNESCO's classification of the French gastronomic meal, this operation, inaugurated the evening of March 19, 2015, takes its cue from Escoffier's Epicurean dinners circa 1912. In hundreds of cities across five continents, French gastronomic dinners are given in both French ambassadors' residences and in restaurants. In the first edition, the high point was the dinner given at Versailles, in the symbolic *Gallery of Great Battles*, which retraces the historic victories won by the French army. Here, a meal dreamed up by 6 three-starred chefs was served to 650 guests, including all the ambassadors of the world stationed in Paris.

Conclusion

In the early nineteenth century, as gastronomic discourse took hold, Utopian Charles Fourier wrote:

> One day, we will see (. . .) empires have their armies battle it out by means of gastronomy, to determine the most perfect of even the simplest dishes (. . .) and a nation's renown will be settled by its *soufflé omelette*. (1973, p. 339)

Time seems to have proved him right, as this battle has effectively begun. In building a sense of belonging to the nation and modeling and imposing its cultural prestige, France has long benefitted from the hegemonic model of its table. Now, faced with the ambitions of other countries making a claim for their own gastronomy, France deploys state communication strategies to maintain for – or reclaim on behalf of – its products, its cuisine, and its etiquette, a certain luster. For this purpose, political actors, advised by communications experts, imagine new concepts, such as la *Vallée mondiale de la gastronomie*, and new facilities, like *les Cités internationales de la gastronomie*. Official events that bring French cuisine and its art of the table to the fore make use of such sites as l' l'Élysée, Versailles, le Louvre, la Sorbonne, and les châteaux de la Loire. These national monuments serve as a gilded backdrop for chefs who themselves wear the garb of those who, during the *Ancien Régime* and *Empire*, cooked in contribution to the nation's greatness. In the absence of evaluations, it is difficult, however, to judge the reach of such initiatives. Though originally modeled on the French court, the culture of the table evolved continuously between the sixteenth and nineteenth centuries, gradually integrating the entire social body: bourgeois or peasant, Parisian or provincial, professional or familial, and refined or extremely simple, the table and its cuisine acquired various forms of excellence. Participating in the affirmation of a French culture, these literally and figuratively fed a shared imaginary around which the French model persisted. But as this prestige, having faltered, has hit a crisis point, gastrodiplomacy and nation branding have been used as rhetorical tools for staging a kind of contrived alimentary splendor that speaks to a glorious, monarchical past. In a France subject to the standardizing effects of agribusiness, where "*bien manger*" is increasingly inaccessible, such stereotypes in fact threaten the foundations upon which the French gastronomic model was historically built. It could have the effect of not, in fact, perpetuating a living, appealing, popular culture but rather of ensuring the survival of a weakened, insincere model that precludes any chance of reconquest.

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Meals and Snacks in Southeast and East Asia

24

Uyen Thuy Xuan Phan

Contents

Abstract

The concept of *meal* and *snack* has recently been the topic of interest of a body of various studies in the food choice domain. Food and drink are consumed as meal or snack. *Meal* and *snack* have a dynamic nature that is influenced by different aspects, especially culture. Culturally, the East and the West are considered to have a very profound influence on the eating and drinking of their people. This chapter explores the multicolored food culture of the East by investigating what people in East and Southeast Asia consume as *meal* and *snack*, how *meal* and *snack* are prepared and constituted, and in which manner those eating contexts happen. Besides, geography, ethnicity, and climate of those Asian subregions are also introduced. The chapter used various sources of information from public census data to research articles as well as unpublished data and prestigious education websites.

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Introduction

According to Holcombe (2011), the concept of Asia was developed by the ancient Greeks only to distinguish this continent to Europe, its counterpart on the same largest landmass on earth, the Eurasia. Nowadays, with about 60% of the world's population (approx. 4.5 billion) (United Nation 2017) and the largest GDP in the world's production, the term Asia means much more than "not European." Asia should be looked at from the human geography point of view rather than physical geography as this continent is the world's most heterogeneous in culture, language, environment, climate, economics, and even history of civilization. The development of Asia has a strong bond with the development of four regions: East Asia, South Asia, Southeast Asia, and West Asia (aka the Middle East). Among these four regions, East and Southeast Asia signify the concept of Asia more than the other two as the physical characteristics of the peoples residing there are significantly different from the people from South Asia (in which India is a representative) and West Asia.

Southeast and East Asia: A Brief Introduction to Geography, Ethnicity, and Economy

East Asia constitutes China, Hong Kong, Taiwan, Macau, Japan, Mongolia, North Korea, and South Korea. These countries and territories are different in geographical characteristics, i.e., continental (China, Mongolia), insular (Japan, Hong Kong, Taiwan, Macau), and peninsula (North Korea, South Korea). Southeast Asia (SEA) consists of countries that are south of China, east of India and North of Australia. SEA consists of two geographic regions: the Mainland Southeast Asia (or Indochina) and Maritime Southeast Asia (or the Malay Archipelago). The Mainland section consists of Cambodia, Laos, Myanmar, Thailand, and Vietnam. The Maritime region houses Brunei, East Timor, Indonesia, Malaysia, the Philippines, and Singapore (Southeast Asia 2015). However, there used to be a variation in the classification of Vietnam as an East or Southeast Asian nation. According to Holcombe (2011), as Vietnam occupies a transitional zone that straddles both East and Southeast Asia and with a historical tie with China, Vietnam used to be labeled "Little China." Even now, Vietnam is often seen belonging to the Sinosphere, which indicates the cultural influence of China on Vietnamese culture. This aspect will be discussed further in the section "The Vietnamese Meals and Snacks" about Vietnamese food culture (see section "The Vietnamese Meals and Snacks").

The ethnicity of East Asia consists of three major ethnic groups, the Han, Yamato, and Joseon (Koreans), and a number of minorities such as the Zhuang, Hui, Tibetan, Mongol, Bai, Ainu, and so on. The Han occupies the majority of the China's population, approximately 1.22 billion (about 91.6%) in 2010. The other 55 minorities comprise the remaining 8.4% (about 111 million) of the total population, with the Zhuang ranked among the minorities (Poston et al. 2015). The Yamato is the dominant ethnic group in Japan, taking up more than 90% of the country's total population (127.5 billion) (United Nation 2017). Besides, Japan also has two primary minority groups, i.e., the Ainu and Ryukyuan people. These three major ethnic groups occupy 98.5% of the Japan's population. Korea is mainly populated by a Joseon or Korean peoples. This ethnic group is very homogeneous and is residing in both North and South Korea. In Southeast Asia, the Austroasiatic peoples share the Mainland with Tai peoples while predominating the Maritime region. However, there has been a large wave of labor migration among the SEA countries (Kaur 2015). The formation of ASEAN and Mekong subregion has created the corridors for many laborers to migrate from Indonesia, the Philippines, and Thailand to Malaysia, Singapore, and Brunei or from Myanmar, Cambodia, and Laos to Thailand. Such movement has strong impact on the economic development as well as creates an intercultural complexity for the area including the diversity of regional foods and drinks.

The climate of East and Southeast Asian countries are influenced by the huge Asian monsoon circulation system. The Asian monsoon is divided into two subsystems, the South Asian (or Indian) and the East Asian monsoon systems (Yihui and Chan 2005). The latter system is also divided into the East Asian summer and winter monsoon. Much of the rainfall in the regions occurs during the summer monsoon season, usually between April and September, resulting in an intensive agriculture with two to three crops per year. Rice, the main crop in the regions, heavily relies on the yearly summer monsoon as many Southeast Asian countries do not have large irrigation systems surrounding lakes and rivers and wells or aquifers are often shallow (www.nationalgeographic.org/encyclopedia/). The winter monsoon does not have so pivotal influence in Southeast and East Asia's economy as its summer equivalent does. This season lasts from October to April, and sometimes is associated with droughts.

East and Southeast Asia, together, are the world's most populous and economically dynamic places. The diversity of ethnicities in the regions, both indigenous and migrating, has developed a multicolor food culture with unique flavors that are often identified as "Asian flavor."

Asian Flavor Signature

According to Kittler et al. (2011), food has a symbolic function of cultural identity. The old proverbial saying "you are what you eat" expresses the powerful influence of what one eats on who one is. A Southeast Asian person, thus, should not be mistaken with a European in that respect, given the profound differences between Southeast Asian cuisine and its European counterpart. As the concept of Asia is signified mainly by East and Southeast Asia (Holcombe 2011), the Asian flavor identity discussed in this section is derived from the cuisines of these subregions only.

Common ingredients in East and Southeast Asian cuisines include rice, ginger, garlic, green onion, sesame seeds, soy sauce, and tofu (Van Esterik 2008).

Depending on specific cuisine, other spices and condiments will be included. Red pepper powder in Korean foods or dried spices such as cloves, nutmeg, and cinnamon in Malaysian dishes are two examples. Besides, flavor paste such as mixture of chili, garlic, shallots, salt, and sugar is the authentic feature of many Southeast Asian cuisines such as Thai and Vietnamese. Asian foods are known for its use of a vast array of green and aromatics herbs and vegetables, either for cooking or garnishing or side dishes to go with noodles - lemongrass, basil, Chinese coriander, cilantro, mint, chives, dill to name a few. Coconut can be considered the most used fruit in SEA cuisines, as toppings or flavorings in dishes such as curries, stews, hot pot, and desserts. Different from European or Western diet, meat is not the central focus of Asian foods (Nam et al. 2010). Many of Asian meat-based dishes use only a small quantity of pork, beef, or chicken.

Fermentation is the popular food preservation method in these subregions. Fermented dishes such as *kimchi*, fish sauce, shrimp paste, and *prahok* are the vital parts of many cuisines in the regions such as Korea, Thailand, Vietnam, Cambodia, and Laos. The use of fermented fish products are the distinguishing element between East and Southeast Asian cuisines. To SEA people, fermented fish products are considered the "taste of home country" (Van Esterik 2008) and thus can partly relieve the nostalgia of the immigrants.

East Asian cuisines are found not to use ingredients that share flavor compounds (Ahn et al. 2011). The authors investigate the authenticity of the ingredients used in North American and East Asian cuisines and found that North American food heavily relies on dairy products, eggs, and wheat, while East Asian cuisine is dominated by plant derivatives like soy sauce, sesame oil, and rice and ginger. Adding these four ingredients to a dish can automatically make it taste "Oriental."

The Chinese Meals and Snacks

Located in a large area with a vast landscape of grassland, mountains, desserts, lakes, and rivers and more than 14,000 km of coastline coping with a population of 1.41 billion and diverse ethnicities, China is famous with a multi-featured food culture that satisfies the eyes and tongues of both gourmets and regular diners. Overall, Chinese cuisine can be separated as Southern and Northern cuisines, which dated back to the seventh century B.C. (Nam et al. 2010). The Southern Chinese dishes lay stress on freshness and tenderness, while the Northern counterparts are heavier in using fat and garlic due to the cold weather. Chinese dishes are also known for the ingenious use of medicinal herbs and spices for prevention and cure of diseases (see Li et al. 2004). Stir-frying is the most notable food preparation method in Chinese cooking. Thus, *wok* (a round-bottomed pan) has become an integral part of Chinese signature in the world cuisine. There are a body of various Chinese restaurants bearing the word *wok* such as China wok, Golden wok, Famous wok, Best wok, Great wok, and King's wok to name a few.

Regional cuisines play a key role in Chinese food culture. The Eight Great Traditions, including Anhui, Zhejiang, Jiangsu (east), Sichuan, Hunan (west), Cantonese, Fujian (south), and Shandong (north), have contributed their own unique features, flavors, materials, and cooking methods to shape the current Chinese cuisine (Nam et al. 2010). Anhui cuisine is known for its simplicity with wild herbs and simple cooking technique. Zhejiang cuisine has its fame in fresh and mild flavor with mellow fragrance and not greasy. Jiangsu dishes make use of a wide variety of seafood and fresh herbs and vegetable, emphasizing natural aromatics. Thus, Jiangsu foods are not overwhelmed with strong spices such as garlic and chili. Sichuan cuisine is the real opposite to Jiangsu's with the dominant use of hot and spicy (somewhat numbing) seasonings as dried chili pepper, Sichuan pepper, broad bean chili paste, etc. Sichuan hot pot, Kung Pao chicken, and Mapo tofu are some Sichuan's most famous and well-received dishes in the world. Hunan cuisine is often compared to its Sichuan counterpart for being hot and spicy. However, Hunan dishes are usually spicier by pure chili content and less oily. Cantonese cuisine, together with Sichuan's, has traveled the most thanks to the economically importance of Hong Kong and the Pearl River Delta region in the 1980s and 1990s and the migration of workforce from Sichuan Province and Chongqing Municipality (Klein 2009). Cantonese foods are restricted in the use of spices and condiments to promote the freshness and quality of the main ingredients. Fujian or Hokkien cuisine stresses the umami taste and often is light but subtly flavorful. The common cooking methods are boiling, steaming, stewing, and braising. Last but not least, the Shandong cuisine completes the eight major cuisines of China with an emphasis on seafood (sea cucumber is a favorite), onion, and soup (clear and milky). Shandong dishes are typically fried, making it crisp, tender, and greasy.

China has a long historical tradition of agricultural practice, and main staple foods are plant-based foods. Rice (*fan*) and side dishes (*cai*) of vegetables are always the main components of every Chinese meal (Klein 2009). This is considered the elementary structure of a Chinese traditional meal. Plain rice is typically steamed or boiled and served separately from the side dishes. In addition to vegetables, there has been an increase in the consumption of meat and meat products, fish and seafood, milk and eggs, fat, and alcohol since 1990s (Klein 2009; Nam et al. 2010). The scarce consumption of meat can be accounted for religious practice of Buddhism and Taoism in the country.

Culinary art is the unique feature of Chinese cuisine. In China, food is also for psychological satisfaction. Chinese foods are artistic and sensitive (Sun et al. 2004). There are several fundamentals in the constitution of a Chinese *meal*. The first one is the pivotal role of rice (饭:*fan*). A Chinese meal is constructed around rice. The word *fan* (饭)can also be translated to *meal* when it is combined with words indicating time of the day such as *zaofan* (早饭:morning meal or breakfast), *wufan* (午饭:midday meal or "lunch"), and *wanfan* (晚饭:evening meal or "dinner"). According to Klein (2009), a proper balance between *fan* and *cai* is the factor distinguishing a Chinese *meal* from a *snack* (*xiao chi* or small eating). The second fundamental is in the food preparation method, in which careful attention is paid to the application of "adequate" heat as well as chopping and cutting the materials to acquire eye-catching appearance. Another specialty of Chinese food is the combination of key spices that create the so-called Chinese flavor to the dish. These normally are ginger, soy sauce, and onion (Nam et al. 2010; Klein 2009).

A Chinese meal is built around social relationship and hierarchy. Family members sit around a table for regular meal. The seating is arranged around the highest honorable person in the family that could be the grandpa or the father depending on whether it is an extended or nuclear family. The underlings are taught to serve food to the elders first, and the meal does not start until the elders begin. Having meal together is a way the Chinese as well as other East and Southeast Asian peoples strengthen kinship and community relationship. In Chinese culture, people usually treat others to meal to make friend or enhance established relationship. Rice is served in a common bowl and so do side dishes. Diners take foods from those sharing bowl by their own chopsticks. Serving spoon or fork or chopsticks are sometimes provided for hygiene reason, though this manner is usually not a common practice at family meal across China (Ma 2015).

The pattern of having three meals a day is also popular in China. However, this pattern is more preferred in urban than rural areas, where people tend to eat two meals a day. According to Ma (2015), the Chinese people eat breakfast around 6:00 AM to 8:00 AM and later on weekends. Residents of big cities such as Shanghai or Beijing do not have breakfast regularly for reasons such as limited time or losing weight. This breakfast skipping trend is also widespread in the world. Chinese breakfast foods are often light and simple such as dumplings, congee, soymilk, steamed buns, or noodles. Lunch normally takes place between 11:00 AM and 1:00 PM. Lunch can be eaten at home, in office, or in fast-food restaurants. In contrast, Chinese dinner is more abundant in foods, commonly two to four dishes and one soup (Ma 2015).

Chinese food culture is also famous with an assortment of *xiaochi* (snack foods) which are the important category of street food. The traditional *xiaochi* are made of grains and beans. Kimura (2012) has named a number of favorite Beijing *xiaochi* including *doufu nao* (unmolded hot soft tofu covered with a sauce), *dou jiang* (soy milk), *youtiao* (deep-fried, twisted bread sticks), *baozi* (steamed buns), *zhima shaobing* (hard bun with sesame), and *douzhir* (supernatant of fermented mung bean milk). *Xiaochi* are sold in markets and street food stands. They have become specialties for dining out in many cities across China. *Xiaochi* foods are traditionally consumed in between meals, as snacks, when diners are visiting markets or temples. *Xiaoye*, the midnight snack, is also formed by *xiaochi* food items. In addition to three main meals, the Chinese do consume snacks and have a flavorful collection of traditional *xiaochi* to snack on throughout the day.

The Japanese Meals and Snacks

The geography and climate of Japan play an essential role in shaping the Japanese food culture. Japan is a multi-island nation whose majority landscape is mountain and is surrounded by the sea. The Japanese cuisine, thus, greatly reflects those two resources, and the Japanese refer to their food as “the delights or treasures of the seas and the mountains” (Ashkenazi and Jacob 2003). Wide valleys and its rivers are also important parts of Japan’s landscapes that provide a vast array of freshwater produces to the Japanese cuisine. Japan enjoys a temperate climate with four distinct seasons: cold temperate winter from December to February, warm-but-not-too-hot spring from March to May, hot and humid summer from June to August, and cooler autumn from September to November. Overall, the country is cold in the north, temperate in the central, and subtropical in the south. The average annual rainfall is high across the country, especially in between summer and autumn. The climate of Japan is also influenced by the monsoon circulation. This is especially crucial for the growth of rice, the most important staple crop in Japan. Rice, of course, is one essential element of a Japanese meal. This is clearly displayed in the word the Japanese use to indicate *meal*, *gohan* (ご飯), which literally translated as "rice." Thus, breakfast is called *asagohan*, lunch *hirugohan*, and dinner *bangohan*. This construction of meal label is very coherent with that of the Chinese meal label discussed in section "The Chinese Meals and Snacks". Three meals a day is also a common food pattern in Japan.

Unlike Western breakfast, Japanese traditional breakfast has all elements of a complete meal, comprising of steamed rice garnished with nori; miso soup, a protein (salted grilled salmon, for instance); and various side dishes such as pickled vegetables (Kittler and Sucher 2001). However, to the Japanese, breakfast is not supposed to be heavy, and thus breakfast foods are often light and not oily. Western-style breakfast has recently emerged in Japan due to its convenience and less time consuming as compared to the traditional style. Cereal and milk, yogurt, toast, butter, eggs, and sausages are some common Western-style breakfast foods in a Japanese household. Many Japanese people have lunch away from home during the week-days, and thus Japanese lunch is lighter and simpler. *Bento*, boxed lunch, has become a unique feature of Japanese food culture. *Bento* can be either homemade or purchased from convenience store or specialty shop and comes in a huge variety (Koh 2003; Ashkenazi and Jacob 2003). *Bento* is also highly appreciated for many other occasions such as picnics or even between acts in the theater. The stay at homes also prefer a light meal such as a bowl of noodles or rice with leftovers from previous night. Dinner tends to be more elaborate and complex as it is the main meal of the day for many Japanese people after a long working day. Evening meal often includes rice, soup, a protein (meat or seafood), side dishes of vegetables, and pickles (Koh 2003). This adheres to the *ichijûsansai* structure (one soup, three dishes) with the unquestioned presence of rice. If missing one of these elements, particularly rice, the eating is considered incomplete or a *snack* before a main *meal*. According to Ashkenazi and Jacob (2003), the three *ichijûsansai* dishes are one of raw fish (*sashimi*), a food cooked in a sauce (*nimono*), and a grilled or roasted dish (*yakimono*). Murakami et al. (2019), using the data from the 2012 National Health and Nutrition Survey in Japan (NHNSJ), has identified various meal-specific dietary patterns, as follows:

– Breakfast (four patterns): "Rice/vegetable/fish/pulse/seasoning," "bread/dairy/fruit/sugar," "meat/egg/fat," and "tea/coffee"
– Lunch (four patterns): "Bread/dairy," "noodle/seasoning," "meat/fat," and "vegetable/pulse/potato/sugar"

– Dinner (four patterns): “Meat/vegetable/seasoning,” “noodle/alcoholic beverage,” “fish/sugar/alcoholic beverage,” and “other grains/fat”

Those patterns confirm the increase of meat consumption in Japanese diet, which used to consume more fish than meat (Nam et al. 2010). In other word, Japanese diets have become more westernized.

The Japanese also enjoy snacks. Murakami et al. (2019) indicated that on average snacks contributed to 8% of the total energy intake of the Japanese participants in the 2012 NHNSJ. Working people often pause for a midmorning snack that can be a quick bowl of noodles or a cup of tea with a rice cracker (Ashkenazi and Jacob 2003). Western-style snacks such as cookies, cakes, or ice cream are also available. *Oyatsu (*お八つ), whose meaning can be either a snack at 3:00 PM or a snack between meals (wiktionary.org/お八つ#Japanese), is included in Japanese diet. Street food vendors or fast-food restaurants are some of the possible places for a Japanese to have a quick bite (Traphagan and Brown 2002).

Korean Traditional Meal

Korean food culture has been developed in close relationship with its long agricultural history and the urge of food preservation due to a monsoonal climate with a hot summer and a harsh winter (Chung et al. 2016a; Kim et al. 2016b). Fermentation has historically become the ideal choice for food preservation in Korea due to the limited production of cooking oil (Kim et al. 2016b). Various fermented dishes made of fish, vegetables, and beans have been the authentic feature of Korean cuisine. Fermented soy products, *jang*, including *kanjang* (soy sauce), *doenjang* (soybean paste), and *gochujang* (hot fermented chili paste) as well as *kimchi* (fermented cabbage and radish are the most two common), are some examples of the popularity of fermented dishes in Korean diet.

Korean food can be commonly defined as “food made with traditional Korean ingredients or agricultural products” or more precisely as “foods made with ingredients or agricultural products that have been traditionally used in Korea, or with similar ingredients or agricultural products, use authentic or other similar cooking methods, have historical and cultural characteristics, and have developed and passed on through people’s lives” (Chung et al. 2016a). The latter definition is praised for its reflection of consistency, patience, consideration, beauty, and appreciation for art (Kim et al. 2016b). K-diet has been defined in the Seoul Declaration of Korean diet (Kwon 2016) as quoted below:

– composed of Bap (cooked rice) and Kuk (soup), and various Banchan (side dishes) with one serving called *bapsang*
– kimchi is always served at every meal
– includes proportionally high consumption of vegetables, moderate to high consumption of legumes and fish and low consumption of red meat
– banchan is mostly seasoned with various jang, medicinal herbs, and sesame or perilla oil

The Declaration also characterized the K-diet as having various recipes based on rice and grains, more fermented foods, scarced deep-fat fried cooking, more meals from seasonal produce, various local cuisine, and more home-cooked meal. In Korean perception, food, revealed from the ten most renowned Korean paintings, is a symbol of power, health supplements and medicine, feelings and affections, and medium to communicate with gods (Chung et al. 2016a).

Korean meals, thus, are typically constructed around that *bap/kuk/banchan* combination. The Koreans also eat three meals a day as the Chinese and Japanese do. Breakfast, however, is a bit lighter than lunch and dinner and/or with fewer *banchan*. Rice, soup, *kimchi*, and any number of *banchan* would make the first meal of the day complete. In addition to the traditional meal type (*bapsang*), the Koreans also like noodles with broth and meat or vegetables at lunch time (Kittler and Sucher 2001). Dinner is considered the main meal of the day and faithfully adheres to the *bap/kuk/banchan* principle. Korean people have a tradition of eating meat, dated back to the invasion time of the Mongolians in the thirteenth century (Nam et al. 2010). Pork, beef, and chicken are the main meat ingredients of the Korean cuisine. Meat is prepared by various cooking methods including roasting, grilling, stewing, steaming, or boiling in soup. Meat is often marinated with *Doenjang* for flavor enhancement. Various meat-based dishes have become an essential part of the *banchan* category. Table 1 presents some of the featured dishes of the Korean *bapsang*.

Home-cooked meal (*jipbap*) would be the most preferred as the Korean people greatly value family relationship, and in their opinion, food represents a mother's love (*umma-sonmat)*. The Koreans also pay much attention to the visual appeal of the food beside flavor. Korean foods are found to possess various aesthetic qualities such as the aesthetics of harmonization and convergence, of waiting and patience, of beauty with various colors, and of refinement (Chung et al. 2016b). *Bibimbap* (a one-bowl rice dish with mixed vegetables and gochujang), *tangpyungchae* (mixture of *chungpo-muk*, beef meat, and vegetables), *seok-ggakdugi* (a food made with white radishes that are boiled for ease of consumption for the elderly), and cherry *pyun* (a traditional Korean snack (*hangwha*) made from a mix of sifted cherries, honey, and starch that is boiled down and hardened) are some examples of such qualities (Chung et al. 2016b). Thus, a Korean meal is a good example of food with both beautiful appearance and authentic taste.

The Vietnamese Meals and Snacks

Vietnam is located on the Indochina Peninsula. It borders China to the north, Cambodia and Laos to the west, the Gulf to Tonkin to the east, and South China Sea to the south (Walther et al. 2015). The country mainland area has an S shape, stretching from latitude 23°23′ north to 8°27′ north (Vietnam Government Portal, http://www.chinhphu.vn). In 2018, the population of Vietnam is more than 94.6 million (General Statistics Office of Vietnam, http://www.gso.gov.vn). The average temperature in Vietnam ranges from 21 °C to 27 °C and gradually increases

Table 1 Some featured dishes of a Korean meal

Category	Name of dish	Description	Source
Rice (*bap*)	*Ssalbap*	White rice, brown rice, black rice	Kim et al. (2016b)
Soup (*kuk*)	*Doenjangkuk*	A soup made with vegetables and *doenjang*	Kim et al. (2016b)
	Miyokkuk	Sea mustard soup	Kim et al. (2016b)
	Soegogimukuk	A beef and radish soup	Kim et al. (2016b)
Side dishes (*banchan*)	*Kimchi*	Fermented vegetables (commonly cabbage or radish) with a variety of seasonings such as red pepper powder, garlic, spring onion, ginger, and salted seafood	Jang et al. (2015); Park et al. (2014)
	Namul	Vegetable side dishes that are either steamed, stir-fried, or marinated and seasoned with sesame oil, salt, vinegar, garlic, green onion, dried chili peppers, and soy sauce	Kim et al. (2016b)
	Bulgogi	A barbecued beef, where beef is sliced and marinated in soy sauce and spices and then cooked on a grill	Nam et al. (2010)
	Samgyeopsal	Grilled pork belly which is unseasoned	Nam et al. (2010)
	Ssam	Loose leaf lettuce, *Perilla* leaf, crown daisy	Kim et al. (2016b)
Sauce (*jang*)	*Doenjang*	A fermented soybean paste traditionally manufactured from *meju*, which is fermented rectangular shape molded from crushed cooked soybean	Park et al. (2003)
	Gochujang	A red pepper paste made from *meju*, rice powder, salt, and red pepper powder	Shin and Jeong (2015); Kwon et al. (2015); Kim et al. (2016a)

from north to south. Average annual rainfall is from 1,500 to 2,000 mm. Air humidity is less than 80%. Because of monsoon influences and terrain complexity, Vietnam is often hit by severe weather such as typhoons, floods, and droughts.

The territory of Vietnam is geographically divided into three distinct regions, i.e., North, Central, and South. Each region has its own unique characteristics in biodiversity, culture, ethnicity, and climate. These characteristics have defined those three regional cuisines. The Northern Vietnamese cuisine focuses on the elegance and delicacy of foods that are often mild, subtle, less spicy, less fatty, and less sweet than the other two regional cuisines. *Pho*, the world renowned beef noodle soup, is the representative of this type of cuisine. The Central cuisine is not so delicate as its Northern counterpart. It is characterized by bold, salty, and spicy flavor. As food resources are scarce due to a severe climate, brining is commonly used for food preservation, and thus dried salted seafood products have become an important part of daily meal in this subregion. Besides, fermented fish products are also popular such as *mam ruoc* (fermented shrimp paste). Salt, *củ nén* (*Allium* genus), peanut, galangal, black pepper, and chili are the typical spices in Central cuisine. The Southern cuisine is distinguished from the other two cuisines by its sweet flavor. Tamarind, lemongrass, and coconut (usually coconut water) are common ingredients (Helmisaari 2015). Southern Vietnamese cuisine pays much attention to the flavor not visual appeal of the dishes.

Vietnamese cuisine, overall, follows the two principles of yin-yang (*am duong*) and five elements (*ngu vi*). Yin-yang principle is shown in the way food ingredients are combined, i.e., "cold" ingredients require "hot" spices and vice versa. Duck meat (cold) has to be cooked/eaten with ginger/ginger sauce (hot), or spicy foods (hot) have to go with sour and sweet tastes (cold). The generating interaction between the five elements which include metal, wood, water, fire, and earth is employed via the harmonious combination of at least five ingredients in one dish. The five ingredients of minced pork (protein, earth; fat, fire), rice vermicelli (starch: wood), salt (metal), and onion (water) in *nem rán* (deep-fried spring roll) are good example of this principle. Duong et al. (2014), by interviewing 100 foreign tourists, reported that tourists perceived Vietnamese foods as delicious foods, diversified in ingredients combination, made of distinctive ingredients, made of fresh ingredients, good for health, and visually appealing.

Vietnam is the most Sinicized country in the Southeast Asia as it has significant historical ties with China (Holcombe 2011). Vietnamese cuisine, consequently, is substantially influenced by Chinese cuisine. The essential role of rice and side "with rice" dishes in the constitution of a Vietnamese meal is the firm evidence. Some characteristics of a Vietnamese meal can be pointed out as below (Van Esterik 2008; Helmisaari 2015).

- Rice is served from a communal pot with people taking individual serving on separate bowls.
- Rice is eaten with a variety of side dishes including fish, vegetables, soup, sauces, and condiments.
- *Nuoc mam* (fish sauce) is a basic ingredient and iconic condiment present at all meals.
- Use of fresh herbs and leafy vegetables such as mint, basil, cilantro, and coriander stands out.
- Pork is the main meat as it is consumed by over 98% of the Vietnamese household.
- Chopsticks are daily used.

A recent study by Phan and Chambers (2018) investigated the inter-regional differences among the people of the North, the Central, and the South of Vietnam in their food patterns and their motives of not choosing certain foods for meals and snacks. The findings from a total of 836 participants (278 North, 213 Central, 345 South) show that rice is more likely to be eaten for breakfast in the North and the Central than in the South where rice noodle soups are the most popular breakfast food. There is no difference in preference for lunch foods among the three regions. For dinner, the Central people do not eat fast foods (pizza, burger) as often as people in the other two regions do.

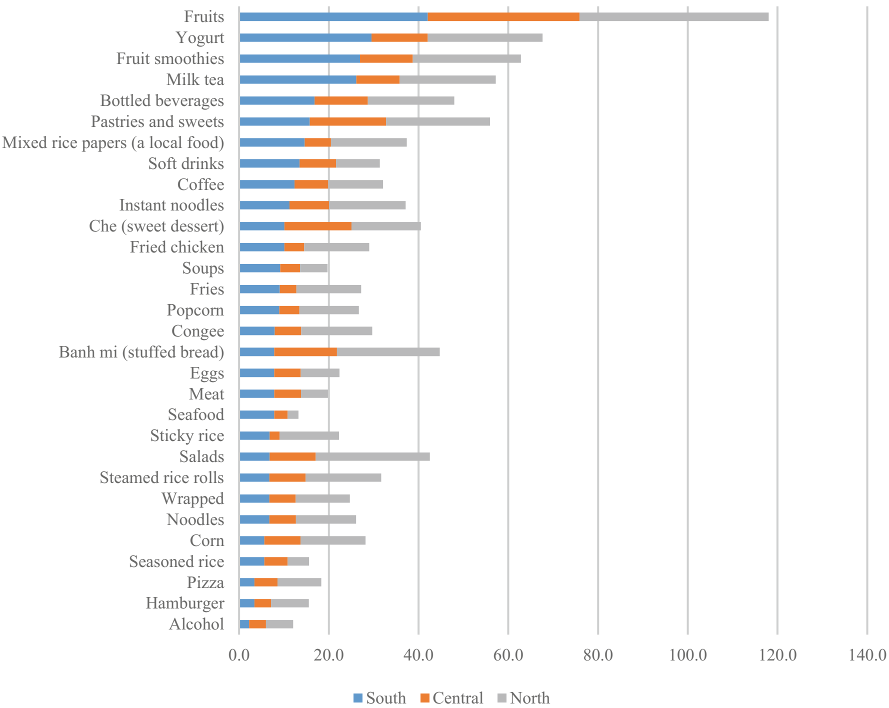

Fig. 1 Consumption likelihood of 31 snack food categories as reported by 310 respondents from the North (85), Central (136), and South (89) of Vietnam. (Phan and Chambers 2018)

Various snack foods can be found in Vietnam, from North to South. In the North, snacks are affectionately referred to as "*quà vặt*," in which *quà* literally means gift and *vặt* can be understood as small, extra eating. Thus snacks are equivalent to treats. Figure 1 presents the likelihood a food can be chosen for snacking by a Vietnamese who is from either North, Central, or South of Vietnam. Fruits, yogurt, fruit smoothies, milk tea, bottled beverages, pastries and sweets, *banh mi* (Vietnamese stuffed bread), and salads (various styles, often seasoned with fish sauce) are the snack categories that many Vietnamese people would choose for their extra eatings. This shows the diversity of Vietnamese snacks, including both sweet and savory dishes, as long as the dish does not contain rice. This somehow reconfirms the "meal-making" function of rice in Vietnamese food culture as the word *meal* in Vietnamese, *bữa cơm*, contains the word rice (*cơm*).

Thai Cuisine and Thai Meal Constitution

Thailand is the only Southeast Asian country that has never been colonized and thus it enjoys the freedom of adopting ingredients and dishes from other countries (Seubsman et al. 2009; Van Esterik 2008). Indian foods, such as curries, introduced by the Khmer in the fifteenth century (Sunanta 2005); chili by the Portuguese in the sixteenth century; herbs, fruits, and stir-fried dishes by the Chinese (Seubsman et al. 2009); and Western cuisine in the seventeenth century (Sunanta 2005) are important examples. Similar to other Southeast Asian cuisines, Thai foods are known for containing lots of fresh herbs and spices such as citrus, basil, cilantro, ginger, galangal, turmeric, garlic, shallots, pepper, and chilies. Fish sauce is also an authentic feature of Thai foods. Thai fish sauce is usually made from fermented shrimp or squid or oyster (Nam et al. 2010) which is different from Vietnamese fish sauce, which is made from fermented fish like anchovies. The regular uses of galangal, kaffir leaves, holy basil, and ginger and the combination of sweet, sour, salty, bitter, and spicy (Zevnik 2016) have created the distinctive Thai flavor that helps distinguish Thai cuisine from other Southeast Asian cuisines such as Vietnamese or Cambodian ones.

Thai meal is often comprised of a number of dishes that are different in color and flavor. Some principles of taste combination can be pointed out as sweet and sour, hot and spicy, and salted or bland (Seubsman et al. 2009). An early work reported that a proper Thai meal is constructed around rice (*khaw*) and also follows the constitution of rice and "with rice" (*kab khaw*) side dishes (Walker 1996). "No meal is complete without rice" was one of the attitudes the Thai participants in that early study stated. A more recent study has confirmed the essential role of rice and vegetables in a Thai daily meal (Papier et al. 2017). Fish and seafood are preferred source of protein. Meat plays a minor role in Thai meals because cows and buffalos used to be the mainstays of farm and village life (Mortero 2005). Thai meal also practices the five elements principle via the combination of ingredients. Besides, the aesthetics of elegance is another feature of Thai meal. This can be observed from various royal dishes.

Thai people has a unique dining etiquette as food must not be eaten fast, and the mouth should be closed while chewing. Soup must be eaten by spoon. Thai people use fork and spoon for all foods except noodles (primarily eaten using chopsticks) (Nam et al. 2010). Fork is set on the left-hand side of the rice plate, and spoon is on the right-hand side. The tradition of using fork and spoon dates from to the nineteenth century in the reign of King Rama III. Thai people generally share meal with family and friends to reinforce their relationship (Thanasabkasem 2014).

Thai people often consume one-dish meal for breakfast and sometimes Western-style breakfast and coffee. In addition to the three-meal pattern, between-meal snacks are common in Thai diets. Nutrition transition has been found in Thai diet as reported by Kosulwat (2002) or Kelly et al. (2013). Papier et al. (2017) recently explored four dietary patterns for both Thai men and women, including healthy transitional (soy milk, beans, and milk), fatty Western (fatty meat and deep-fried and Western foods), highly processed (fruit with added sugar, processed fruits), and traditional (fermented fish and soybean, glutinous rice, bamboo shoots, and chili dipping sauce). Among those, traditional diets are characterized by "high sugar, starch availability, and lower dietary diversity" and so are highly processed.

Thai food preparation methods are passed down from generation to generation. Following methods are those playing essential role in the designation of Thai food (Thanasabkasem 2014).

- *Tam*: Pounding food with mortar and pestle
- *Yum*: Combining cooked meat with vegetables, fresh herbs, and seasoning with salad dressing
- *Gaeng*: Cooking meat and vegetables in water or coconut milk
- *Tom*: Boiling
- *Yang*: Grilling or roasting over low or medium heat (charcoal is often used)
- *Larb*: Mincing or grounding pork or poultry and seasoning with herbs and toasted rice
- *Tom* Yum: Making spicy soup by using lemongrass, kaffir lime, and chilies and seasoned with lime juice and fish sauce
- *Ping*: Grilling over medium fire until done, resulting in crispy surface

The following statement by Thompson (2002) has beautifully and precisely described Thai cuisine: "Thai is not an instant cuisine. . ., it expects time and effort to be spent and it requires honed skills, but it rewards with sensational tastes."

Conclusions

Southeast and East Asian cuisines represent not only the food cultures but also the geographic, social economic, historic, climatic, and ethnic characteristics of the regions. Southeast and East Asian food cultures have interrelationship with each other, especially there has been a strong Chinese influence on the food cultures of the majority of Southeast Asian countries. Due to this Sinicization, meals in East and Southeast Asia share a common feature in its strong bond with rice. However, each cuisine has managed to develop unique flavor codes via the remarkable harmonization and combination of various ingredients, especially herbs and spices, condiments, and sauces. This very fine practice is the key of success for anyone who would like to create the so-called Asian flavor.

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25 Meals in Western Eating and Drinking

Mari Niva and Johanna Mäkelä

Contents

Abstract

Meals are a way of organizing eating into events that have a particular structure and form, and they play an indisputable and even self-evident role within the rhythms and routines of everyday life. In late modern societies, concern about the fate of meals has arisen in both public and academic discourse. It has been suggested that eating is characterized today by individualization, destructuration, and informalization and that communal meals are increasingly being replaced by snacks and solitary eating. This chapter focuses on meals in today's affluent societies and reflects on why meals are considered important, how meals are defined, and what material elements and social dimensions they contain. It looks at how societal and cultural changes and ecological concerns may influence the organization and future of meals, and it suggests that the content of meals will change in response to the need to diminish the ecological burden of food production and consumption. In particular, plant-based options will at least partly need to replace meat and other animal-based foods. However, there is no reason to expect that the meal as a social institution will break down. Despite the fact that

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not all meals are characterized by conviviality and companionship, they continue to serve as a significant arena of human sociability and togetherness. Sharing food is, after all, an essential part of being human.

Introduction: Why Do Meals Matter?

Meals are considered to be a profound element of human sociality, and they are important in our lives in numerous ways, both practically and symbolically. In the *practical sense*, food is fundamental in keeping us alive and going, and what is eaten at meals is significant for both short- and long-term health and wellbeing. Procuring food, planning and preparing meals, eating, and cleaning up afterward take up a significant portion of our waking hours, and meals both shape and are shaped by the schedules and rhythms of daily life. Meals punctuate our days and separate weekdays from weekends and the everyday from the feast. Buying food demands financial resources, and, for those with small incomes, finding the money to obtain food that is both liked and nutritionally adequate may be a constant struggle and cause of distress (Holm et al. 2018).

In the *symbolic sense*, meals signify diners' positions in their social networks and reflect their cultural and culinary capital as well as their ideas about what is good and proper eating. The characteristics of the foods that are eaten and the social organization of a meal, such as how and by whom it is cooked and with whom and at what level of formality it is enjoyed, are all loaded with symbolic meaning. It is difficult to find any "occasion for significant human interaction" in which food does not play a role; a celebration or other important gathering without eating together would be most exceptional (Lalonde 1992, p. 71). And as Mary Douglas (1972) has noted, the ways in which people orchestrate their eating into meals reflect the forms of social relationships of which they are the core. Sharing a meal with somebody is a sign of belonging to a particular community. Food communicates who people are within their communities and social relations, and both the symbolic meanings and practical organization of meals may differ according to the diners' social positions (Bourdieu 1979/1984).

Contemporary ideas about good eating are informed by a range of food-related discourses on such topics as healthiness, family communion, commensality, good taste (in both the sensorial and sociocultural meanings of the word), expectations of the preferences of diners, know-how and skills in cooking, and, increasingly today, concerns about what is sustainable in terms of eating. The cook and the person eating are now expected to take a stand not only on the "private virtues" implied by the consumption of food, such as taste, price, convenience, and nutritional value, but also on the "public virtues" relating to the wider society, such as ethics, justice, and ecological impact (Micheletti 2003; Niva and Jallinoja 2018). Such expectations broaden the scope of what good meals and eating are about and make new demands on consumers and meal providers to eat in socially and environmentally responsible ways.

The current discourse on food and eating often centers on food choice, a term adopted in both popular discourses and in many disciplines. Individualistic in its tone (see Murcott 1998), food choice is used as a general denominator of what people choose to eat and the individual characteristics, motivations, and attitudes influencing their choices. From the perspective of everyday life, however, where most eating takes place in the context of meals, one might ask whether it would be more useful in studies of eating to think of meals rather than food choices as the analytical unit of investigation. In his reflection on how meals influence food choices, David Marshall (1993) concludes that not only acceptability but also *appropriateness* to purpose is essential when people consider what food to eat. Appropriateness refers to the context in which the food is to be consumed and embraces the type of eating event (breakfast, lunch, dinner, or snack), the social company, and the formality of the eating event (on the application of the concept of appropriateness in consumer and sensory sciences, see Giacalone 2019). The food has to fit within the "meal system" (Marshall 1993, p. 280) of the household and accord with various often implicit rules concerning what, how, and when it is appropriate to eat. In this way, appropriateness determines what is chosen as food. Similarly, in a later chapter, Marshall (2005) contends that the meanings of food reside more in the routines, conventions, and rituals of meals than in the foods that are eaten at them. In this sense, food choice can be seen as subordinate to how meals are socially organized and regulated in the routines and habits of everyday life (see also Warde 2016; Murcott 2019).

There are strong social norms around meals. As noted in the Introduction, one of the more important norms relates to commensality (Fischler 2011), i.e., eating at the same table with other people and sharing food with them. Numerous studies have shown that commensality is regarded as an essential part of eating and of what is considered to be a "proper" meal (e.g., Mäkelä 2009; Charles and Kerr 1986). For instance, Sobal and Nelson (2003, p. 188) emphasize the significance of commensality by rephrasing the saying "you are what you eat" to "you are who you eat with." Social psychologists use the concept of "social facilitation" to describe the tendency of people to adapt to other people's eating in social situations (Higgs et al. 2019). For instance, people often adjust what and how much they eat to the behavior of significant others present in the situation. The commensal units and circles (Sobal and Nelson 2003) in which people operate reflect social relationships in family life, work, and society at large. The most important commensal unit is the family, followed by groups of people getting together for lunch or coffee at work. Commensal circle refers to a wider network of people who could, in principle, take part in a meal, with the family still at the core of the circle.

Due to the strong connotation of eating together as a sign of family communion, family meals have been described as the "archetype" of commensality, with the combination of food and family creating an idealized "symbolic icon" (Sobal et al. 2002, pp. 391–392). Families are seen to reaffirm their cohesion by eating together, and those failing to do so are dismissed as failed families. So powerful is the social norm of family eating that food providers, particularly in middle-class families, tend to praise commensal eating as the ideal although that does not necessarily mean that they are able to eat family meals regularly (Backett-Milburn et al. 2010) or that meal provision is something that parents actually enjoy. Kinser's (2017) study shows that, even though mothers work hard to cook and share meals with their families, they may have decidedly mixed emotions about the obligation and responsibility to do so. The participants in Kinser's focus groups provided meals at the expense of their own needs and interests and struggled to arrange family meals for "the health of it, and . . . for the *status* of it" (p. 38). Overall, their accounts of family meal provision were characterized by notions of work, burden, battle, fighting, and control. As the quotation shows, the mothers were well aware of not only the claimed benefits but also the social value and normative expectations of family meals.

Such everyday struggles are forgotten, however, when the ideal of the family meal is celebrated in both public discourse and in numerous nutritional, psychological, and social scientific studies that demonstrate the multiple benefits to children of regular family dinners. Adolescents who frequently eat a family meal have lower odds of cigarette smoking, alcohol use, and drug experimentation even when controlling for family structure and parental education and employment (Mure et al. 2014). Brown et al. (2019) show that adolescents who feel loved by their parents and like to spend time with them are more likely to eat family meals than others. Studies also show that adolescents and young adults themselves value family meals (e.g., Hunt et al. 2011), so it is no wonder that parents see it as their responsibility to provide the shared experiences of eating with their children. School meals are also expected to be commensal events that enhance the school community and lead to better academic performance, improved behavior, and more energetic children (Elliott and Hore 2016).

Shared meals are lauded not only by families with children but also by newlyweds and cohabiting couples. Marshall and Anderson (2002, p. 193) found that, for young Scottish couples, a shared dinner was an important part of living together and spending time with one's partner and that "eating properly" was a metaphor of family life. Similarly, according to Sobal et al. (2002), eating together is a major spousal obligation through which newlywed couples in the US negotiate their "food lives" (Sobal et al. 2002, p. 384) so as to enjoy commensal meals within "doing marriage" (Sobal et al. 2002, p. 391) and strengthening their conjugal ties. "Proper meals" involve eating with a "proper person" (Sobal et al. 2002, p. 391); for newlyweds, that is self-evidently the spouse.

Such is the power of the ideal of shared meals that eating alone is frowned upon. A lonely diner is pitied, and people are assumed to prefer eating in company if they have the opportunity to do so. Indeed, a person declining the company of others at a meal is regarded as strange because people are expected to share their food (Fischler 2011). It has been found, however, that older people who live alone may actually enjoy eating alone, deciding by themselves when and what to eat, and not having to worry about other people's preferences. Eating in solitude may thus symbolize control, independence, and competence (Thomas and Emond 2017). At the same time, a growing body of literature focuses on "solo dining," understood as eating alone in the public sphere (e.g., Lahad and May 2017). Some solo diners may dine alone because they are travelling alone while others may take great pleasure in going out for a solitary meal to enjoy the taste of food and the dining experience without having to socialize (beyond discussing the food with the restaurant staff).

An important element of commensality has been the idea of sharing the same food, but this ideal has not always been fulfilled in practice. Historically, there is evidence of privileging men's nutritional needs over those of women, with women obliged to settle for inferior food compared to men (Murcott 2019). Research in Britain in the 1980s showed that, in unemployed families with tight budgets, women would do without meat and fish so that their husbands and children could eat adequately (Charles and Kerr 1986). Interestingly, the variation in foods eaten at a shared meal today is often based on individual choices and dietary restrictions rather than differences in family members' autonomy and power relations. Allergies, chronic illnesses, and the increasing popularity of, for instance, vegetarian and vegan diets pose challenges to the ideal of a meal as an event for eating and enjoying the same food (on veganism, see the chapters in this book's section on ethics of eating; on vegan diets and family conflicts, see, e.g., Roth 2005).

What Is a Meal?

Contemporary Western eating can usefully be described as an "eating system" (Mäkelä et al. 1999; see also Gronow and Holm 2019). This system includes three dimensions: eating pattern (the rhythm and the number of eating events as well as the alternations of hot and cold eating events), meal format (the composition of the main course and the sequence of the whole meal), and the social organization of eating (where and with whom people eat and who did the cooking). In a similar vein, Yates and Warde (2015, p. 300) define the cultural complex of a meal as comprising the foods and dishes that are served, the patterning of the eating events (i.e., the structure of the sequential episodes), the format of the event (i.e., the organization of dishes in parallel and in series), the preparation and provisioning of the meal, and finally, the social occasion of the event. Lalonde (1992, p. 70) has suggested four interpretations of a meal: It can be thought of as "timely repast," as an object with a particular structure, as "scripted" action with certain objectives, or as a socially meaningful event.

The roots of exploring meals as a vital part of people's everyday lives can be traced to British meal research in the 1970s and 1980s. Scholars such as anthropologist Mary Douglas (1972/1997; see also Douglas and Nicod 1974) and sociologist Anne Murcott (1982) explored British working class and Welsh middle-class meals to characterize the grammar of a "decent" and "proper" meal in the British context. In their classic article, Douglas and Nicod (1974) describe the structural and taste characteristics of the meals using the binary pairs of salty/sweet, hot/cold, and liquid/dry. In addition, they found that the classifications of meals were based on their abundance, complexity, and ceremonial aspects. According to Douglas and Nicod, the British working-class meal model comprises many distinct, complementary, and often contradictory classifications.

Douglas and Nicod (1974) also devised a meal system that consists of three meal types. The first is a major meal or the main meal (A), the second is a minor meal or the second meal (B), and the third category consists of even less significant meals, or third meals (C) (Douglas and Nicod 1974). They found that the meal categorized as a main meal in Britain was based on the elements of a staple (potato), a center (meat, fish, or egg), trimmings (vegetables), and dressing (gravy). Anne Murcott (1982) pursued the same approach in her work on proper meals in South Wales. Not surprisingly, she found that a proper meal possessed the same structure that Douglas and Nicod had found: It consisted of one meat-based course, two vegetables, and gravy, which tied the ingredients on the plate into a proper meal. Indeed, a proper meal was a plateful of ingredients that were carefully chosen to represent a particular element of a meal.

The British meal research tradition has been very influential worldwide but especially in the Nordic countries (see, e.g., Gronow and Holm 2019). In the late 1980s, Marianne Ekström (1990) applied the idea of a grammar of meals in her study of Swedish meals. She concluded that a cooked (i.e., proper) meal consists of four components. The main ingredient was usually meat or fish, the first trimming was the starchy element (e.g., potatoes), and the second trimming comprised vegetables. Finally, extra trimmings could be vegetables or condiments. Later in the 1990s, a research project on Nordic meal patterns (Kjærnes 2001) defined a proper meal in the Nordic countries as a plateful of food consisting of at least three elements: a center (C), a staple (S), and vegetables (V) or, instead of vegetables, bread (B). In addition, a proper meal might include trimmings, such as sauces, condiments, or pickles (see Mäkelä 2001). A study in 2012 found that dinners in the Nordic countries are still typically one-course meals with relatively simple structures (see Holm et al. 2019 in this collection). This Nordic meal model contrasts with, for instance, Italian or French traditions favoring meals with several courses (Poulain 2017).

As the above examples of meal research suggest, eating events are largely organized around meals, be they minor, such as breakfast, or major, such as lunch during the day and dinner in the evening. These are concepts that people in developed countries know so well that they are essentially self-evident (e.g., Marshall 1993). When talking about breakfast, for instance, people generally assume that others can infer not only that they mean a morning meal but also that it includes certain culturally specific but recognizable elements. Bread is an example of a breakfast item identifiable across Europe whereas bacon, eggs, and beans would be associated with an English breakfast and a croissant with a French one. Similarly, lunch in the contemporary vocabulary refers to a meal that is typically larger than breakfast and takes place later in the day, around noon or somewhat later. Lunch may be hot or cold, depending on national and cultural traditions and institutional arrangements relating to work and school life (e.g., Holm et al. 2019). Dinner is assumed to be the major meal of the day, often with a culturally specific established structure varying from one-course to several-course meals. As with lunch, typical dinner times vary from country to country, and there are also in-country variations. In the Nordic countries, for instance, hot dinner usually takes place between 4:00 and 8:00 pm (Holm et al. 2015) with nationally varying peak times (Bøker Lund and Gronow 2014). Thus, even though Western food cultures seem to share the “idea” of breakfast, lunch, and dinner as meal events taking place at certain times of the day, their structures and practices vary somewhat.

A snack, which is generally considered to be not a meal but a separate, more unstructured type of eating event (see Marshall 1993, 2005; Warde and Yates 2017), is a more arbitrary concept. A snack can take place at any time between meals, and there are typically no strict rules about its content or where it should be consumed. We may note that this distinction between meals and snacks is itself a token of the social and cultural significance of meals. However, as Warde and Yates (2017) have noted, meals and snacks should not be understood as diametrically opposed to each other but rather as different types of eating events. The increasing consumption of snacks is often somewhat disapprovingly referred to as “grazing” (e.g., Fischler 2011), but the fact that the number of eating events per day is slightly increasing (Bøker Lund and Gronow 2014; Poulain 2017) suggests that snacks are becoming more important in contemporary eating.

Changing Meals

Meal patterns are culturally specific and change in time. Although the discourse on meals during the past few decades has fretted over the individualization and destructuration of meals (see Mäkelä 2009; Gronow and Holm 2019), research has shown that individually varying mealtimes were not uncommon in earlier centuries and decades. In eighteenth- and nineteenth-century France, the number of daily meals and mealtimes varied according to the diners’ social positions, and not all family members necessarily ate together (Flandrin 1996). In nineteenth century Britain, upper-class children never ate with their parents, and, unlike their parents, they were served a very limited variety of foods (Murcott 1997). The names of meals at various times of the day have changed too; in France, what was formerly termed *dîner* (dinner) is now known as *déjeuner* (lunch) (Flandrin 1996). Similar changes have taken place in other countries. In the USA, industrialization and the emergence of (male) professions in cities in the late 1800s gradually led to a shift from eating a large meal at midday to eating the main meal in the evening (Erby 2017). In Finland, breakfast in the 1920s was still a full, hot meal similar to lunch and dinner. Breakfast evolved from a hot meal to a coffee-with-bread eating event only when working days were shortened by legislation to eight hours and coffee became affordable to the working class (Prättälä et al. 1993). In 1950s Britain, over 40% of the population had a hot weekday breakfast (typically bacon and eggs) whereas only 6% did the same in 2012 (Yates and Warde 2015).

Erby (2017) suggests that, in the USA, the idealization of the family meal started in the mid-1800s, when industrialization, market capitalism, and individualism began to influence the dynamics of family life. While men increasingly worked in paid labor outside the home, women, at least in the more affluent households, stayed home and were expected to focus on the domestic realm. It was their task to provide meals, which now acquired new meanings as tokens of caring for the children and the husband (so that he could enjoy the homely atmosphere and gather strength at home both during the midday break and after a hard day’s work). The American family meal was born out of this romanticizing of the home as a “wellspring of virtue and love" (Erby 2017, p. 674). At the same time, attention was now paid to table manners, moderation in eating, and the foods served at meals. In the middle-class domestic ideal, family meals were an arena for practicing self-restraint and proper behavior.

As these and other examples show, industrialization, economic development, and changes in working schedules outside the home have primarily been responsible for large-scale societal changes in mealtimes and the social organization of meals over the past 200 years (Flandrin 1996; Prättälä et al. 1993). Similarly, in affluent contemporary societies, what people eat and when and with whom they take their meals are to a large extent demarcated by the increasing share of single households and non-nuclear families, the urban way of life, the working hours of adults, the school schedules and extracurricular activities of children, and the commodified and commercialized organization of the food supply (see, e.g., Gronow and Holm 2019; Murcott 2019). The organization of meals can thus be seen as an indicator of how, in a given society, everyday life is configured around paid work, household work, school, and leisure – at least for the majority who participate in work or educational institutions.

In the past few decades, both popular and academic discourse has raised concerns about a general destructuration and invidualization of eating, including the "demise" of meals, particularly shared meals, which have allegedly been substituted by "grazing" and snacking (Fischler 2011). In the social sciences, one of the more widely cited proponents of this view is the French sociologist and anthropologist Claude Fischler, whose concept of "gastroanomy" (Fischler 1988) has gained wide popularity in discussions about the decline of meals. However, as Anne Murcott (2019) has pointed out, there is more evidence of a century-long concern about the decline in family meals than of such a decline's having actually taken place. She has also noted that the middle-class family has come to represent the ideal family, and it is against this ideal that many commentators worry about the decline of family meals (Murcott 1997). Similarly, Andersen and Hedegaard Larsen (2015) note that the myth of the vanishing family meal emerged from the idealization of times past and serves the interests of those who wish to criticize modern "unhealthy and unsociable" ways of eating (Andersen and Hedegaard Larsen 2015, p. 287). Furthermore, it should be noted that the meanings of concepts such as "meal" and "family" are changing over time and vary in diverse cultural contexts.

As social scientists have pointed out, the celebration of commensal and family meals rarely acknowledges that commensality does not always equal conviviality. Meals also involve power struggles over what, how much, and when to eat and over the gendered division of responsibility in providing meals; they are occasions when the potentially tense relationships in a family become evident (e.g., Andersen and Hedegaard Larsen 2015; Murcott 1986, 2019; Roth 2005). Andersen and Hedegaard Larsen (2015) argue that the family meal should be seen "as a symptom of a happy family rather than its cause or as a solution for making families (more) happy" (p. 289). The celebration of shared meals, particularly family meals, has also been challenged by feminist studies. Research into how households manage food provision has shown that family foodways are, to a great extent, still dictated by patriarchal values that strongly moralize mothering practices that deviate from the norms of good and caring mothering, including self-prepared meals enjoyed with the whole family (Kinser 2017).

Conceptualizations of the elements of meals and proper meals are also changing. For instance, in Britain, the "meat and two veg" ideal still exists, but it is increasingly reserved for special occasions, and raw ingredients are often mixed with ready-prepared convenience foods in home cooking (Gatley et al. 2014). Since the 1950s, midday meals in Britain have become much simpler, evolving from typically hot meals to sandwich-based meals. Evening meals still exhibit a staple-and-center structure, but more pastas (probably with mixed ingredients) as well as pizzas and burgers are eaten than in earlier decades, particularly among younger people (Yates and Warde 2015). In the Nordic countries, it appears that, from the late 1990s to the early 2010s, dinners have increasingly become one-course meals, "platefuls," that include more components than before. Nordic dinners are still dominated by meat dishes, but vegetarian dishes are becoming somewhat more popular (Holm et al. 2015). At the same time, particularly on weekends, restaurants and cafés offer meals that combine the conventional meals, and new names for such "hybrids" are emerging. The most common is probably "brunch", a portmanteau of breakfast and lunch. Terms describing the combination of lunch and dinner have also recently emerged, including lunner, linner, or lupper. Such examples show that meals are not a static system but continually evolve, not only in what is eaten but also in how different meals are imaginatively combined in new constellations.

Another challenge to meals comes from concerns about the sustainability of our current foodways. This relates particularly to the position of meat and other animal-based foods in contemporary meals. As noted above, meat has a central position in Western meals and is ascribed many positive meanings (Latvala et al. 2012). Questioning its status may lead to increasing tensions in families if some family members would like to reduce the share of animal-based foodstuffs in family meals while others would not. As Roth (2005) has noted, a family member who adopts a vegetarian diet in a meat-eating family challenges the family foodways and threatens the family's homeostasis by redefining the meanings of meat and turning upside down the hierarchy of various foodstuffs in the family's meal system. The vegetarian may be interpreted as questioning the entire family system by refusing to eat meat, which signifies maleness, power, strength, and, typically, male dominance in families. The family meal may then become an arena of contention because, by refusing food that other family members would happily eat, the vegetarian challenges the family identity and puts into question his or her membership in the unit. In such a situation, the power relations within the family are renegotiated, and families use diverse strategies to reconstruct family cohesion. According to Roth (2005), because families know that vegetarianism is (often) not only about abstaining from meat but also about embracing an ideology that resists the dominant culture's values, institutions, and practices, they may dismiss vegetarianism as "just a phase," pressure the vegetarian to eat meat, challenge the moral justification of vegetarianism, or force the vegetarian to develop strategies of conflict avoidance, such as agreeing to eat meat occasionally or to refrain from discussing moral justifications of vegetarianism.

Social scientists in the 1980s and increasingly thereafter have noted that meal patterns in Western countries are changing due to various societal changes, particularly women's increasing participation in working life, the availability of alternatives to meals cooked from scratch, increasing incomes, the declining share of food expenditure in the total consumption expenditure of households, and the increasing number of restaurants and cafés that offer alternatives to home meals (see, e.g., Gronow and Holm 2019; Murcott 1997, 2019; Yates and Warde 2015; Warde 1997, 2016). We are undoubtedly seeing a trend towards less formal eating, "lighter" meals (i.e., having simpler structures), snacking, and less ritualistic meals (Marshall 2005; Gronow and Holm 2019), but this does not necessarily mean that meals as a social institution are threatened. As shown above, the organization of meals was not stable in earlier decades either. When society changes, patterns of meals and eating change too. The position of the meal as a central social institution structuring everyday life (Mäkelä 2009) and as a "lived experience" (Lalonde 1992, p. 75), does not seem seriously threatened, although the number of meals eaten alone may increase with the growing number of single households.

As Marshall (1993) has noted, "Different meals are marked by the time at which they occur, the frequency with which they occur, people who are present at the meal, the number of participants, the nature of the food served, the food combinations, the purpose of the event and the time spent on the food preparation, consumption and the duration of the meal" (p. 284). When one or more of these characteristics and their relations evolve over time, meals change too, but it seems that Marshall's proposition that "meals have become the things that occur between snacks" (1993, p. 286) holds true only in the literal sense that meals and snacks necessarily alternate during the day. People in Western countries still eat meals, major and minor, and little evidence suggests that snacks risk their cultural and social significance. However, Marshall rightly notes that meals are becoming less formal and that what were previously classified as "minor meals," i.e., cold meals and meals with fewer elements, are becoming more common.

Conclusion: The Future of Meals

What does the future of meals look like? Are shared meals challenged or even on their way to vanishing, as assumed in much contemporary writing? Is eating going to based more and more on whims, personal tastes, genetic predispositions, nutrigenetic diets, and laboratory-grown ingredients that scarcely resemble the plants or animals from whose cells they are produced? Are the demands of sustainability or the need to adapt to climate change and declining biodiversity going to restrict our diets in profound ways?

These large questions surround the discourses on meals and eating patterns in the late 2010s, and the answers will depend on political decisions; cultural, societal, technological, and economic developments; and changes in the biosphere and our living environment now and in the coming decades. The current patterns of eating are challenged by health, ethical and ecological concerns, and the necessary changes are going to affect the content of future meals.

However, our analysis suggests that there is no reason to expect that the position of the meal as such in Western patterns of eating is at risk, simply because meals have such a strong grip on the sequential arrangements of everyday life. In addition, individualism and commensality are likely to coexist in the future (Mäkelä 2009; Gronow and Holm 2019). Even though food and its origins may change, the role of meals as the essential social glue between people probably remains unchallenged because sharing food seems to be an essential part of humanity.

What will probably change is the food on our plates and how we organize our eating in a way that entails as little ecological burden as possible. This will mean reducing the share of animal produce in meals and replacing it with plant-based options as well as making greater efforts to avoid wasting food. One of the authors of this chapter noted in 2009 that "the heated discussion on climate change pushes forward increasing awareness of sustainability of both the production and consumption of food" (Mäkelä 2009, p. 46). In the 10 years since that remark was made, the question of climate change has become more pressing than ever (Willett et al. 2019). Solving it by changing patterns of eating may be easier said than done, however, due to the deeply ingrained nature of our routines and habits of eating as well as the failure (so far) of policy-makers to adopt serious measures to alter animal-based agricultural practices. Meat and dairy products are part and parcel of Western meals, and changing that will require a profound change in what is produced on farms; manufactured in the food industry; sold in grocery stores, cafés, and restaurants; and prepared in homes and in public food provision. The same goes for addressing food waste; all actors in the food system need to reduce the amount of wasted food, which will not happen without a reordering of the system of food provision. The reasons for food's being waste are very practical. No one in the food system wants to waste food, but the objectives, practices, and unexpected events in the flow of business and everyday life generate excess and, consequently, waste (see, e.g., Evans 2012; Murcott 2019). The focus in efforts to reduce waste should, therefore, be on those practical circumstances rather than on educational campaigns and blaming consumers.

Anne Murcott (1986, p. 79) has pointed out that, to the same degree that "we are what we eat," it may be argued that "we eat what we are." Our social identities are inextricably tied to what, where, how, and when we eat. The need to look at food from the perspective of sustainability gives Murcott's notion extra strength by linking our "eating identity" to the global ecological and social challenges of our time. If we eat what we are, then sustainable eating should become a part of our social identities just as "we are what we eat" is understood to encourage people to eat healthily. But it must be added that what we eat is not a purely voluntary, autonomous choice; that choice is made amidst a myriad of cultural norms and meanings, social relations, institutional arrangements, and political regulations, and it should go without saying that this is particularly true for the many surviving on meagre incomes who struggle every day to feed and care for themselves and their families.

"We eat what we are" must be understood as pertaining not only to individuals as diners, consumers, and parents but also to everyone in our roles as citizens, farmers, educators, lobbyists, government officials, politicians, or employees in the food system. What we eat in our future meals will depend on all of these as well as on the economic costs associated with the transition to more sustainable diets.

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Packaging of Food and Drink in Japan

26

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Contents

Abstract

This chapter outlines the trajectory of change that the packaging of food and drink in Japan underwent between the late nineteenth century and the present day. It argues that three developments lie at the root of this transformation: the Westernization of Japanese diet, the growing reliance on mass-produced (semi) processed food, and the shifting landscape of the food retailing. In addition, the impacts of the environmental legislation and the growing labor shortage are also signalled.

The chapter begins with an overview of the contemporary state of affairs and later zooms deeper into the issues that the author considers of particular importance for the understanding of the historical shifts. They include the rise of paper and plastic into the position of the dominant packaging materials in Japan and the decline of glass, despite its spectacular growth during the first half of the twentieth century. The chapter further discusses the "packaging revolution" of the 1960s and the growing market for gifts that contain food and drink and how

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the gift-giving practices in Japan affected innovation within the packaging industry.

Along with providing insights into the history of the Japanese packaging sector, this chapter contributes to the understanding of the culinary transformation of Japan in the course of the twentieth century.

Introduction

In her book *Wrapping Culture* (1995), Joy Hendry turns our attention to the practice of "wrapping," an aspect that fascinates foreign visitors to Japan, as well as recipients of Japanese gifts, meticulously wrapped in multiple layers. Hendry explains in the introduction that indeed the idea for the book began with the interest in the wrapping of presents, but the author applied the concept of wrapping in a much broader context, including exploring polite language as the wrapping of thoughts and intentions, garments as body wrappings, and constructions and gardens as wrapping of space.

Hendry begins her analysis with the description of what she calls "mundane wrapping," which includes such items as supermarket vegetables in plastic bags, individually wrapped biscuits and cakes, and seasonal gifts of vacuum-packed cured meats in elegant satin-lined cardboard boxes (1995, pp. 8–10). She is quite right in pointing out the meticulous attention to detail in terms of hygiene, convenience, and esthetics that constituted a characteristic feature of Japanese wrapping culture at the time of the Bubble Economy of the second half of the 1980s and years that followed. Yet, her book is misleading by implying a connection between the long-standing features of Japanese society with the contemporary packaging conventions.

Hendry is not the only one who has fallen into the trap of taken-for-granted continuity between the contemporary landscape of the Japanese packaging scene and pre-modern packaging practices (Japan Package Design Association 1976; Saito 1999). Yet, as the exhibition "Packaging Design from Japan: Too Pretty to Throw Away" (Machotka and Cwiertka 2016) made compellingly clear, this perception was fuelled by the appeal of retro branding, which had been a dominant trend in Japan since the 1980s (Nikkei Design 2012, p. 2). Retro designs, which can broadly be defined as consciously derivative of lifestyles, trends, or art forms from the historical past, add a cache of exclusivity and nostalgia to the commodities they adorn. In addition, by manufacturing a connection with an imagined past, they offer soothing relief from the uncertainties of modern life characterized by discontinuous and chaotic change.

This perception of continuity between pre-modern and contemporary Japanese designs is further sustained by the notion of timelessness of the "Japanese spirit," presented as being rooted in Japanese objects regardless of the period in which they are made. This concept is commonly exploited in exhibitions and other activities sponsored by the Japanese government with the purpose of global promotion of Japanese culture (Machotka and Cwiertka 2016, pp. 14–16). However, as this chapter will demonstrate, exploration of the historical trajectory of contemporary packaging practices invites quite a different interpretation, at least as far as the packaging of food and drink is concerned.

As elsewhere, the twentieth-century developments in food production and retailing one by one revolutionized the existing packaging conventions in Japan. The root of dramatic changes that took place in the packaging domain lay in the culinary transformation that swept Japan since the late nineteenth century. Three aspects in particular proved influential in this respect: the Westernization of Japanese diet, the growing reliance on mass-produced (semi)processed food, and the shifting landscape of the food retailing (Cwiertka 2006). Local neighborhood stores that had long remained the preferred location for shopping for ordinary ingredients have since the 1990s been replaced by supermarket and convenience store chains. The complex retail networks required increasingly sophisticated packaging solutions, leaving the ever fewer food items – fresh or processed – unpacked.

Japanese Packaging Industry Today

Without a doubt, the most important transformation that the routines and procedures related to packaging underwent in Japan during the last century is a shift from the multi-use to single-use, disposable containers. Wooden crates, boxes, barrels, wicker baskets and mats, wrapping cloth, and ceramic containers of different shapes and sizes were ubiquitous in pre-modern Japan, as was the case in the rest of the world (Nihon Hōsō Gijutsu Kyōkai 1978, pp. 5–7). While packaging solutions intended for a single use had not been entirely lacking in the past – straw, bamboo sheaths, and different types of leaves – they were utilizing material at hand, not especially manufactured with the packaging objective in mind. In contrast, today, a myriad of containers routinely discarded immediately after their content has been emptied are all products of sophisticated industry with a high degree of specialization.

A register of Japanese packaging businesses lists several hundred companies, divided into 81 categories (Nippō Ai Bii 2009). Each is dedicated to a particular aspect of the packaging process. There are firms concerned solely with the fabrication of packaging materials, from paper, cardboard, glass, and metals to different varieties of plastic. Other companies focus on the production of containers – jars, bottles, tubes, boxes, trays, etc. Labels are often designed and produced by yet other ventures. Finally, the machinery required for the manufacturing of all those components, as well as automated packaging robots, is a separate business altogether. This means that even a relatively straightforward product, such as a bottle of mayonnaise or a milk carton, is the result of the joint efforts of a manufacturer of plastic and paperboard, which is used by another firm to produce the bottle and carton itself. Certain products may also require a label, if it is not already printed on the container, which is then filled with the product – milk or mayonnaise, respectively – utilizing specialized machines and packaged again in boxes or crates for transport. Needless to say, those boxes are also manufactured by specialized firms. The packaging design, which is entrusted to marketing and branding professionals, must be integrated in terms of cost and schedule into the logistics of the entire process.

In 2013, the value of the Japanese packaging industry amounted to 6.05 trillion yen, which was more than the Japanese agriculture, fisheries, and forestry production taken together and slightly less than Japan's defense budget (Nihon Hōsō Gijutsu Kyōkai 2014, p. 3). Currently, Japan is the third largest single national packaging market in the world, following the United States and China (World Packaging Organization 2008, p. 4). In terms of per capita expenditure on packaging, Japan is possibly the front-runner, although the complexities of global trade make such a comparison problematic.

It needs to be pointed out that these statistics do not cover exclusively the food and beverage sector but are also utilized by the healthcare, cosmetics, and other consumer markets. While we may presume that the manufacturers of packaging in Japan keep detailed accounts of their customers and thus are in the position to calculate the share of the food and beverage industry in the overall use of packaging, this information is proprietary. The data provided by Transparency Market Research (TMR) for plastic packaging, available since 2005, is an exception. It reveals that the share of food and drink packaging in Japan has remained relatively stable in terms of both quantities and value, at around 65%. This is in line with the global data on packaging regardless of the material, released by the World Packaging Organisation. It indicates that food and beverage industry represents the lion share – over 50% – of the end-use market for packaging (World Packaging Organisation 2008, pp. 37–40).

Paper and Plastic

The two dominant packaging materials in Japan today are paper (in all its forms, including cardboard and cartons) and various types of plastic. In 2015 they represented, respectively, 40.80% and 31.3% of the total value of packaging on the market (Nihon Hōsō Gijutsu Kyōkai 2015). Paper and plastic are used separately or in combination with one another, as is the case with paperboard coated or laminated with LDPE (low-density polyethylene), which is widely utilized in fruit juice and milk cartons.

Plastic has infiltrated the Japanese packaging market at a phenomenal speed. In terms of quantity (expressed in weight), its share more than doubled during the last three decades of the twentieth century, from around 9% in the 1970s to around 19% in the early 2000s. Since plastic is relatively light compared to other packaging materials, its success becomes even more apparent from the perspective of value. Comprising just 4.6% of the total value of Japanese packaging industry in 1958, by 2005 it skyrocketed to 30% of the total value of packaging in Japan. In terms of quantity, paper and paperboard have accounted for more than 50% of the total production of the Japanese packaging industry since the 1950s and exceeded 60% in the year 2000. It is important to note that this increase in share was not caused by the use of increasing quantities of paper and paperboard; rather, it is due to the ubiquitous replacement of metal and glass packaging with plastic, which, as a lighter material than metal and glass, results in lighter overall packaging. Consequently, the same quantity of paper and paperboard will constitute a larger percentage of this smaller whole. In contrast to the quantities, the share of paper and paperboard packaging in terms of value decreased from around 50% in the early 1960s to around 42% in the early 1990s, where it has remained ever since (Nihon Hōsō Gijutsu Kyōkai 1972, 2015).

Domestic production of plastic began in Japan in 1955 with polyethylene (PE), followed by polyethyleentereftalaat (PET) and polystyrene (PS) in 1959 and polypropylene (PP) in 1960. These new substances were soon to become the material of choice in the packaging of food. One of the first commodities that utilized this new material was *miso* (fermented soybean paste), a rather ordinary ingredient in the Japanese kitchen that had been used on a daily basis for centuries. It had customarily been manufactured at home or bought directly from local merchants. As was the case with other everyday commodities, such as tofu, soy sauce and sake, customers brought their own containers to take the purchased article home. Miso packed in a polyethylene bag, at the time still imported, went on sale in 1954 (Minakuchi 2010, pp. 162–163).

In contrast to plastic, paper has been manufactured in Japan for centuries but only emerged into a mainstream packaging material after the mechanized papermaking technologies were introduced from Europe in 1874 (Ōji Seishi 2009, p. 21). *Washi* ("Japanese paper") refers to handmade papermaking conducted primarily as off-season winter work for farmers (Hughes 1978; Barrett 1983). Next to the publishing industry, different types of *washi* were utilized throughout the early-modern period in the manufacture of a wide variety of objects, ranging from sliding screens/doors and lanterns to fans, umbrellas, and even clothing. However, paper was still relatively costly, and those objects were by no means intended for a single use. The notable exception were fireworks and toilet paper (known as *otoshigami* and *chirigami*). The latter was a by-product in the paper manufacture, made from the outer dark bark and fiber residue that would otherwise be discarded (Hughes 1978, p. 173, 176).

At the time when the technology for the manufacture of "Western paper" (*yōshi*) was introduced in Japan, the paper industry had been thriving on both sides of the Atlantic to an extent that the 1860s was heralded by the contemporary "The Age of Paper" (Hunter 1978, pp. 386–388). The skyrocketing popularity of paper was caused primarily by the nineteenth-century innovations that transformed papermaking into a mechanized industry relying on wood pulp, instead of cotton and linen rags which had traditionally been used (Magee 1997). A dramatic rise in the productive capacity of paper mills caused a steep decline in paper prices, which, ultimately, was one of the factors that prompted the proliferation of paper in the food packaging industry. In addition, the development of mechanical processes to mass-produce paperboard cartons, in the final two decades of the nineteenth century, contributed to the further popularization of this form of packaging (Tweede 2012).

Although Western-style paper quickly gained ground in the newspaper business (Ōji Seishi 2009, pp. 28–29), and old newspapers evolved into a handy wrapping material at food stalls, it took several decades before the Japanese food packaging sector embraced cardboard boxes on a mass scale. The notable exception were caramel candies retailed in a pocket-size, yellow carton box. Launched in 1914 by the pioneering Western-style confectioner Morinaga, the product was the first turned into one of the most iconic merchandizes of the century and is still available today. Morinaga Milk Caramels – a box resembling a pack of cigarettes, containing 20 candies wrapped individually with wax paper – became a sensation, primarily due to the portable packaging, which could be easily carried to cinemas, picnics, zoos, and hiking trips (Mitsuda 2017, p. 72). The success of Milk Caramels positioned Morinaga as the leading producer of Western-style confectionery in Japan, and the company soon diversified into mass production of chocolate, biscuits, and candy.

Commercial success of pioneering producers of Western-style confectionery notwithstanding paper and paperboard did not develop into a mainstream food packaging medium before the dawn of the postwar "economic miracle" (1955–1973), a name given to this time span due to a spectacular increase of the GNP, with the average growth of real per capita consumption of 7.51% per year (Horioka 1993). The rising levels of personal consumption went hand in hand with the growing veneration of the American way of life, of which mass-produced food packed in colorful boxes was one of the most representative features. The 1960s witnessed a launch of a great variety of Western-style confectionery, such as Fujiya's Milky, Glico's Bisco, Morinaga's Chocolate Balls, and Meiji's Almond Chocolate, to mention only the most iconic brands. In addition, domestic production of paperboard drink cartons began in 1962, introduced 6 years earlier by the Swedish firm Tetra Pak. Milk companies saw potential for replacing glass bottles to restructure and extend distribution, and the shift was also encouraged by the Ministry for Agriculture, Forestry and Fisheries, which aimed at propagating milk consumption. By the mid-1990s, cartons comprised about 85% of milk containers and 39% of fruit juice containers (Penna 2002, p. 99).

During the high-growth period, paper also came to be extensively utilized in the packaging of souvenirs (*omiyage*), which are closely related to the rise of mass tourism. The origin of the custom of bringing a gift from a trip is centuries old, but the habit was considerably transformed by the proliferation of railway. Today, an ideal *omiyage* should contain a specialty food from the area one is visiting, and packaging design is one of the most essential elements of the branding strategies of their producers. These gifts are customarily distributed among relatives, neighbors, and colleagues; sweet and savory snacks (*kashi*) are particularly popular because they can be shared with others (Cwiertka with Yasuhara 2020, pp. 79–87). It is estimated that between the 1960s and the 1990s, the number of Japanese who travelled for pleasure – and thus purchased multiple *omiyage* items – increased fourfold (Kim 2011, pp. 202–204). Although the manner in which gifts are presented, including the way they are wrapped, has traditionally been of great importance in Japan, elaborate packaging of *omiyage* has since the 1970s attracted repeated criticism of being wasteful.

Yet, the biggest contribution to the phenomenal expansion of the use of paper in the Japanese packaging industry over the decades are corrugated containers (*danbōru*). They remain the largest volume paperboard product in Japan and are the vanguards of the packaging revolution that took place since the 1950s. The replacement of wooden crates/boxes, usually laid with straw, which had served as the main vehicle in the transportation of goods for centuries by cardboard boxes began as a by-product of the military procurement boom inspired by the Korean War (1950–1953). As a territory since 1945 occupied by the Allied Powers, Japan was developed into the base of logistical supports for all the troops fighting in Korea under UN Command. Japan Logistical Command (JLC) in Yokohama functioned as a requisitioning agency for all goods for Korea, from munitions and petrol to boots and ice cream. Moreover, goods shipped from San Francisco customarily arrived in Japanese rather than Korean ports and were stored in depots throughout Japan. In addition, the Procurement Section of the JLC purchased a wide variety of items from local merchants and producers in Japan (Cwiertka 2013).

Corrugated boxes were at the time the designated packaging containers in the US military, which meant that all the supplies ordered by the Procurement Agency had to fulfill these requirements. Under a strict guidance of the packaging professionals dispatched from the United States, and vigilant assistance of the Ministry of International Trade and Industry, seminars were held all over the country to familiarize Japanese businesses with the American packaging requirements (Nihon Hōsō Gijutsu Kyōkai 1978, pp. 83–84).

Largely owing to corrugated boxes, the use of paperboard in Japan expanded from 0.18 in 1950 to 12.52 million tonnes by the end of the century (Penna 2002, p. 96). Along with the supplies procured by the US military, *danbōru* soon began to be used in the domestic transport of fruit and vegetables and later the ever diversifying products of the food-processing industry.

The Packaging Revolution

Elaborate packaging of food and drink, referred to by Hendry as "mundane wrapping," has only become emblematic of Japanese consumer culture during the final decades of the twentieth century. It was, in the first place, conditioned by the postwar economic growth, which, in turn, initiated the shifting of the landscape of the Japanese retailing in the direction of self-service. The very first supermarket opened in Japan in December 1953, and by the end of the decade, over a thousand such self-service stores were in operation across the country. However, their growth remained slow. During the 1980s, the market share of supermarkets within the Japanese retail industry had barely surpassed 35% (Kensei 1997, p. 3). In fact, the expansion of large stores was intentionally hindered by the Ministry of Economy, Trade and Industry, motivated by protecting the livelihood of small retailers. The policy was revised in 1990s, and by the end of the century, the Large-Scale Retail Stores Law was repealed altogether (Grier 2000/2001). Today, supermarkets and convenience store's chains account for over 85% of food retail sales (Aoki 2018).

Along with those legislative measures, the shifting consumption patterns were also a factor at play in the proliferation of supermarkets. They emerged as the primary destination to find innovative products, such as processed and frozen food, and their production grew from 5,000 t in 1960 to 562,000 t in 1980 (Yano Tsuneta Kinenkai 2000, p. 294). By the mid-1990s, less than one-third of the food consumed by an average Japanese person was in the form of fresh foodstuff cooked at home (Ishikawa 2002, p. 170).

Thus, between the 1970s and the 1990s, the packaging conventions of food and drink in Japan were undergoing transformation under the influence of three concurrent developments, on top of the abovementioned shifts in retailing. To begin with, the share of processed food in the Japanese diet grew rapidly. All these products requiring appropriate packaging in the face of the retail network became increasingly complex and in self-service stores the new normal. As the competition between brands increased, producers increasingly used the packaging of their products rather than its content to differentiate themselves. These circumstances prompted a wave of innovations within the packaging industry, in terms of design and functionality.

The launch of ready-to-eat curry in a retort pouch, marketed in 1968 under the name Bon Curry, is a case in point. Within 5 years of its introduction, the product was selling 100 million packets a year, and it remains popular today (Arita 2008). Curry on rice, a British import that began to gain popularity in Japan around the turn of the twentieth century, had by the 1960s acquired a status of a national dish that was primarily enjoyed while dining out (Cwiertka 2006, pp. 8, 48–49). Thus, it was not the dish itself but rather the novelty and convenience of the packaging that were responsible for the product's success – Bon Curry was ready to eat after simmering the pouch in boiling water for 3 min. The pouch was constructed from a flexible metal-plastic laminate that was able to withstand the thermal processing used for sterilization – a process very similar to canning. The product was developed jointly by three Japanese companies: the food-processing business Ōtsuka Foods, the canning giant Tōyō Seikan, and the manufacturer of automatic packaging and filling machines Tōyō Jidōki. The technology utilized was quite new, having only been applied commercially in the United Kingdom and the United States a year earlier (Matsuoka 2010, pp. 141–142). The cutting-edge character of this packaging was confirmed by the fact that in 1969, a year after the launch of Bon Curry, a number of foods in retort pouches were selected by NASA for the Apollo 11 moon orbit mission. Until that point only dehydrated and freeze-dried foods were used by cosmonauts (Hefnawy 2010, p. 173).

Bon Curry was not an isolated case but rather an indicator of the growing sophistication of the Japanese packaging industry. Following the success of 1966 Tokyo Pack, the very first international packaging fair organized in the capital, Japan took up a leadership role in the global packaging business by initiating the establishment, in 1967, of the Asian Packaging Federation and, the following year, the World Packaging Organisation (Nihon Hōsō Gijutsu Kyōkai 1978, pp. 58–59). During the 1970s, the first signs of the transformation in the Japanese packaging industry could be observed, from a latecomer catching up with the technology developed in Europe and North America to creating its own innovative solutions for packaging problems. In 1976 Mitsubishi Gas Chemicals Co. Ltd.

marketed the first oxygen scavengers, also known as oxygen absorbers (Coles et al. 2003, p. 285). The first patent dates from 1938 in Great Britain, which used iron, zinc, or manganese to scavenge oxygen from canned foods. Further experiments were conducted by the US Army with the purpose of utilizing the technology in military rations, but the Japanese were the first to release it commercially (Cooksey 2010).

A great variety of oxygen scavenging systems are available on the market today, but little sachets containing iron sulfite are most commonly used worldwide. They help to extend shelf life of foods by decreasing the level of oxygen in the package. All sealed packages, even those closed hermetically, can permit the entry of air, which contains oxygen. Oxidative reactions – microbiological, enzymatic, or biochemical – are the primary factor in deteriorating foods, affecting their color, flavor, and texture. In the case of biochemical deterioration, the higher the temperature and the higher the moisture concentration, the more rapid this reaction is (Brody et al. 1995, pp. 5–6). Thus extracting oxygen is critical to prevent the loss of quality in packaged foods, particularly in hot and humid climates like that of Japanese summers.

Japan was not only the birthplace of commercial oxygen scavengers but also used to be their largest consumer. For example, during the 1990s approximately 2 billion oxygen scavengers were used across Japan annually, compared to 100 million in the United States (Brody et al. 1995, p. 15, 17). The estimates for the global oxygen scavenger market in 2001 were 12 billion units in Japan, 500 million in the United States, and 300 million in Western Europe (Souza Cruz et al. 2012). The hot and humid climate, along with the custom of exchanging perishable food gifts (see below), may be considered the primary factors driving the use of oxygen scavengers in Japan. Although the most current data suggest that the rest of the world has in the meantime managed to catch up with the Japanese market, they can be definitely marked as evidence of the rising Japanese leadership in the packaging innovation.

Packaging Embellishments

Gifts represent a major form of consumption in Japan and an important segment of the Japanese economy. A great deal of shopping activity in Japan is not for oneself but to buy gifts for others. Yano Research Institute valued all the gifts exchanged during the year 2016 at 10,206 trillion yen, which corresponds to 77% of total supermarket sales in that year (Cwiertka with Yasuhara 2020, pp. 77–78). Food and drink constitute the most important category of gifts. Consumable gifts are devoid of personal connotations and leave no trace in the house, which are reportedly the reasons behind this preference. This holds true not only for the mentioned-earlier *omiyage* but also for presents exchanged during the two traditional gift-giving seasons – the year-end *oseibo* and midsummer *ochūgen* (Machotka and Cwiertka 2016). These occasions signify gratitude to those whom people feel indebted including relatives, neighbors, teachers, and superiors in professional organizations.

What distinguishes gifted food and drink from ordinary commodities one would purchase for one's own consumption is the exclusive packaging design and an additional layer of wrapping paper, which envelops the already neatly packed content. Confectionery belongs to the most favored gift items, including high-end chocolates, a variety of Western-style cookies and cakes, as well as traditional Japanese-style confections (*wagashi*). Today, each individual *wagashi* is customarily wrapped and often placed on a plastic tray with tiny compartments for each one of them. Not infrequently, the tray is again sealed in plastic, with an oxygen scavenger sachet included for extra protection. The tray then may be inserted into a paperboard box, which in turn is wrapped in a sheet of wrapping paper. The design of this outside layer of packaging often utilizes decorative patterns that in the past used to adorn silk fabric, lacquer boxes, and other art objects. This gives the packaging an aura of sophistication and tradition (Machotka and Cwiertka 2016).

A variety of confections that comprise the *wagashi* category is enormous. Many are proud descendents of exquisite delicacies crafted centuries ago for Kyoto aristocracy and later for a slightly less genteel clientele of merchants, artisans, and entertainers (Nakayama 2001, p. 73). A characteristic feature of the business has always been its local character. Professional confectioners operated in the vicinities of their workshops and delivered their creations in wooden or lacquerware boxes (*seirō*), often with the shop's logo prominently visible on the outside (Nihon Hōsō Gijutsu Kyōkai 1978, p. 293). Contrary to the presumptions that contemporary conventions might impose on the past, *wagashi* were never individually wrapped. In fact, in his study of the early twentieth-century challenges faced by the *wagashi* sector, Tatsuya Mitsuda highlights the allegedly unhygienic conditions in which Japanese-style sweets were manufactured and sold (2017, pp. 62–63). For example, only 1 out of 20 *wagashi* workshops that operated on the fashionable Ginza street in Tokyo is reported to have passed the hygiene inspection executed in 1934 by the metropolitan police. Particularly illuminating historical evidence used in Mitsuda's study is a report by a contemporary from his study trip to North America, published in 1909 in *Jitsugyō Shōnen* (Industrious Youth), a new magazine targeted at aspiring businessmen (Satō 2016). The article remarks that in contrast to the practice of handing over the sweets to the customers in bags made from old newspapers and magazines, which was customary in Japan at the time, in the United States, customers are presented with their purchase in "beautiful boxes, wrapped up in beautiful paper, and tied up so that they could be easily carried" (Mori 1909, p. 6).

Such accounts are valuable because they directly contradict the taken-for-granted assumptions of continuity between the past and the present packaging conventions in Japan that had been discussed at the beginning of this chapter. No, the contemporary sensibility toward the hygiene and esthetics of food packaging is not an uninterrupted continuation of centuries-old tradition. The nowadays common practice of "individual packaging" (*kohōsō*) of food items that are already packed in a larger container, which results in multiple layers of packaging, was one of the big trends of the 1980s. This is clearly indicated by the statistical information of the value of *kohōsō* packaging machines. In 2009 their value was twice as high as in the 1980s, despite the fact that production had declined since 1992 (Minakuchi 2012, p. 12).

Individual wrapping of *wagashi*, at the time still by hand, emerged in the early 1950s, when cellophane, parchment paper, and glassine paper – all used for decades as wrapping material in Europe and North America – started to be utilized for this purpose (Nihon Hōsō Gijutsu Kyōkai 1978, p. 294). It is unclear what considerations have prompted this new practice, but we might surmise that due to growing demand, the sites of production of *wagashi* shifted from local stores that manufactured them on the spot to larger-scale workshops from where they now had to be transported. This, in turn, required more careful packaging than was the case before. Although concerns about overpackaging were voiced during the 1970s, which for the first time prompted consideration for the waste of resources (see the next section), the practice continued undisturbed.

Glass

Among all the categories of materials differentiated in the Japanese packaging statistics today, glass ranks lowest in terms of value (Nihon Hōsō Gijutsu Kyōkai 2014, p. 428). Owing primarily to their weight, which directly affects shipping costs, glass containers have been successively pushed away from the packaging market by aluminum cans, PET bottles, and laminated cartons and pouches. Despite this decline, the importance of glass in Japan's packaging history cannot be overlooked. Glass containers of different sizes and shapes had been employed for decades in the retailing of beer, sake, lemonade, and other liquids. Glass also played a role in the creation of many historical icons, commodities that in a split second reflect the spirit of the time (Heisei Botoru Kurabu 2017).

Like paper, the technology of glass manufacture arrived in Japan via two different channels: first from Ancient China and several centuries later from Europe. By the eighteenth century, a cottage industry of glassmaking developed in various parts of Japan, but the quantities and quality were low. In 1889, Shinagawa Glassworks began industrial production of beer bottles, still using the mouth-blowing method. Over 70 local companies that had ventured into beer brewing during the 1860s and 1870s utilized bottles imported from abroad. The consolidation of the industry in the early twentieth century left only six beer brewers on the market, of which Dai Nippon Beer and Kirin Beer companies were the largest (Alexander 2018, pp. 36–37). The two giants co-funded the first automatic bottle-making factories, which began production in 1916 (Jōkō and Ogawa 1995, p. 30).

Along with beer, glass bottles found an array of other applications in Japan's food and beverage retail sector. In 1909, the Ajinomoto flavor enhancer – chemically extracted monosodium glutamate in granulated form – went on sale in a slender glass bottle that looked like it might hold perfume. Suzuki Chemical Company, which marketed the product, appealed to the bourgeois housewives and their newly found sense of self as culinary professional and guardian of her family's well-being. The year 1931 marked the arrival of the product in a salt-shake-style bottle for use at the dining table, rather than in the kitchen, which symbolized Ajinomoto's acceptance as a daily necessity for the middle-class urban families (Sand 2005). Although the shape of the bottle has changed over the years, it can still be found today on every supermarket shelf (Heisei Botoru Kurabu 2017, pp. 50–51).

Regardless of its impact, the Ajinomoto shaker is not the most iconic glass container of twentieth-century Japan. This distinction should, in my view, go to none other than the *isshōbin*, the 1.8 l bottle. Traditionally, soy sauce and sake – the two essential liquids in Japanese daily life – had been kept in wooden barrels/kegs (*taru*) and ceramic bottles (*tokkuri*). When purchasing these two commodities, customers usually brought their own containers, into which the liquids were poured from barrels using a funnel and wooden measuring boxes (*masu*) of 1 *gō* (0.18 l), 5 *gō* (0.9 l), or 1 *shō* (1.8 l). *Gō* and *shō* are the units of volume belonging to the Japanese system of measurements used until the mid-twentieth century, when the metric system was legally adopted.

The sale of sake in glass bottles is said to have begun in 1886, primarily in anticipation of the prospects of foreign exports. Around the turn of the twentieth century, several brands – including Sawanotsuru, Hakutsuru, and Yamatodamashii – launched the *isshōbin* bottle. Other makers soon followed, joined a decade later by soy sauce brewers (Yamamoto 1990, pp. 137–144; Heisei Botoru Kurabu 2017, pp. 52–53). A total of 1.8 lbottles were by then manufactured in Osaka by Tokunaga Glass factory using the fully automated bottle-making machines developed and patented by the cutting-edge American glassware manufacturer Hartford-Empire. They gradually replaced ceramic bottles as the mainstream sake container. In the mid-1960s, sake was retailed exclusively in glass bottles, of which the majority were *isshōbin* (Dainakkusu 2018, p. 1).

With the successive Westernization of Japanese lifestyle since the 1960s, whisky and beer, and later wine, have swiftly replaced sake as Japan's "national drink" (*kokukshu*). The share of sake in the total domestic consumption of alcoholic beverages dropped from 80% during the 1930s to less than 7% today (Stegewers 2017, p. 143). This shift does not only affect the commercial future of the sake industry but also threatens the fate of *isshōbin*. With the growing popularity of smaller bottles and cup-size containers, along with the increasing use of laminated cartoon as packaging of cheaper types of sake, the 1.8 l bottle is truly on the verge of extinction.

Conclusion: The Future Challenges

In October 1973, the Arab members of the Organization of Petroleum Exporting Countries (OPEC) placed an embargo on the export of oil to countries supporting Israel in the Yom Kippur War. The embargo lasted until March of the following year and prompted a phenomenon, commonly referred to as "Oil Shock," which brought about far-reaching economic and political consequences worldwide, also for Japan. The Japanese economy fell into a recession, and the crisis reinforces the realization that resources and energy that the country needed for development were not infinite and that the culture of disposability, which had been constructed in the previous decades following the American example, had to be reconsidered. These circumstances were instrumental in initiating movements toward effective utilization of resources through recycling (Siniawer 2018, pp. 94–96, 122–129).

It took another two decades for the post-Oil Shock sentiments to be translated into national legislative action. The year 1995, which marked the enactment of the Law for the Promotion of Sorted Collection and Recycling of Containers and Packaging (usually abbreviated as Containers and Packaging Recycling Law), can be considered a turning point in this respect. The law established a system in which glass containers, PET bottles, and paper cartons are collected from households by municipalities and retailers and are then delivered to the Japan Containers and Packaging Recycling Association (JCPRA) for recycling. The manufacturers of these products are obliged to pay an annual fee to the JCPRA, which contracts recycling companies to process and recycle the waste. A 2000 amendment expanded the law to include non-PET plastic packaging and non-carton paper packaging as well (Tompkins 2019, p. 16).

The effects of this legislation are clearly visible in the statistics, which indicate a steady decline in waste generation in Japan starting in the early 2000s (Waste: Municipal waste 2019). The commitment toward recycling, outlined by the government as the main solution to solve environmental problems related to waste, has since the 1990s exerted an ever-increasing impact on the industry. This can clearly be observed through the pages of *Hōsō Times* (Packaging Times), a weekly newspaper targeted at packaging professionals, which has been published continuously since 1966. The journal now frequently reports on the topics related to energy and resources conservation, the search for alternatives for plastic, and other environmentally relevant issues. These aspects are likely to remain at the center of the industry's future concerns. However, there is an additional challenge that the Japanese packaging industry is facing at the moment: the shortage of human labor.

According to the data of the Cabinet Office, the percentage of elderly in Japan (defined as people aged 65 and older) is now the highest in the world, reaching 27.7% in 2017. In terms of labor force, this translates into approximately two working-age people supporting one elderly person (Annual Report on the Ageing Society 2018, p. 5). What makes these statistics particularly striking is a high pace of change that has led to current situation. The share of elderly in Japan used to be classified as "lower rank" until the 1980s and as a "medium rank" during the 1990s; the number of working-age people supporting 1 elderly declined dramatically from 7.4 in 1980 to 4.4 in 1995 and further to 3 in 2005.

In what way are these developments related to the packaging of food and drink in Japan? The answer to this question is provided by the front page of the recent edition of *Hōsō Times* (11 March 2019), which featured detailed statistics related to the packaging machinery produced in Japan between 1985 and 2018. The value of those machines has more than doubled over the course of this time span, and during the 2018 the sector registered a growth of 10%, compared to the previous year. This was a third consecutive year in which the reported growth was 10% higher.

In the analysis of those figures, provided by the journal, two major factors have been outlined – the growing interest in the Japanese packaging machinery by overseas importers on the one hand and the tenacious shortage of labor that inflames the domestic demand. Thus, a growing investment in automation has increasingly influenced the Japanese packaging industry and is very likely to expand even further in the future.

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Consumer Research For Wine

27

Larry Lockshin and Armando Maria Corsi

Contents

Abstract

Wine is complex alcoholic beverage composed of a wide array of sensory and product attributes. Therefore, while wine is an interesting product to research consumer preferences for, there are a series of academic and practical challenges one needs to take into account.

The purpose of this chapter is threefold. First, the chapter explains the reasons why wine is considered a complex product. Second, the chapter illustrates the various quantitative techniques one can use to investigate consumer preferences toward different wines, showing the main advantages and disadvantages of each technique and some notable examples of research conducted with each of these techniques. Third, the chapter provides some practical advice in order to conduct

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research for wine in an appropriate manner. In particular, the chapter explains what the researcher should keep in mind to set up the objectives of the research and how to apply these to the research approach. The chapter then continues by providing some indications of the costs one should keep in mind based on the approach one intends to use and the advantages and disadvantages of conducting research in-house versus outsourcing it to a research firm.

Introduction

Most people reading this chapter would be familiar with some aspects of consumer research especially in the food area, so why is it necessary to discuss consumer wine research specifically? There are three reasons why wine is a unique consumer product, and each of these affects how research should be conducted:

1. Wine is an *alcoholic beverage*, which brings a range of testing and tasting restrictions into play.
2. Wine is a *very complex product* composed of a large number of product attributes used by consumers in making their purchases.
3. Wine is composed of a *complex array of sensory attributes*, in addition to the product attributes.

Conducting useful research on wine, whether academically or commercially based, has a number of issues, which this chapter will explore. The first section covers the specific aspects of conducting research on an alcoholic beverage as well as the basics of the complexity of wine as consumer research product. The next section focuses on the quantitative research methods adapted to the complex system of product attributes exhibited by wine, including combining the extrinsic (packaging and label) attributes with the intrinsic (sensory) attributes in preference research. The final section explores some of the practical aspects of conducting consumer research on wine.

Why Wine Is Different as a Consumer Research Product

Wine as an Alcoholic Beverage

Research on any alcoholic beverage brings with it both ethical and legal responsibilities for the researcher. Researchers should clearly present the research as being alcohol-based and set forward considerations the potential respondents should agree to before participation. Some respondents, such as pregnant women or those taking medication that is antagonistic to alcohol, should be cautioned about participation and recommended to not to participate. Research by Mueller et al. (2009) showed that some respondents began to reach the legal limit for alcohol in the bloodstream (0.05 g /100 ml in most jurisdictions) after approximately

180 ml of consumption (6 $\times$ 30 ml samples), with females generally having the highest readings. Even those with lower blood alcohol readings stated the task became more difficult after the first six samples and the standard deviations within each subject increased as well, showing that the usefulness of the data can also be compromised with too many or large samples. When conducting consumer wine research, no more than six samples (30 ml) should be given to any respondent. Smaller samples can be used, but it's important for respondents to be able to re-taste each sample. Also, it is an important ethical consideration to have the means to measure the blood alcohol for all respondents and make sure it is below the legal limit in the jurisdiction where the research is conducted before allowing them to leave the testing facility.

Wine as a Complex Product of Extrinsic Attributes

The second important aspect to understand when conducting consumer research with wine is the complexity of the product (Hall and Lockshin 2000). Wine is one of the few products where the location of production plays a part in both the identification and preference for the specific product as well as influencing the sensory characteristics (Lockshin et al. 2000). There are dozens of wine-producing countries, hundreds of regions, hundreds of different grape varieties, and over 100,000 wine brands sold in the world. Because of these complexities, it is impossible to compare all options available to a consumer when conducting research. Researchers must decide which aspects are most important and focus solely on these in any one project.

There are a number of studies of consumer wine choice behavior (too many to list here), but a recent review of research in this area by Lockshin and Corsi (2012) confirms that previously tasting the wine and its price, brand name, grape variety, origin, any medal/award, an attractive label, and recommendations by others are the main factors consumers consider in choosing a wine. Lockshin and Cohen (2011) showed that the importance given to these attributes varied across the 11 countries in their study. This means that wine researchers need to use the most relevant attributes based on the country where the research is occurring or where the product will be sold.

Wine as a Complex Sensory Product

Food and beverages in general often have complex sensory profiles across visual, oral, olfactory, taste, and even aural dimensions. Each of these dimensions can be manipulated to some degree, more so for processed versus fresh products.

Wine is both an agricultural and processed product. The flavor profile for the grapes that become wine is a function of both its genetics (mainly grape variety but also clonal selections) and where and how it is grown. Grapes are one of the most sensitive plants in reacting to changes in their environment. A Cabernet Sauvignon grape, for example, grown in a warmer area will have a different profile from one grown in a cooler area.

Wine flavor is the result of all the factors from the grapes plus the outcome from a large number of decisions made in processing the grapes into wine. These range from the time and date of picking, through temperature of the fermentation, the use or not of cultured yeast, additions of acid or other adjustments, filtration, aging in oak or not, and even the type of container the wine is sold in, including the type of closure.

Consumer sensory research on wine is often used to measure preferences based on manipulations of some of the production factors in the vineyard and/or in the winery. Just like the many aspects of the extrinsic product features, testing changes in the intrinsic factors must be carried out carefully with only a few factors changed, while most remain the same. This is to ensure accurately measuring the results of a known change and being able to attribute preferences to a specific manipulation. Because wine is such a complex solution, changes in multiple variables will often have interaction effects that will be hard to attribute to a specific change in process.

Methods for Measuring Consumer Preference in Wine

The investigation of consumer preferences toward wine using quantitative techniques can be done using one of two types of data. One can ask people what they would do if they were to face a particular scenario, or one can look at what people have actually done. In the first case, one would refer to the use of Stated Preferences (SP), while in the latter one would refer to the use of Revealed Preferences (RP). One can group several techniques under these two large families of preferences. Below are brief explanations of the techniques used most often when analyzing consumer preferences toward wine, highlighting the advantages and disadvantages associated with each of them.

Stated Preferences

Rating-Based Models

Rating-based models have respondents rate each alternative, product, or construct statement on either a metric or a semantic scale. These scales are easy to present to respondents and are not expensive to collect, and they can be gathered through mail surveys or self-administered questionnaires online and hence do not cause linear dependency problems, which are inherent in ranking scales. Rating tasks require less time to respond to than ranking ones, and they give more information on consumer preferences, together with preference ordering of the options proposed. Rating scales form the basis of a widely known modelling approach: structural equation modelling (SEM) (Kline 2015).

However, rating scales present several drawbacks. First of all, the quality of data can decrease because respondents do not put much attention on the actual statement they are requested to judge. It is recommended that a quality control question (e.g., please select "strongly disagree") is included among the statements respondents are presented with. One doesn't need to do it for every construct, but having 2–3 quality control questions throughout the questionnaire will improve the quality of the dataset by eliminating those who respond wrongly.

Second, cultural differences influence the way people rate items. When one wants to compare data collected in different cultural settings, one risks having biased estimates of respondents' behavior. For example, it has been shown that some countries such as Italy or the USA use the extremes of the scales more than Japanese, Australian, or French people (Usunier et al. 2005; Lee et al. 2007). In some countries, one risks having a higher rating than in others, although the importance people place on the same item is identical. Good translations or lexical equivalence is also necessary for unbiased cross-cultural research.

Third, the spatial position of the "strongly agree" Likert scale rating influences choice. Friedman et al. (1994) demonstrated that people express higher agreement when this rating is located in the left-hand side of the questionnaire compared to the right-hand side.

A vast number of papers use rating-based models in wine consumer research, making it impossible to select a few one could consider exemplar for the application of these models. Instead, it is recommend to read the papers of Hein et al. (2008) and Mueller et al. (2009), as they provide comparisons between the use of rating-based models and other common acceptance and preference methods.

Ranking Tasks

A step above in terms of preference validity is provided by ranking tasks. When using ranking tasks, the researcher fixes an origin within which respondents give a judgment to each alternative from the "most preferred" to the "least preferred." Ranking techniques provide the most appropriate conceptual mapping to people's values. Ranking scales offer an advantage even in comparison to basic discrete choice experiment (DCE) tasks, as people may express their preferences not only on the most preferred alternative but also on all the options proposed to the respondent. The limitations of ranking techniques are as follows: (a) they are often difficult for respondents, as they demand considerable cognitive sophistication and concentration; (b) they are time-consuming and may therefore be more expensive to administer; (c) they are difficult to conduct through telephone surveys; and (d) the set of ranked items is often linearly dependent; hence, it is not always possible to employ conventional statistical techniques in the analysis of the latent content of ranked preference data.

Some notable applications of ranking tasks in wine consumer research are Quandt (2006), Balinski and Laraki (2013), and Cao and Stokes (2017).

Pick-Any Method

The pick-any method, also known in the literature as the check-all-that-apply (CATA) technique, is a technique where consumers are presented with a list of terms and are asked to select *all* that apply to the objects under investigation (e.g., wines, brands, regions of origin, etc.) (Ares and Jaeger 2015). The method was first developed in the branding literature (Bogomolova and Romaniuk 2010; Nenycz-Thiel and Romaniuk 2009), but it has been applied to other research fields, such as tourism (Bowe et al. 2013), sensory analysis (Ares and Jaeger 2013), and wine (Sjostrom et al. 2016). When using the pick-any method, researchers can establish what terms are perceived to be more strongly connected with the objects under investigation, allowing the discovery of which objects are perceived to be competing more closely.

The pick-any method improves the method of paired comparison in two significant ways. First, the pick-any method extends the comparison from just two alternatives to multiple alternatives across the list of terms the researchers intend to investigate. Secondly, the pick-any method is a "free response" measure, because respondents are free to link each term to one, none, or all the objects under investigation (Driesener and Romaniuk 2006). This reduces the discomfort respondents might encounter in selecting choices they would not make if they had the freedom to do so (Dhar and Simonson 2003).

There are two main ways in which one can analyze pick-any data. The first is numerical, while the second is graphical. A paper by Corsi et al. (2011) explains the formula for the numerical calculation. The more graphical approach consists of the application of correspondence analysis (CA) to the data. This multivariate statistical technique is conceptually similar to principal component analysis (PCA), but instead of using continuous variables, it is applicable to categorical data. As in PCA, the output of CA is a set of coordinates onto the *i* dimensions of a CA plot for each of the items included in the analysis. For ease of interpretation, the plot is often reduced to two dimensions. However, different to PCA, where each axis can be defined by the factor scores each original variable loaded onto, the axes in CA have no other meaning than a bidimensional representation of the associations between the items displayed in the plot (Beh 2004).

The main limitation of the pick-any/CATA method is that the binary-response format does not make it possible to measure the intensity to which a respondent attaches an item to the object under investigation (Meyners et al. 2016). For this reason, the rate-all-that-apply (RATA) technique has been developed (Ares et al. 2014). The main difference between CATA and RATA is that with RATA, the respondent is also required to rate the intensity to which they attach an item to the object under investigation, generally using a 3- or 5-point scale (Ares et al. 2014). However, it should be noted that subsequent studies (Vidal et al. 2015) didn't find any clear superiority of one technique over the other.

Some notable applications of the pick-any method in wine consumer research are Remaud and Lockshin (2009), Vidal et al. (2015), Sjostrom et al. (2016), and Corsi et al. (2017).

Discrete Choice Experiments (DCEs)

Discrete choice experiments (DCEs) are a quantitative technique, which allows the elicitation of respondents' preferences through the combination of selected product features (e.g., country of origin, region of origin, price, label style, etc.) into sets of competing alternatives (e.g., bottles of wine with different features). The product features to be included in a DCE are usually a combination of previous literature and qualitative pretesting, such as interviews or focus groups. The alternatives are allocated into choice sets using an experimental design. In the most basic form, respondents are asked to select the alternative they would buy/prefer for each of the choice sets they are presented with.

DCEs are based on random utility theory (RUT), the sound and well-tested behavioral theory of decision-making and choice behavior (Louviere et al. 2000). RUT assumes that the choice between the alternatives is driven by an underlying, latent construct called “utility.” This can be broken down into two components: a systematic and a stochastic component. The higher the “utility” associated with a product feature, and its relative levels, the more critical that feature is for the choice of a product. The most basic model for the estimation of utilities is the multinomial logit model (MNL), but many more complex and elaborate models have been developed over the years.

Some notable applications of DCEs in wine consumer research are Corsi et al. (2012), Jarvis et al. (2010), Lockshin et al. (2006), and Williamson et al. (2016).

It is worth noting that there have also been attempts to combine DCEs with sensory testing Mueller et al. (2010b). The attempt is commendable, because this research was probably among the closest to mimic real purchasing: taking the product from the shelf, tasting it, and making (or not) a repurchase decision. Results showed that price was a very positive driver of informed liking, but liking didn’t relate to the sales volume or to the choices respondents made in the DCE. Instead, the choices respondents made in the first DCE were strongly correlated with the choices they made in the second DCE, which was also combined with a tasting, confirming the anecdotal evidence that repurchase decisions are a combination of the extrinsic product characteristics plus intrinsic sensory attributes.

Another promising development of DCEs is represented by hybrid choice models (Kim et al. 2014). Their main advantage to traditional DCE is their ability to include attitudinal variables into the estimation model. One problem that traditional DCEs pose is that while they provide a very accurate estimate of consumers’ preferences, they lack the ability to incorporate anything that is related to the personality, attitudes, beliefs, values, etc. of the respondent, despite the fact that these might actually help the researchers understand why respondents have a certain preference structure. In this sense, hybrid choice models provide the ability to disentangle the causation, mediation, and moderation effects typical of structural equation modelling while having a more accurate dependent variable than a rating-based willingness to purchase. To date the only example of hybrid choice models applied to wine consumer research is the work of Palma et al. (2016).

Best-Worst Scaling

A recent evolution in the family of DCE models is represented by best-worst scaling (BWS) (Marley and Louviere 2005), also called “maximum difference scaling.” Similar to the pick-any method, BWS can also be considered an extension of the paired comparison method, offering similar benefits, but a more efficient questioning structure. Respondents are asked to pick the item they consider the most preferred (*Best*) and the item they consider the least preferred (*Worst*) from a set of three or more items for each of the choice sets presented to them – generally not more than 20. Choice sets are created through designs, including full factorial designs, fractional factorial designs, Latin square designs, and balanced incomplete block designs (BIBD).

The relative choice probability of a given pair of *Best* and *Worst* items is assumed to be proportional to the distance between the two chosen attributes on a latent utility scale. The cognitive process, seen from a statistical perspective, is equivalent to identifying every possible pair of attributes available, calculating the difference in utility between the two attribute levels in every pair (this consists of a fixed component plus a random component), and finally choosing the pair that maximizes the difference in utility between them.

The most useful method to calculate the scores was proposed by Mueller-Loose and Lockshin (2013). Alternatively, the same estimation approaches mentioned above in relation to DCEs can also be applied to the analysis of BWS data.

The main limitation of BWS is the time necessary to complete the task, which tends to be higher than other techniques. In addition, in case the number of attributes and levels the researcher wants to test is high, the researcher is forced to acquire experimental design skills to generate designs which could be administered within a reasonable time frame.

There are different types of BWS tasks depending on the objectives of the research. If the scope of the research is simply to identify a ranking between objects (e.g., choice criteria for wine selection), one would use BWS (Type 1) (Flynn 2010). This is the most used type of BWS in wine consumer research. The papers of Cohen (2009) and Goodman (2009) are classic examples of BWS (Type 1). A second type of BWS task can be considered if the researcher needs the respondent to choose the best and worst attribute under different scenarios. Imagine, for example, a case where a researcher wants to understand the most and least important factor for the choice of wine under different consumption occasions. There have not been any BWS (Type 2) in wine consumer research. Lastly, BWS (Type 3) is when one designs a DCE, but respondents are required to select both the best and worst scenarios (e.g., bottle of wine) for every choice set the respondent is presented with (Flynn 2010). The works of Costanigro et al. (2014) and Lockshin et al. (2017) present useful examples of BWS (Type 3).

Experimental Auctions

Experimental auctions are a technique belonging to the family of non-hypothetical choice models. Respondents are given an incentive to buy or obtain a product by bidding for it or by choosing it against some alternatives (i.e., similar to what happens in DCEs and BWS tasks) (Combris et al. 2009). The main advantages are individuals participate in an active market environment, they are exposed to market feedback and they face real economic consequences to the responses given. However, experimental auctions seem to lead to different willingness-to-pay (WTP) estimations, with estimates under auctions conditions significantly higher than those calculated from choice experiments. By providing more product information to consumers, it is possible to reach more consistency between these two techniques.

Some notable applications of experimental auctions in wine consumer research are Combris et al. (2009), Grebitus et al. (2013), and Vecchio (2013).

Neuromarketing Responses to Wine Packaging and Labelling

Neuromarketing techniques (e.g., eye tracking, electromyography, electroencephalography, etc.) have emerged in the last few years. These techniques address the fact that often respondents are not able to express or report how they feel about something, or even more worrying for the researcher, a respondent states/chooses one option, but in reality, subconsciously prefers something else. Fortunato et al. (2014) provide a succinct yet comprehensive review of the advantages and disadvantages of neuromarketing techniques.

Some notable examples of neuromarketing techniques applied to wine consumer research are Gofman et al. (2009), Lopes-Cardoso et al. (2013), Horska et al. (2016), and Laeng et al. (2016).

Revealed Preferences

Revealed preference data can be classified as to whether the individual responsible for the purchase is shown in the dataset. If yes, the researcher is dealing with panel data; if not, the researcher is dealing with scanner data.

The main advantage to using either scanner or panel data is they reflect what consumers have actually done, instead of hypothetical scenarios. These data can be used for both descriptive and inductive approaches. The main disadvantage is they can be very hard to collect, either because retailers do not provide access to these data, although they regularly collect them, or because they are very expensive to purchase. In addition, unless these data are collected before, during, and after an experiment is specifically conducted to influence in-store purchases, it can be hard to measure the causes explaining the phenomena emerging from the datasets, making deductive approaches difficult.

The main advantage of panel data is their ability to link each purchase to a specific individual. This allows the calculation of several brand performance measures (e.g., market share, penetration, purchase frequency, etc.), which form the basis for the analysis of loyalty at specific points in time and over time, and cross-category purchases. In addition, if one also possesses the sociodemographic profile of each individual, one can conduct insightful segmentation analyses. Conversely, the main advantage of scanner data is they provide information about distribution, price, and trade promotions and they allow for very robust time series analyses.

The most common techniques applied in the analysis of consumer preferences toward wine using panel data are Dirichlet modelling and the polarization index. The most common technique adopted with scanner data is regression analysis.

The Dirichlet Model

The Dirichlet model is a stochastic preference model, which allows the understanding of the level of competition between brands (or product attributes, such as grape variety, price point, or origin) in a given market. In order to test whether the market observed by the analyst is Dirichlet-like or not, it is recommended to follow the instructions suggested by Bound (2009) in relation to the use of the Dirichlet software (Kearns 2009). If the data show that one is in a Dirichlet-type market, certain patterns occur in that market, summarized as double jeopardy, growth by penetration, the lack of niche or change-of-pace brands, and the occurrence of the Duplication of Purchase Law (Sharp 2010). This knowledge is useful for a brand manager, because as long as they propose brand strategies whose foundations are based on the abovementioned patterns, they can be sure their brand will grow.

Some notable applications of Dirichlet modelling in wine consumer research are Jarvis and Goodman (2005), Cohen et al. (2012), and Habel and Lockshin (2013).

The Polarization Index

The polarization index, referred to in the literature with the symbol φ *(phi)*, was developed as an independent, standardized measure of repeat purchase behavior, related to but independent of market share. φ is based upon two statistical distributions: the Dirichlet-multinomial distribution (DMD) and the beta-binomial distribution (BBD). These distributions treat individual purchases “as-if” random and offer a highly accurate predictive benchmark of brand loyalty based on market share within a category. The index reflects patterns of consumer loyalty by comparing consumers’ repurchasing behavior toward individual brands to average loyalty levels for the overall category.

Some notable applications of the polarization index in wine consumer research are Jarvis et al. (2007), Krystallis and Chrysochou (2010), and Corsi et al. (2014).

Regression Analysis

Regression analysis is a statistical technique, which allows the estimation of relationships between variables. A wide array of regression analysis approaches have been developed over the years, but only a handful of regression analysis papers using scanner data in wine consumer research have been published (Carew et al. 2004; Stasi et al. 2011; Mueller-Loose and Szolnoki 2012; Torrisi et al. 2006).

A different application of regression is used in *hedonic price analysis* (Rosen 1974). In this case, the price of a good is the dependent variable, against which any other product feature hypothesized to influence the price is regressed (Schamel and Anderson 2003). Some notable applications of hedonic price analysis in wine consumer research are Oczkowski (1994), Combris et al. (1997), and Costanigro et al. (2007).

Practical Aspects of Conducting Consumer Research for Wine

This final section focuses on the practical aspects of conducting consumer wine research. The most important aspect in conducting any research is setting the proper objectives. Next, we look at budgeting or costing the research along with whether it is better to conduct the research in-house or hire an external provider. We discuss some basics of research design and then complete this section with some directions for research reporting. The majority of this section is based on extensive experience in conducting commercial and academic research on wine marketing. Readers interested in a well-written straightforward market research textbook with more detail on issues such as setting objectives, writing survey questions, and presenting results might consider books such as *Applied Marketing Research* (Malhotra et al. 2017).

Setting the Objectives

Setting the proper objectives is the most important aspect for any type of research, academic or applied. Without clear objectives chosen for their relevance and achievability, no research project will provide useful outcomes. It is important not to overreach in setting objectives, but to clarify what the research is to be used for. This will help determine the proper method and the budget to conduct the research.

Research can usually be broken into exploratory or decision-making. Exploratory research is often conducted to understand the context of wine consumption. For example, recent exploratory research in China was conducted to understand who is drinking wine, what are the motivations for choosing wine over other alcoholic beverages, where people tend to buy wine, at what occasions wine is consumed, and who or what might influence these decisions (Cohen and Lockshin 2017). When very little is known about the area in question, exploratory research is usually conducted using interviews. This allows the researcher to ask general questions that can then be explored and followed up. For example, we might interview Chinese wine consumers aged 21–35, who are relatively new to drinking wine, and ask initially about the last occasion they consumed wine. Then we can follow that with questions about the wine: what was it? What country or region? What price was paid? Then, we can move to questions about the consumption occasion: where was the wine bought? Was it consumed there or elsewhere? Who was the wine consumed with? What was the occasion/reason for purchase? These questions can give the basis for writing survey questions to a larger and more representative group, so there is better idea of the population's behavior in buying and consuming wine. This basic understanding is necessary as a prelude to measuring what flavor profiles or packaging or communication concepts are preferred by consumers in a country, region, type of retail outlet, etc.

Designing the Research

Exploratory research in wine lends itself to direct questioning, especially to understand the basic *who*, *what*, *when*, *where*, and *why* (what situations or occasions), since many of these questions concerning wine vary across countries and cultures. This exploratory survey research, when collected from a representative population sample, can provide a good estimate of the competitive landscape for individual brands, regions, or countries, by charting the frequency of purchase/consumption, and if the sample is large enough, brands and origins can be related to different consumption occasions and purchase locations.

Researchers are often interested in what motivates the purchase of a particular bottle of wine. The objective can be to understand why or why not a certain brand, region, country, or wine style is purchased (or not), or it can be focused on how to manipulate the packaging or flavor profile to increase the probability of purchase. These are more decision-based research objectives, and the methods to measure them are different from those used in exploratory research. It is now well-understood that researchers cannot gain much useful information from asking directly why someone bought a specific bottle of wine, because the actual process of selecting a bottle of wine is mostly subconscious and consumers are not able to articulate the underlying reasons (Mueller et al. 2010a). Respondents will provide answers to survey questions about why they chose a specific bottle, but these are often not accurate and are subject to "demand effects" where the respondent tries to answer in a way they feel the research wants.

A better method is to use indirect methods to understand what influences a specific decision as noted in the sections on "Discrete Choice Experiments" and "Best Worst Scaling" above. It is important to specify the consumption situation when conducting a DCE or a BWS experiment, because the same consumer might choose a different wine for different occasions. For example, consumers will choose more expensive wines if the situation is given as a business dinner or a celebration compared to a bottle of wine to have at home with family or friends. Unless the occasion is specified, variance in responses will occur, which will reduce the predictability of the DCE.

DCEs are complex and often expensive to conduct, so it is best to hire someone with expertise to design and run them. The expense is usually in creating the realistic looking bottles to be used in the experiment and in programming the software to provide the choice sets in a randomized design to the respondents. The upside is that complex combinations of attributes can be tested in a realistic manner, including price, label characteristics, regions or countries of origin, and even different consumption occasions.

Sometimes researchers want to test less complex questions about consumer preferences, such which of several label designs is more appealing to consumers or which attribute is more important in choosing a wine (rather than which combination of attributes). The standard method for researching these questions has been to use some sort of Likert scale. As noted in the previous section, BWS can be used to generate ratio level importance weights for attributes or in this case label designs.

Cost of Research and Whether to Do the Research In-House or Hire a Market Research Firm

DCEs and BWS experiments are usually more expensive to design and implement compared to standard Likert scales, but are usually more accurate in predicting consumer preferences for specific attributes (Louviere et al. 2000, 2015). When researchers or companies want to understand the relative importance of changing one or more attributes of a wine, these two choice-based models are the best methods, as noted in the review of techniques above. Ranking works well for comparing overall preferences for small (up to six or seven) products. So the cost to do research goes back to the objectives for the research. The biggest cost for experimental research is in developing the graphics for the bottles. Depending on how many are to be made, this can cost a few thousand US dollars to $20,000 and up for complex designs. If a general rank order of preferred label designs is needed, standard Likert questions can usually separate the top few from the rest, but it is unlikely there will be one design that stands out in this author's experience; ranking can be used to find a preferred design if there are only a few to compare. When a range of label designs are compared, several will be likely rated nearly the same overall, although there may be differences if the sample is broken down into segments, such as age or gender.

Another practical question for conducting wine marketing research is whether to do it in-house or hire a research firm to conduct the research. Whichever direction is chosen, the key to useful research is a clear set of objectives that can be met by the intended research. Larger companies with trained research staff usually opt to do much of their research themselves. Unless tastings are used as part of the research, most wine marketing research is now conducted online. Simple surveys can be designed in-house, and a panel provider engaged to provide the necessary sample. Or the whole process can be outsourced from designing the questionnaire to data collection, analysis, and reporting.

If a wine company wants to conduct research in a foreign country or multiple countries, it is usually easier to hire a market research provider that can conduct all the research across the countries. This way, the translations will be handled professionally, and the data will come back in the same format from each country. It is important to get references from market research companies and to check them before engaging the company. International research can be difficult, so it is important to get an experienced company and an experienced project manager on board. This can be more difficult in regions like Asia, South America, Africa, and parts of Europe. In these places, there are a few multinational market research firms that are often able to manage complex projects, but the cost will be higher than in countries where there is more competition for research management. It is important to do a soft launch for most market research projects, especially large or international ones. Obtaining 50–100 respondents and thoroughly checking their responses to make sure any internal links work, and that any open-ended questions are understood will reduce expensive problems later on.

Smaller wine companies often decide to use their sales facility (cellar door) or customer database as a means to do market research. These methods can provide an indicative direction of consumer opinion but cannot be used to quantify the preferences of the larger wine drinking population. Some wineries will trial new blends with visitors to the winery to see which they like better. This is a good first step in understanding general preferences before deciding on one or two final blends for testing on a more representative audience. Producers should remember that visitors and mailing list customers are a biased sample that knows more about the winery and has more positive thoughts than the general wine drinking public. However, if most wine is sold directly from the winery, then visitors are a good resource to use.

When engaging a panel provider to recruit respondents, expect to pay between US$0.50 and up to US$20 per respondent depending on the difficulty (narrowness) of the recruitment criteria. Very narrow criteria, like people buying luxury-priced products, can cost over US$100 per respondent. General samples of drinking age consumers are rather inexpensive, but recruiting consumers, who drink specific styles of wines (e.g., imported red wines or wines above a certain price point), or specific age groups or geographic locations are more expensive. It is more expensive yet to recruit samples that can be generalized to a population, especially when there are less populated geographic regions or cities to be included and tested to see whether they differ from more populous locations. Our own research shows that the lower availability of wine in less populated regions and cities does affect the size of various subgroups. For example, there are likely to be fewer imported wine drinkers in less populated areas due to the lower availability of these wines, not because wine drinkers don't like them.

More recently there are services that provide respondents for a very low price, such as Amazon's Mechanical Turk (MTurk). Recent research has shown that the quality of responses using these self-selecting panels can be as good as hiring a panel provider, as long as the researcher can clearly specify the respondent profile and conduct some simple data cleaning. The cost per respondent drops dramatically when using these services compared to professional panel providers. On the other hand, panel providers can often reach hard to find consumer subgroups (segments) and can even provide translation services for collecting data in multiple countries. The use of Facebook or other social media is not recommended, because these produce biased samples which cannot be generalized to a population.

One of the specific issues in wine marketing research is the juxtaposition of sensory (tasting) and consumer research, e.g., label and price preferences. Sensory preference measurement is often conducted blind; that is, the respondents do not know anything about the wine they are tasting, except perhaps its color and sometimes the grape variety or origin. They do not see the label or information on the label and do not know the price of the wine. Blind tasting can help establish which blends or sensory profiles are preferred, but it is well known that taste preferences also depend on label information and price. In fact, Plassman et al. (2008) showed that the pleasure centers in the brain were activated during tasting by the subject being told the wine was expensive compared to the subject being told the same wine was inexpensive and the signals were not mediated by sensory organs; the results were provoked merely by the price.

Different label designs and overall packaging can similarly affect consumer preference. Consumer preferences are influenced by knowing the brand, the region, whether or not the wine has won any awards or has high/low point scores by wine writers, and other information available on the package or shelf.

These results show that it is best to use the wine as packaged for the market in order to compare to competitors or to the new packaging for the same brand. Either the actual price or price range should be provided, so consumer expectations fall in line with the actual price of the wine. If only the sensory aspects are being tested, many researchers will not use any price or packaging. However, there is good evidence that price affects the sensory attributes consumers perceive when tasting wine (Plassmann et al. 2008). The recommendation here is to at least provide consumers a price range when doing sensory testing to locate the sensory preferences in a known set of price-based expectations. Current packaging can be compared to potential packaging concepts as long as all the wines are at the same or similar price points and have the same or similar grape varieties and origins. Otherwise, these attributes could influence consumer preferences and bias the research findings.

Conclusion

This chapter has shown that wine possesses some unique characteristics, which affect how research is conducted in order to understand consumer preferences. First, the issue of doing consumer research with an alcoholic beverage was discussed. Then, the complexity of the extrinsic label and packaging attributes and the intrinsic sensory characteristics were used to show how standard Likert-type questions are often inadequate to measure the impact of the different attributes on consumer preference and choice. The bulk of the chapter covered a range of quantitative techniques used successfully to measure consumer wine preferences. Each technique has references of key wine-related literature using those techniques. The final section provided some practical suggestions for conducting research including sampling, cost effectiveness, and research design.

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Australian Wine's Taste Evolution

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Abstract

Today, beer, wine, cider, spirits, and RTDs (premixed ready-to-drink alcoholic beverages) are a customary part of Australia's drinking culture. Statistics indicated that Australia was a land of beer drinkers. While beer may still dominate the consumption figures, wine has made a significant impact on the Australian beverage market, both as a social drink and particularly when eating at home or outdoors or dining in cafés and restaurants. This chapter traces the story of Australian wine. It explores Australia's early alcoholic beverage consumption; explains how wine became part of Australia's social drinking and dining culture; describes the production, flavors, and use of some wine styles; highlights Australia's unique wine styles; and discusses emerging wine trends. It outlines some strategies the Australian wine industry has utilized to endure market, pest, and climate change pressures to permit its survival and growth on the global wine stage such as promotion of Australian wine regionality and quality, biosecurity, and the use of grape varieties more suited to Australia's climatic conditions. Some topics are discussed within a global perspective.

Introduction

Australians' Relationship with Alcoholic Beverages

Australians live with a somewhat romantic notion of Australian camaraderie interlinked with drinking, that goes as far back as the First Fleet c1788, and many tales exist about celebration and insobriety on the first day of settlement. Australia developed and colonized the bush, where alcohol played a part in terms of being available and a source of solace and leisure for people in a very isolated situation with limited recreational opportunities. Mateship is a common British and Australian colloquial term for an unconditional, strong friendship bond, often between men and sometimes formed under adversity. Ballads and literature produced in the nineteenth and twentieth centuries by convicts and the likes of Australian writers CJ Dennis, Andrew Barton "Banjo" Paterson, and Henry Lawson often made mention of alcohol as being part of the fabric of "mateship" where people worked together during difficult circumstances and celebrated and enjoyed life's milestones or drowned their sorrows with alcohol (Syson 1998).

Australians see themselves as a heavy drinking country (Midford 2005). From the earliest colonial years, it was certainly heavy per capita consumption compared with today, almost double at 13–14 l of pure alcohol, per head. However, volumes consumed in Australia were frequently less than one would have found in Britain during certain periods of the 1800s, so this legend being unique to Australia may be exaggerated (Dingle 1980; Room 2010). Yet, the stories of the bushman working hard for long periods, receiving his pay, and then using the entirety in one go or most of it in a local public house (pub) or inn are pretty accurate (Roche et al. 2009). As Australians have become more health aware, per capita consumption has decreased, and only a small proportion of the population continue a style of drinking where larger volumes of alcohol are consumed over short periods in a week (Roche et al. 2009).There are national and state government programs and laws that are in place to educate people about responsible alcohol consumption and deter drink-driving (Midford 2005).

Total alcohol consumed in 2017–2018 was 9.51 l for each person in Australia aged 15 years and over (Australian Bureau of Statistics Database 2019). It may seem unusual to incorporate the data of under 18 year olds in these statistics (18 years old is the legal alcoholic beverage drinking age in Australia), but the Australian Bureau of Statistics (ABS) states it uses this population as "it is consistent with international standards for measuring trends in apparent alcohol consumption over time." This figure was just above the lowest annual figure since 1961–1962 (9.4 l), and the ABS states that this stalls the recently observed downward trend, which started around 2008–2009. Just above three-quarters of all alcohol consumed was either beer (39%) or wine (38%). Alcohol consumed as wine has declined recently, but it is the decrease in beer consumption that has mainly driven the falling alcohol consumption, with an average decline of 2.4% per year over the last decade (Australian Bureau of Statistics Database 2019).

Figure 1 highlights the Australian per capita consumption of beer, wine, spirit, and alcohol at the beginning of each decade since 1950 until 2010. Alcohol consumption reached a peak in the 1970s and 1980s mainly driven by beer but with a consistent upturn in wine consumption. This increase in wine consumption could link to a number of social factors. At that time, there was a change of women's role in society, the invention of the wine cask (bag-in-box), changes to hotel trading hours, greater accessibility to imported international wine, purported health properties, and the change in cultural scene due to immigration of people from wine-producing countries postwar and a more affluent middle class (Roche et al. 2009)

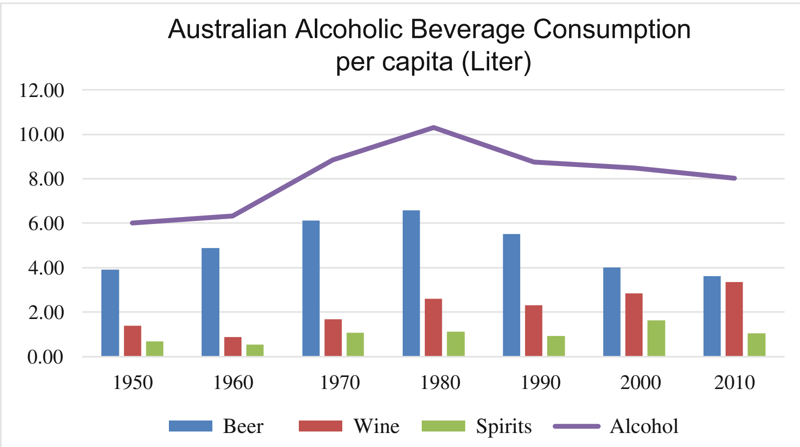
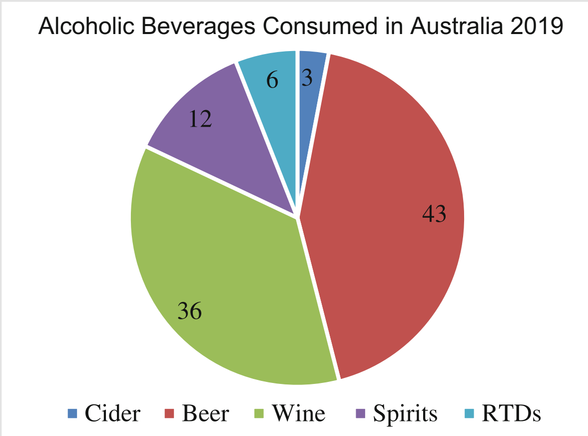


Fig. 1 Consumption of beer, wine, and spirits in Australia per capita (L) over the past seven decades. (Data used for this figure was extracted from Holmes and Anderson (2017))

Fig. 2 Alcoholic beverage consumption in Australia today. (Data used for this figure was extracted from the database of Australian Bureau of Statistics (2019))



From a relatively small base, the consumption of wine has now risen to 36% of the beverage market (Fig. 2) with some even suggesting it has become the most popular alcoholic beverage for Australian consumers (Neo 2019). The ABS data within Fig. 2 is estimated consumption for an average Australian 15 years old and over and based on supply information. Apparent per capita consumption data that is included in this publication are calculated by dividing the quantity of beverage or pure alcohol available for consumption, by the estimated resident population of Australia of persons aged 15 years and over in Australia at 31 December each year. Australian's have a diverse, almost overwhelming, range of local wines to choose from with current wines being made by approximately 2257 wine producers. It is a popular alcoholic beverage consumed usually with meals in many settings. Hail and Lockshin (1999) reported that wine is purchased for various reasons and circumstances, including social status, cellaring, immediate consumption, gifting, a barbeque, dinner at home with family or friends, dinner out, celebrations, wakes, weddings, achievements, and milestone events.

The Current State of Art of the Australian Wine Industry

Today, Australia, a new world wine country, is a significant player in the global wine scene. It is the seventh largest wine producer by volume (generating 1.2 billion liters per year) in the world and the largest in the southern hemisphere (but frequently vies with Argentina for this position). Australia is the fifth largest wine exporter (780 million liters), while domestically, 40% of what is produced is consumed (Wine Australia 2019). From 1 July 2017 to 30 June 2018, Australia's total wine exports rose 20% to $AUD2.76 billion. Australia's top 5 export markets by value in 2017–2018 were China, including Hong Kong and Macau (40% of export value); the USA (15%); the UK (14%); Canada (7%); and New Zealand (3%). Germany and the Netherlands were the only European countries that made Australia's top 10

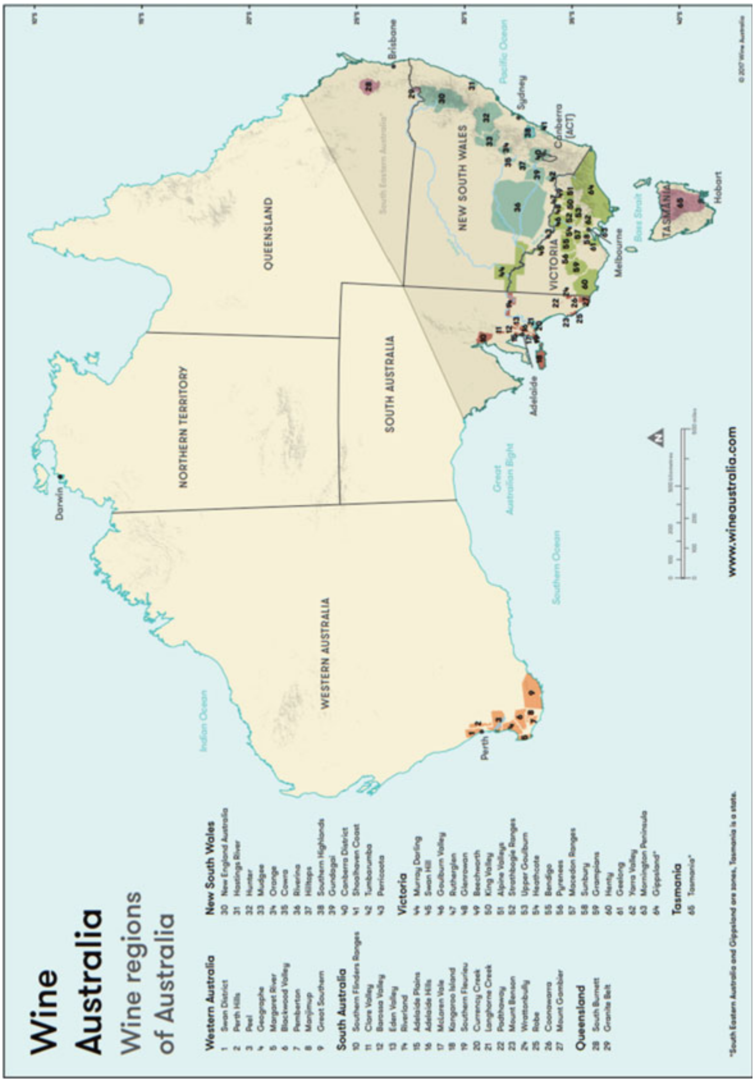


Fig. 3 Map of Australian wine regions which lists Australia's 65 wine geographical indications (GIs) and their location which relates to areas with suitable wine grapegrowing conditions. Note the majority exists in South Eastern Australia, but a cluster of nine GIs are located in southern Western Australia. (Source: Wine Australia)

export markets ranking at numbers 7 and 10, respectively. To meet domestic and international demand, an increase in wine grape plantings/production surged in the late 1990s (Iland et al. 2004) increasing from about 400,000 t in the mid-1970s up to about 1.79 million today (Australian and New Zealand Wine Industry Directory 2019). Now, Australia's 65 wine regions (Fig. 3) produce a diverse range of wine styles – sparkling, dry white, semisweet and sweet white, red and fortified, and from traditional "noble" and new and emerging varieties. These regions have suitable growing conditions for wine grapes, with the remainder of the country being desert or having tropical climes.

Approximately 100 different grape varieties are planted over 135,000 ha of vineyards in Australia, with six red varieties and six white varieties having more than 1,000 ha each (Wine Australia 2019). Shiraz and Chardonnay are the most highly planted grape varieties in several regions, accounting for a combined 46% of Australia's wine production (Wine Australia 2019).

Australia's Grape Varietal Mix Today

Plantings in Australia are dominated by the traditional or noble varieties Shiraz, Cabernet Sauvignon, Merlot, and Pinot Noir (for reds) and Chardonnay, Sauvignon Blanc, Pinot Gris, Semillon, Muscat Gordo Blanco, and Colombard (for whites) (Table 1). Other red varieties include Tempranillo, Grenache, Mataro, Durif, and Sangiovese. The white varieties Verdelho and Viognier further add diversity to the taste and choice of Australian wine. In more recent years, the alternative Italian grape varieties Montepulciano and Nero d'Avola (reds) and Vermentino and Fiano (whites) among others have captured the interest of winemakers and consumers alike.

Nowadays, Australian wine is internationally recognized as being of high quality and good value for money (Bastian et al., unpublished). It is also winning accolades on the international wine scene, for example, just recently an Australian Shiraz wine from the Barossa Valley in South Australia was regarded as the best out of 309 wines entered from 19 countries, in a prestigious and rigorous international wine competition – Syrah du Monde® – that recognizes the world's best Syrah/Shiraz wines.

Distinct Eras of Australian Wine Culture

We refer to the "the beginnings" as the period of pre-British settlement, the "early" years from the arrival of the British to about the 1850–1870s, the "recent" years from about the 1870s to about the 1950s, and the modern era as the years from about the 1960s to present. These four periods encompass the historical alcoholic beverage of our Aboriginal people, the beginnings of grape-based wines, the period in which fortified wine dominated production and then the evolution of the modern Australian industry with the rise in table wine (dry, i.e., no sugar and not fortified with spirit) consumption.

Table 1 Australian wine grape intake for top red and white varieties. (Source Wine Australia 2019)

Variety	2018 (tonnes)
Red grapes	
Shiraz	429,106
Cabernet Sauvignon	248,650
Merlot	105,489
Pinot Noir	53,373
Petit Verdot	22,070
Grenache	13,958
Ruby Cabernet	12,576
White grapes	
Chardonnay	407,940
Sauvignon Blanc	92,610
Pinot Gris	76,232
Semillon	60,437
Muscat Gordo Blanco	58,136
Colombard	56,485
Riesling	25,613

The "Beginnings" (Pre-British Settlement)

There is no doubt European settlers in Australia brought with their arrival an alcoholic culture, but the local indigenous people had one too. We now know, for example, that Aboriginal people tapped the gum trees allowing the sugary sap to collect either in tree hollows or at the base. Natural yeasts present there would ferment this liquid to an alcoholic beverage akin to cider that the local Aboriginal people named Way-a-linah. The European settlers apparently adopted this practice, and when the species was first described in 1844 by British botanist Sir Joseph Dalton Hooker, it was already known as the cider tree or cider gum (Jiranek 2018).

The "Early and Recent Years" (From British Settlement to the Wine Revolution of the 1960s)

Australia's grape wine story is just over 200 years old. It begins with the arrival of the British First Fleet in 1788 at, what is now called, Sydney in the state of New South Wales. During the voyage, grapevine cuttings and seeds had been collected at Rio de Janeiro and the Cape of Good Hope (Gregory 1988). These cuttings and seeds provided the source of Australia's first vineyards at Farm Cove, the site of the first settlement. We know that the first plantings provided table grapes as Maiden (1917) writing for the agricultural gazette of New South Wales provides a quote from a letter written by Elizabeth Macarthur, wife of John Macarthur, a founding figure of the Australian wool and wine industries:

The grape thrives remarkably well. The Governor sent me some bunches this season, as fine as any I ever tasted, and there is little doubt in a few seasons there will be plenty.

Later plantings were established further west along the Parramatta River. We do not know what proportions of table grapes and wine grapes made up the plantings at Farm Cove and along the Parramatta River. We also do not know when or who produced the first Australian wine. Perhaps the people who set up those early vineyard plots made small batches of wine for their own pleasure. Records indicate that privately owned vineyards were planted soon after the establishment of the colony. Julie McIntyre (2012) reports in her book "*First Vintage: Wine in Colonial New South Wales*" that Philip Schaeffer, the colony's first free settler, was producing wine at his farm called "The Vineyard" by 1795. John Macarthur also planted vineyards in that period at his properties "Elizabeth Farm" at Parramatta and at Camden Park to the southwest of Sydney.

We presume that in the early years, the gentry and Government officials would have enjoyed the wine. It is unlikely that the working class were part of the wine scene of those days. They would have preferred their beer, rum, or spirit. The wine would have been produced from Portuguese and South African varieties as the vine cuttings that arrived on the First Fleet were collected at Rio de Janeiro and Cape Town and thus likely to be Portuguese and South African varieties. It was not until the early 1820s that vines from Spanish and French varieties would be producing grapes for wine.

One can only imagine the taste of those very early wines. Wines would have been made using rudimentary equipment and fermented by the natural yeast present on the grapes. If the fermentation did not go to completion, then the remaining sugar would have given them a sweet taste. It is likely that the wines would have been drunk early in their life, as it would have been difficult to store the wine without it becoming oxidized. Some spirit may have been added to preserve them.

Food in the early days of British settlement was likely sourced from farms stocked with sheep, pigs, cows, and chickens. Orchards and vegetable gardens would have been established to provide food for the new settlers. The harbor would have provided a source of fresh fish. Lack of refrigeration would have meant that fresh food needed to be eaten or salted (e.g., corned beef) for storage. Stews, often mutton and sometimes kangaroo, bread, and some vegetables would have been regular offerings. Meat and vegetables, following traditional British eating habits, were common and remained so for many years, particularly in working-class families. A colonial-era cookbook (Abbott 1864) featured recipes for lamb, kangaroo, and even wombat stews, roasts, and grills. Bush ingredients – wild spinach and other native herbs – would have been part of the food preparations. Wonga wonga pigeon was a revered local game bird served from about the 1840s with a traditional English bread sauce and was similar to pheasant when roasted (Ancestry 2016). The drink – to wash this all down – would have been beer, rum, or "some sort of spirit" (probably produced illegally). Maybe Australian or local wines were served in some circles, as by the early 1800s a small wine industry had emerged.

In 1816, John Macarthur travelled with his sons to France and collected vine cuttings for shipment back to Australia. In 1831, James Busby travelled to Europe to study grapegrowing and collected and shipped about 650 types of vine cuttings to his vineyards in Australia. Official records indicate that 362 arrived alive and healthy. Plantings were made of these cuttings at the Sydney Botanic Gardens, Kirkton in the Hunter Valley, and the Macarthur family's property at Camden Park. These collections brought French and Spanish grape varieties into the varietal mix of Australian vineyards.

"The James Busby Collection" of colonial vine stock material is a unique and important historic legacy, unmatched by any other new world country (Caillard, 2016, personal communication; Iland et al. 2017). This collection formed the foundation of Australia's fine wine industry. Material from Busby's collection established many vineyards planted in the1800s. Varieties including Riesling, Semillon, Grenache, Mataro, Shiraz, Cabernet Sauvignon, and Pinot Noir can be traced back to the Busby collection or perhaps to William Macarthur's own importations of 1838. Some of these old vineyards still survive today – many in the Barossa Valley, South Australia. Most notable are the Shiraz in the Langmeil "Freedom Block" (the term block in this context refers to a section or portion of a vineyard), Tanunda; the Cabernet Sauvignon in Block 42 in the Penfolds Kalimna block near Nuriootpa; the Mourvedre in "The Old Garden" plot at Rowland Flat; and the Grenache in the Cirillo family's "Old Grenache" block near Nuriootpa. These special, over a century old, vines are most likely the oldest continuously producing vines of each variety in the world. These treasured sites have survived because of the absence of phylloxera, which to date has never been found in South Australia. Grape phylloxera (*Daktulosphaira vitifoliae*) is a tiny aphid-like insect pest (less than 1 mm in length) that destroys grapevines and ornamental vines by feeding on their roots. Once infested, vines will usually die within 6 years. As no eradicative treatment exists, infested vineyards require replanting on phylloxera-resistant or phylloxera-tolerant rootstock. This is expensive, and replanted vines will take approximately 3 years to produce a crop and longer to mature. Due to the leadership and work of wine industry strategy and advocacy bodies, like Vinehealth Australia (https://vinehealth.com.au/) and Australian Grape and Wine Incorporated (https://www.wfa.org.au/), there has been wide uptake by the Australian wine industry of vineyard biosecurity measures. These include limiting visitor access and disinfecting footwear when entering vineyards plus strict quarantine regulations regarding transport of vine material across State and international borders, which has so far prevented infestation by this pest.

The wine industry grew throughout the mid- to late-1800s. Wine was sold through merchants/agents in the cities, and an export market had been established. Domestic sales were to the restaurants and cafés of the day, either direct or through wine merchants. Up to the early 1900s, most wine was sold in bulk – sometimes in cask, other times in 5 or 10 gallon lot containers and sometimes flagons. Some wine was probably sold direct to locals in the vicinity of the winery. Wine exports to Britain began about the 1850s. England was not a wine-producing country, and the ruling classes were keen to develop a wine industry in Australia for a ready supply to the homeland (Woodhouse and Osborn 2012). By 1839, there were 60 varieties of grapes in the colony including Riesling, Cabernet, Shiraz, Tokay, Verdelho, Malbec, Grenache, Carignan, and Mataro (Woodhouse and Osborn 2012). These remained the main varieties for many years. Some of these grape varieties produced Australian fortified wines, wine styles similar to those these grape varieties produced in their countries of origin of Spain and Portugal. Fortified wines, meaning a wine produced through the addition of a spirit (usually Brandy) to a dry or sweet wine, with its higher alcohol and often sweetness levels, were in demand in the British motherland and well suited its cold climate. However, although these wine styles would probably have been less agreeable to consumers in Australia's hot weather, they still dominated early wine style consumption patterns even up until the 1960s and 1970s.

Even though local wine was available, in the early years, the wealthy would have drank mostly imported wine – French and German – as was the custom in the homeland. Although table wines were available, fortified wine production steadily dominated wine trade during the late nineteenth and early twentieth centuries. The shift to fortified wines at around the turn of the century was most likely due to two factors – difficulty with spoilage of dry wines and that fortified wines were easier to produce and sell. By the 1950–1960s, fortified wines were the major part of the wine market.

Port and Sherry (as they were called then) were enjoyed across the socioeconomic spectrum. Men, particularly working-class men, drank beer, but in many homes, there was a bottle of Sherry or Port, often supposedly for cooking and medical purposes or a visit by the church Vicar or Priest. It was not uncommon for ladies – of all social classes – to have a "tipple" of sweet Sherry at the end of the day**.** At social dinner parties and formal functions, it is likely that both beer and wine were served, but after dinner men retired to the parlor to partake of Port and to discuss matters of "importance."

The wines from the 1800s and early 1900s included table wines and fortified wines. A list of wines available from James T. Fallon (grapegrower/vigneron) in 1874 included Riesling (dry and fruity options), Verdelho, Tokay, Shiraz (dry or fruity options), and Clarets (made from Malbec, Hermitage, Mataro, and others). The wine was available in bulk, oak casks – known as quarter-casks (80 l/21 US gallons), hogsheads (242 l/64 US gallons), and puncheons (500 l/132 US gallons) – or in quart or pint bottles. Table 2 displays the 1913 wine list of Thomas Hardy & Sons' Adelaide Wine Cellars. A large proportion of the wine in the 1800s and early to mid-1900s was exported. Frank Osborn of d'Arenberg fame in McLaren Vale began to produce bulk wine in 1928 specifically for the export market (Woodhouse and Osborn 2012). Other companies – Thomas Hardy & Sons and Penfolds – were exporting wine prior to this. Today, exports form a large part (about 60% of total production) of the modern Australian wine industry. It is interesting to see the varieties listed, as in these periods generic terms – for example, Champagne, Hock, Chablis, Burgundy, Claret, Sherry, and Port – were mostly used (see the section "What's in a Name" below).

By the end of the nineteenth century, grapegrowing and winemaking had become a significant part of Australia's agricultural landscape, but beer still dominated the

Table 2 The 1913 wine list of Thomas Hardy & Sons, Adelaide, Wine Cellars (Bishop 1977) which is one example that highlights the availability of dry white and red table wines, relative to sweet and fortified wine styles at the time

White wines	Red wines	Sweet wines
No. 0 Hock	No. 0 Claret	Frontignac
Hock	No. 1 Claret	Madeira
Chablis	Tintara Claret	Muscat
Old Sherry	Old Burgundy	Hardy's Sherry
Oomoo White (a first-class white wine, slightly sweet)	Burgundy	Old White
	Old Port	Old Brandy
	Invalids' Old Port	
	Adelaide Port	
	Old Red (sweet)	

drinking pattern. There was a pub/hotel on the corner of almost every street of every town and city. The corner pub supposedly arose out of the need to house and feed builders constructing dwellings along the street, and pubs either were sold off to pay for remaining building works or were retained to act as focal social gathering places for the locale. Across Australia, in most states, closing time at the public bar was 6 pm in the early twentieth century (Phillips 1980; Room 2010). Six o'clock closing, introduced during World War I, was partly an attempt "to improve public morality" (despite their having being a major drive for this by the temperance societies commencing in the 1870s) and also a war austerity measure. Before this licensing reform by referendum, most Australian hotels and public houses closed around 11 or 11:30 pm (Phillips 1980). A beer on the way home with your mates was a common practice. With 6 o'clock closing, a 1 h, heavy drinking session ensued between "knock-off" time at 5 pm and mandatory closing at 6 pm. Men stood crammed in at bars to consume as many drinks as possible before "time gents" was called. The phrase "6 o'clock swill" is Australian and New Zealand slang for the urgency to buy drinks at the pub before closing time. Bar closing times were extended across Australia in different years. Closing time was changed to 10 pm in Tasmania in 1937, but not until 1955 in NSW and 1966 in Victoria, with the state of South Australia being the last to abolish "the swill" in 1967.

Beer was the drink at dinner and celebrations for men (and some women). Ladies often drank a "shandy," a mix of beer and lemonade (the sweetness of the lemonade most likely masking the bitterness of the beer), in the lounge area, because up until the late 1950s, in Australia women were not permitted in the public bar. Despite the fact that earlier in Australia's colonization, many women were publicans, by 1900 for "respectable women," it had become socially unacceptable to frequent hotels, an outlook that prevailed until the late 1950s (Kirkby 2003), at which time surveys found that only one in four women drank alcohol. Right up until 1970 in Queensland, to serve women alcohol in the public bar was prohibited. Women were able to purchase a drink in the ladies lounge or beer garden, although at a higher cost. However, the public bar was the men's domain. Inequitably, women could be barmaids in the public bar, but they couldn't be customers.

When wine started to be served at restaurants is uncertain. The appearance of restaurants in Melbourne in the 1850s arose probably out of need as the population soared after gold was discovered in 1851. Restaurants where respectable men and women dined together in public appeared relatively late, as occurred in England. Hotels were major providers of food throughout the nineteenth century. Gentlemen also dined at their clubs. The first restaurants of note were European rather than English with the French style dominating international fine dining. Records indicate there was considerable interaction and intermarriage between restauranteurs and wine merchants who supplied the former (Erlich 2008). References also indicate that restaurants were established in the capital cities in the 1870s and 1880s with sixpence meals (Inside Story 2016). The shilling restaurants also provided alcohol, and there was a separate room for the women (Erlich 2008). When hotels were required to close at six o'clock in 1916, the practice of not serving liquor after six spilt over into restaurants, where due to licensing laws most were unable to serve liquor at all, and those limited establishments that could were obliged to have all glasses off the table by mid-evening. The diners of the time became accustomed to having wine served in cups. Wine was being offered at hotels and restaurants in the 1940s and 1950s (and probably earlier). For example, Café Rigoni's advertised 'It's the atmosphere that counts. For something just a little different take her to Café Rigoni's – Soft lights, Sweet Music. Light Wine Served'. Several other restaurants of that period advertised 'wine served with meals' or 'Best select wines and expresso coffee'. Night Clubs offered dinner, wines, dancing and a show (Thompson and Smith 2015). Dining at restaurants had become part of the norm. Before the practice of Bring Your Own "BYO" wine in the mid-1960s, due to the expense of liquor licenses, some restaurants still served wine, just covertly in soft drink bottles and tea cups (The Age 2004). BYO was popular for another 20 years or so, and some restaurants still continue this practice with varying corkage (serving your wine to you) charges.

There is much written about people, vineyards, and wine companies, but there is little information of the taste of the early wines. There are references in the literature of red wines being "full-bodied" and "strong wines." It is likely that some may have had spirit added to them at the completion of fermentation to preserve them. The quality of the wine in those days was variable, but there are several references to excellent wines being produced in this period. For example, in 1827, Gregory Blaxland of Bush Farm sent three pipes (a pipe equals about 500 l) of some colonial wine, lightly fortified with 10% French Brandy (to protect the wine from spoilage) to a London competition. This wine won a Ceres Gold Medal. In the first half of the twentieth century, wine quality would have improved as wine companies introduced modern winemaking equipment, such as stainless steel tanks, presses and refrigeration systems, and more efficient bottling facilities. Wine people talk of the great red wines from across several of Australia's wine regions, for example, Reynella, Coonawarra, and the Hunter Valley of the 1930s to the 1960s.

Food was still influenced largely by traditional British eating habits. Chinese restaurants offered alternative dining venues and cuisine. "Fish and chip" shops were common in many towns and cities. But most dining (eating-out) places were in hotel dining rooms (although there were a few "restaurants"). By the early 1900s, some cafés/restaurants offered a wider variety of alternative style cuisine, for example, French, German, Italian, or Chinese. However, most of the time eating-out and at home was along the traditional British eating habits of "meat and three veg," often potatoes. Meat and three vegetables was the norm (particularly for the working class) right up to the mid- to late 1900s. Below, we present a selection of menus described in the book *Traces: Where Adelaide Ate Out* 1836–1960 by Thompson and Smith (2015) to illustrate this point (Fig. 4).

The advertisements for restaurants in the 1940s and 1950s promoted "Continental and Australian Food" and "Best Continental Foods" and "Finest Italian Specialties and expresso coffee". The Copper Kettle Wine Restaurant was offering oyster cocktail, chicken fricassee, filet steak, Cordon Bleu, and pancake flambé. The choice of cuisine had expanded. Further change was to come with the "Evolution/Revolution" of Australian wine and food that began in the 1960s and continues today.

By the 1940s, the wine industry had progressed from rudimentary winemaking to more modern practices. By the 1950s, Leo Buring was making the sweet lighter wine styles branded under the label "Rhinegold." "Barossa Pearl", a sparkling white wine (made from Muscadelle and Semillon), was created by Colin Gramp in time for the 1956 Melbourne Olympic Games. It was an immediate success. He had introduced pressure tanks from Europe (to trap the carbon dioxide from the fermentation) to produce a fruity, fizzy wine style, modeled on the sparkling wines of Germany. A new segment of wine drinkers were being introduced to wine. However, the large changes came in the 1960s and 1970s. Guenter Prass, one of Australia's well-known and acclaimed winemakers of the mid- to late 1900s, is quoted (after the revolution) as saying, "In the 1950s when you went to dinner you had a sherry as an aperitif, beer with the meal and perhaps a port after the meal. Today you have a glass of wine anytime. .... This is not only a difference, but a revolution" (Allen 2012).

A selection from the menu of a supper at the Southern Cross Hotel in 1839:

Selection of pies — Veal, Giblet, Quail, Pigeon, Pork or Pickled Tongue; **Remove** — Saddles of Mutton, Butt of Beef, 2 Legs of Mutton, 2 Forequarters of Lamb, 6 Roast Geese, 6 Hams; **Dessert** — 6 Plum Pudding, 18 Raspberry, 12 doz Custards, 2 Sponge Cakes.

The menu of the York Hotel in the early 1900s:

Soups — Crème of Chicken, Consomme of a la Creol; **Fish** — boiled Snapper, Oyster Sauce; **Entrees** — Croquettes of Chicken with Peas, Scallops of Veal with Nouilles; **Joints** — Roast Sirloin of Beef, Roast Saddle of Mutton, Roast Black Duck, Salade; Cold Yorkshire Pudding,

Cold — Roast Beef, Lamb, Ox Tongue, York Ham; **Vegetables** — Spinach, Cauliflower, Boiled Potatoes, Baked Potatoes, Mashed Potatoes; **Sweets** — Baked Apple, Dumplings, Cup Custard, Wine Jelly.

Fig. 4 Examples of entries in "Traces: Where Adelaide Ate Out 1836–1960" (Thompson and Smith 2015). These entries present examples of dishes from menus of hotels in Adelaide, South Australia, in the nineteenth and twentieth centuries

The Modern Era (The 1960s Through to Today): The Revolution – The Rise of Table Wine

By the 1960s, fortified wine production was at its peak. However, the influx of migrants and returning soldiers from Europe after World War II saw a rapid change in consumer tastes (Santich 2006). A move away from older Australian drinking practices to a more sophisticated table wine and food restaurant dining culture quickly developed (Kirkby 2003), with a boom in red wine sales during the 1970s and a swing to white wine consumption during the 1980s. Sparkling wines became popular, particularly for celebratory occasions. Varietal wines (wines labelled by grape variety) also became popular and replaced generic terms like Claret and Hock. This simple labelling system made it easier for people to understand wine. Brand names including Penfolds, Jacob's Creek, Rosemount, Wolf Blass, and Lindeman's dominated domestic and international wine trade.

The change in drinking patterns coincided with a change in Australia's eating and dining patterns. During the 1950s and 1960s, men who were interested in wine joined local Bacchus and Beefsteak and Burgundy Clubs. Women also had clubs – the Chicken and Chablis Club. Although, more formal wine tasting clubs are less popular in Australia, today men and women drink both white and red wines, and the clubs are not segregated.

Some Events/Factors that Drove the Rise of Table Wine

The introduction of refrigeration, cultured yeast, stainless steel fermenters and storage vessels, modern presses, and the use of inert gases and a greater understanding of winemaking principles through the wine schools established at Roseworthy Agricultural College (later to become The University of Adelaide) and at Charles Sturt University probably culminated to drive better-made, microbiologically and chemically stable, higher-quality wines. As a result, a table wine culture arose. Most of Australia's winemakers have studied at these two institutions and would have been abreast of this wealth of winemaking innovation and technology but also were more globally mobile and aware of what world wine styles were on offer. With our warm climate and outdoor lifestyle, table wines were clearly more suited than higher alcohol and warming fortified styles and the Australian wine consuming community responded. The invention of the wine cask (bag-in-box) in 1965 by Thomas Angove of the Riverland (Fig. 5) (Byrne 2017) took 2 years to develop and was considered by the press as "an extremely novel idea." It was not designed to replace glass but offered the convenience that people could buy wine in bulk and have just one or two glasses without the need to open a bottle (which in many cases would rapidly oxidize and go brown and smell of bruised fruit even after 24 h). The cask was stored in the refrigerator in the kitchen. It became more common for wine to be served and enjoyed at home with a meal and at gatherings. Special events commanded a higher price offering – often interpreted as serving "a bottle" of wine rather than a cask.

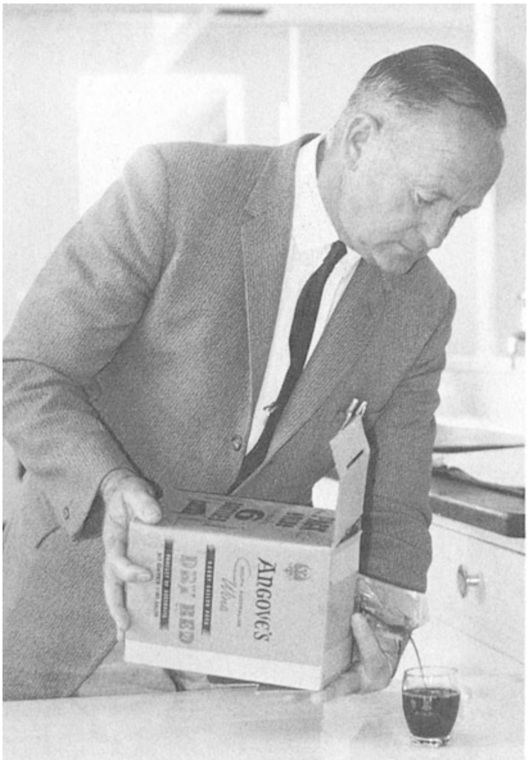


Fig. 5 Bill Marshal demonstrating Angove's bag-in-a-box in 1965. (Photograph provided by Angove Family Winemakers "Angove Family Collection")

Angove Family Winemakers, like many Australian wine companies, have now moved away from the wine cask, preferring to present their range of wines in bottle.

In the 1970s and 1980s, alcohol consumption peaked in part driven by increased wine consumption. The introduction of wine in a flagon and cask had a large role in this increase. Marketing campaigns also drove sales. Many Australians remember the advertisement "Where do you hide your Coolabah." Coolabah was the popular brand of cask red and white wine produced by the then Orlando wine company.

Alongside the increasing interest in the large-volume, medium-priced popular brands of the 1980s Australian wine boom (Anderson and Aryal 2015), a "wine connoisseur" culture developed. These people, often professional men, sought out special wines from both overseas and locally (Johnson and Bastian 2015). Wine knowledgeable people including James Halliday started writing newspaper articles; wine magazines such as Winestate (established 1978) were published, and wine companies ran publicity campaigns (e.g., a popular women's magazine in conjunction with a wine company produced, "Woman's Day and Lindeman present your guide to wine & entertaining," c1983); and interest and knowledge of wine increased. The number of Australian wineries swelled, from just under 500 in 1985 to over 2500 by 2013 (Anderson and Aryal 2015). Doctors, lawyers, scientists, as well as people of other professions established wineries – often as a hobby or as a weekend escape from the city. A boutique winery culture emerged. New vineyard plantings and generational change, in traditional and new wine regions, during the late 1990s and early 2000s saw the wine sector achieve new ambitions (Anderson and Aryal 2015). More recently, interest and activity have increased in cool climate wine styles, sustainability, organic and biodynamic viticulture, preservative-free, terroir, and so-called natural wines. These, along with traditional approaches, have led to a diverse, dynamic, and exciting present-day wine culture. Australian wine is known and appreciated in export markets around the world, especially the UK and the USA, and now more recently China (Wine Australia 2019).

Food and Wine Scene Today

Increased worldwide connectivity through news and entertainment media, the World Wide Web and social media mean patterns in the global food and wine scene are reflected in Australia. The modern Australian café, restaurant, and home meal scene is a melting pot of many cultures. Similar to other nations, immigration leading to Australia's multicultural population has brought Italian, French, Chinese, Vietnamese, Spanish, Lebanese, Thai, Mexican, and many other countries' food culture to the plates and glasses of Australian diners and families. TV shows now feature cooking demonstrations and competitions. People are interested in what they eat and where it comes from (Giles-Smith 2014) and how it is prepared. The phenomenon of world-renowned "celebratory chefs" and "food gurus" has gained a large following by the so-called "foodies." Restaurants, as in Europe and elsewhere around the world, are judged and rated – much like wines are in wine shows. Hats, and other awards, similar to those in European countries, are prized achievements.

Currently in Australia, Chinese cuisine is more than "sweet and sour chicken," "beef and black bean sauce," or "fried rice"; in our large cities, you can enjoy Chinese cuisine in many forms, such as Cantonese, Sichuan, Hong Kong influenced, and Shanghainese. The same could be said of other cuisines, for example, Southern or Northern Italian cuisine. Many of Australia's restaurants are based on locally farmed and grown produce. The food is fresh, creative, diverse, and exciting, and diners today are discovering ingredients that our early settlers used in their food preparation. It is now not uncommon to find indigenous ingredients appearing on restaurants' menus. Offerings can include the likes of wattleseed, lemon myrtle, lilly pilly, and quandong. For example, Orana Restaurant in Adelaide quotes its philosophy as – "to respect the Aboriginal people and Australia's varied food history while celebrating the nutritional properties of indigenous ingredients". Their menu includes dishes such as soup – crocodile with Australian botanicals and kangaroo, smoked potato, feral plum, and wattleseed. Australian cuisine has come a long way from mutton stew and wild spinach eaten by the early settlers. Today, Australian chefs and cooks have a rich and long Aboriginal cultural base – over 60,000 years – to draw inspiration from. Add to this our British heritage and influence of immigrants from many countries, Australia has developed a diverse, interesting, and exciting food scene along with a high-quality and diverse range of wines to partake in with those foods (Santich 2006). With Australia's close proximity to the rest of Asia, its cuisine has been shaped by this Asian influence more so than the USA, Canada, Western Europe, the UK, and other Western nations arising as a result of British colonial settlements. "Modern Australian-Asian fusion" and "Pan-Asian food" are terms often used now to define a number of Australian restaurants' fare.

What's in a Name?

In the old world of France or Italy, top quality wines have been labelled by the region (e.g., appellation, Appellation Controlee AC or Denominazione di Origine Controllata e Garantita, i.e., Denomination of Controlled and Guaranteed Origin, DOCG, respectively) in which they are produced, not by grape variety. These classifications act today as wine quality indicators and have strict controls over various aspects like grape yields and wine production, maturation, tasting, analytical testing, etc. Over the generations, consumers of European wine became familiar with what to expect from a wine from these regions. At the time wine production commenced in Australia in the early 1800s, there were no recognized wine regions, and the wine-consuming population only had experience drinking European wines. For whatever reason, Australia's early winemaking pioneers were not sufficiently confident to label their wines by their variety (e.g., Shiraz) or region.

Up to the 1980s, the wine regions of France and Germany such as Beaujolais or Moselle were commonly used for Australian wines in bottle and in cask. Consumers before this period in Australia's wine history would have grown up with and understood their meaning. However, these names did not relate to the grape varieties that would constitute these wines made from those regions overseas. Claret, an old English word from the 1700s, was also a popular wine description on Australian labels and is a term broadly considered to reflect a light, dry red wine or a Bordeaux wine. In retrospect, the use of these old-world regions for Australian wines was not well considered, as frequently the Australian wine style was nothing like those from those old-world areas.

Clues to the taste of Australian wines throughout most of the first half of the 1900s may (or may not) be gained from their generic names after the "old-world" appellations. Names for white wines included Champagne, Hock, Chablis, White Burgundy, Moselle, and Sauternes. The names broadly reflected a style (e.g., see Table 3). They were frequently made with multiple varieties and did not need to be produced from the variety that contributed to the European style. For example, France's White Burgundy is made solely from Chardonnay, while in Australia the name reflected a style not a grape variety and could be made from a mix of white grapes. Books (Young 1983) and wine show specifications of the mid-1900s indicated, briefly and generally, the following styles in Table 3. In those days, a wine labelled in any of the categories could be produced from any and several varieties.

Red table wines were often labelled Claret or Burgundy (Table 3). Claret was frequently made from both Shiraz and Cabernet Sauvignon and referred to a style of wine that was firm and astringent, often high in tannin and with good cellaring

Table 3 An example of Australian wine styles pre- and mid-1990s (Young 1983)

Wine Name	Wine Style and Taste
White Burgundy	Fuller, rounder, softer white wine
Moselle	A sweet style white wine, usually fragrant
Hock	Fresh, light, dry, fairly acidic with a fragrant bouquet
Burgundy	A full-bodied, fruity red wine with a smoother, round, and softer finish than a Claret
Claret	A full-bodied red wine that is firm and astringent

potential. Wines labelled "Burgundy" hailed mainly from the Hunter Valley in New South Wales, Swan Valley in Western Australia, and northeastern Victoria – all regions quite climatically different to France's Burgundy region. These wines were softer, fruity, and less acidic than Clarets and made from either Shiraz, Pinot Noir, or a blend of both or other reds like Grenache. The Shiraz grape variety is not even grown in France's Burgundy region, which is an area producing Pinot Noir and Gamay grapes. Pinot Noir plantings have diminished in the warmer regions of Australia and are now planted in cooler climates. There have been considerable replantings in Australia to ensure varieties fit the region's climate such as Mediterranean varieties (see below). Australian fortified wines were referred to as Sherry and Port.

The situation changed in the mid-1990s when Australia started labelling their wines by grape variety and its own geographical indications (GIs wine regions; Fig. 3). Wine producers adopted labels displaying grape variety and the region, e.g., Cabernet Sauvignon, Coonawarra, and the like. Then, in 1994, the Winemakers Federation of Australia, a national wine industry advocacy body, signed a wine agreement with the European Union, assenting to cease the use of old-world wine region names on Australian wines entirely. These names are actually akin to the way Australia now uses its own wine region names on its wine labels, for example, the Barossa Valley, Mornington Peninsula, or Hunter Valley. As Australia has become a global wine heavyweight and its winemakers confident, skilled, and knowledgeable of wines from around the world, it too has gradually turned to designate its wine by origin. In so doing, it infers wine quality, grape variety, and wine style to the international market in an effort to assert that Australia generates premium, not just cheap and cheerful, wines of provenance.

Recently, Australia has faced a number of commercial challenges including the enforcement of naming restrictions from the European Union. Examples include the requirement to rename its Rutherglen Tokay (a fortified sweet wine style made from Muscadelle grapes) to Topaque, as the former was considered too close to Hungarian Tokaji (a sweet and complex botrytized wine made from unique, Hungarian varieties such as Furmint and Hárslevelű, plus another four permitted varieties). Wines previously named Champagne are now known as sparkling wine in Australia. Australian winemakers carbonate their sparkling wines with a number of methods including the "methode champenoise." However, labels will not use this term and include "methode traditionnelle" instead if the wine has undergone further fermentation in bottle indicating it is a sparkling wine of high quality. Australian-made Sherry is now labelled with the Wine Australia registered term Apera, yet this name is also under challenge by the Campari group, as it believes it could impact the aperitif Aperol. Prosecco is a documented white grape variety (originating from Italy) on the internationally recognized grape variety list maintained by the International Organisation of Vine and Wine (OIV). Prosecco was being used to label and market sparkling wine styles in Australia with considerable success. Yet this too was challenged as a protected term. The European Commission (EC) asserts that the term "Prosecco" is a geographical indication (GI). The EC attempted to register Prosecco in Australia, which was successfully opposed by the Winemakers' Federation of Australia on the grounds that it is a grape variety. In Australia, we do not prevent the use of the term as a grape variety. This is supported by the TRIPs (Trade-Related Aspects of Intellectual Property) agreement, which is an agreement of the World Trade Organization (WTO) (World Trade Organization Analytical Index (2019)). The agreement specifically provides that a signatory country does not need to prevent the use of a registered GI that is also a grape variety (as a grape variety). Until 2009, the EC recognized Prosecco as a grape variety; however EC Regulation 1166/2009 introduced a decree stating that the vine variety "Prosecco" be renamed as "Glera," another synonym for the prosecco grape instead. Since then, the use of the term Prosecco as a grape variety in the EU has been prohibited.

Increasing Interest in Australian Wine Regionality/Subregionality

A regional wine's style, quality, and prestige are influenced by its place of origin. Protected geographical indications (GIs) have evolved to identify goods originating from a particular area "where a given quality, reputation or other characteristic of the product is essentially attributable to its geographical origin" (World Trade Organization (WTO) Analytical Index 2019). GIs assist in the differentiation between products in the global market (Bowers 2003). Climate and vineyard attributes including geology and soil modify grape chemical composition (Van Leeuwen and Seguin 2006) enabling the discrimination of grapes from different regions (Son et al. 2009; Teixeira et al. 2014). Unlike Europe, Australia does not have the wine laws where local and government regulations constrain viticulture and winemaking practices. The flexibility of winemaking and labelling laws allows winemakers the choice and opportunity to make Australian wines in many different ways. Blending has been a part of Australian winemaking culture for many years, resulting in unique Australian wine styles, such as blends of Shiraz and Cabernet Sauvignon. This follows the rationale of a Bordeaux wine blend where Shiraz replaces Merlot to round out the middle palate of the wine and provide fruit intensity to support Cabernet's tannin structure. Australian wine laws also allow winemakers to make wines from a single variety within a region, from two or more varieties from within a region or from multi-regions. However, in 1993, the Australian wine sector developed a geographical indication (GI) system mimicking the Appellation Controlee of France. The GI system officially describes Australian wine zones, regions, and subregions (see Fig. 3). Although the system is likened to the European appellation system, it is much less restrictive. It aims to protect the use of the regional name, such as Barossa Valley, Coonawarra, Hunter Valley, or Margaret River, under international law and limits its use to describe only wines produced from grapes grown within that GI. The Australian GI system ensures at least 85% of the grapes come from the region and vintage, acknowledged on the label (Johnson et al. 2013). Furthermore, wines from a designated GI should possess unique sensory characteristics and varietal expression deriving from the region, rather than overt viticulture and/or winemaking practices (Johnson et al. 2013).

Knowledge of the specific composition of wines originating from different GIs would allow the characterization and authentication of the wines and valuation of each GI. As such, wine aroma, flavor, and chemical profiles that differentiate wines from distinct regions have received much research interest globally (Cadot et al. 2012; Di Paola-Naranjo et al. 2011; López-Rituerto et al. 2012). European appellations strive to preserve wine typicality by strictly regulating, e.g., the use of permissible grape varieties, harvesting methods, maximum yields, minimum alcohol levels, and production methods (Van Caenegem 2003). Furthermore, traditions and human practices may vary markedly by region or appellation. In vineyard-driven classifications (e.g., Burgundy, Mosel, Barolo), human intervention is strictly regulated, while in other appellations, distinct wine styles are defined by the local winemaking practices (e.g., Amarone della Valpolicella, Champagne, Port). Bordeaux has achieved great economic success by classifying quality of individual wine estates.

Along with their fruit-driven, easy-drinking style and good value for money, the uncomplicated and clear varietal labelling contributed to the enormous success of Australian wine in the 1990s (Easingwood et al. 2011). Australian Shiraz became internationally recognized as a unique wine style with examples coming from the Barossa Valley, McLaren Vale, and Hunter Valley. Aromas and flavors can range from plum, red, blue, and black berries and chocolate to liquorice and spice (Herderich et al. 2007) resulting in medium- to full-bodied wines with varying structure depending on region, climate, and winemaking techniques. As Australia did not have a firmly ingrained concept of terroir, it commonly used brands and price points to create a sense of fine or quality wine in consumers' minds (Johnson and Bruwer 2007).

Today however, the Australian wine industry has an increasing interest in wine regionality. The concept of regional typicality of wine is an important one as it not only delineates geographic areas but also permits promotion of Australian wines with recognizable and desirable sensory characters (Lecat and Chapuis 2017; Luykx and Van Ruth 2008; Maitre et al. 2010). This notion is also related with terroir, that is, wine provenance, a holistic definition including the interaction between location (topography, climate, soil), people (tradition, winemaking and viticultural practices), and product (grape varieties, wines) (Vaudour 2002). Terroir has defined many famous regions in Europe, including the prestigious vineyard sites of Burgundy, Mosel, and Barolo or the classified wine estates of Bordeaux. Wine consumers have relied on provenance to predict wine quality and are willing to pay a premium price for them (Benfratello et al. 2009; Casini et al. 2009; Charters and Pettigrew 2007; Johnson and Bruwer 2007). There is also an increasing interest in the production of single vineyard Australian wines – wines that express a "sense of place." Currently, there is industry-wide belief that production of regional and single-site wines will enhance Australia's image as having a segment of high-quality, "terroir"-focused fine wines. From an economic view point, establishing a fine wine image through regional typicality has been a focus of Australian wine businesses as it is seen as a strategy to raise Australian wine's global image around quality and thereby demand higher prices.

Australia has many regional styles; some examples being Clare Valley Riesling, Hunter Valley Semillon, Margaret River Cabernet Sauvignon, Coonawarra Cabernet Sauvignon, Mornington Peninsula and Yarra Valley Pinot Noir, Barossa Valley Shiraz, and Rutherglen Muscat. Several research projects have explored the taste and chemical composition of Shiraz and Chardonnay wines from different regions and within regions. One of the authors of this chapter, Dr. Sue Bastian, and colleagues have led several of these studies. Chardonnay, the white variety most important to Australia at present, encompasses 44% of all white wine production. Yarra Valley, Adelaide Hills, Tasmania, Tumbarumba, and Margaret River are cited as top Chardonnay-producing regions with wine sensory descriptors covering the fruit spectrum, from citrus and green apple to peach, apricot, and tropical fruit (Bruwer and House 2003; Gambetta et al. 2014). Chardonnay is an extremely flexible grape with regard to various winemaking techniques (Gambetta et al. 2014) resulting in diverse wine styles within and across regions (Saliba et al. 2013). Chardonnay grapes are a neutral variety unlike the aromatic floral and perfumed Riesling or tropical and herbaceous, sweaty Sauvignon Blanc grape wines. Australian Chardonnay wines have experienced an evolution of style over the past 40 years. This has been partly driven by the Australian wine show system and reduction in sales. Show judges encouraged a move away from oak forward styles with too much buttery aroma and softened, round mouthfeel due to higher alcohol and yeast lees contact (where the wine is stored in tank or barrel on a deposit or sediment of the now dead yeast that conducted the fermentation) and full malolactic fermentation (MLF, a secondary fermentation performed by lactic acid bacteria that converts grape-derived malic acid to lactic acid to soften the acid taste, provide wine microbial stability, and enhance flavor complexity). Instead, wine shows now reward Chardonnay wines of more elegant, restrained styles with pristine fruit supported (not swamped) by well-integrated oak, maybe partial MLF, and fresher acid or reductive oyster shell notes. This change in style also reflects establishment of more Chardonnay vineyards in cooler climates. The influx of New Zealand Sauvignon Blanc also saw the temporary demise in Australian Chardonnays. Encouragingly, measurement of elements (minerals), amino acids, basic chemical composition, and free and bound volatile aroma compounds, followed by chemometric analysis of the data sets, allowed the discrimination of Chardonnay grapes originating from seven different GIs in South Australia, across two vintages (Gambetta et al. 2017). Classification of Chardonnay grape samples according to region of origin using the fingerprint region of the mid-infrared spectra (1,500–800 cm^{-1}) had an overall success rate of 83% and 81%, for the 2014 and 2016 vintages, respectively (Gambetta et al. 2019). This work provides potential chemical measures to target in future studies of larger numbers of Chardonnay from across Australia's different GIs for characterization and authentication. Authentication of Australian wine provenance is seen by the Australian wine industry as an important piece of the Australian regionality puzzle, particularly as wine consumers globally become increasingly aware of what they consume (Giles-Smith 2014), health, and food safety and are becoming more knowledgeable about wine and wine regions in general and demand authenticity and assurance of wine provenance. Numerous studies are ongoing at the University of Adelaide and other Australian wine science institutions to identify the markers of authentication of Australian wine provenance.

In another study (Johnson et al. 2013), the regional characteristics of 29 Australian Shiraz from ten different GIs utilizing sensory Descriptive Analysis and Multidimensional Scaling were examined. The authors found that for some regions some of the wines from each region were, based on their sensory properties, grouped together. However, it was not definitive to the degree that all the wines of one region identified with a particular region. The greater the diversity of the region in terms of geography and meso-climate, the more difficult was the determination of the common sensory properties. Differences in winemaking practices would also have added to the difficulty in identifying regional origin. The authors suggested future research should use wines made under controlled conditions and/or encompass subregions within regions that are smaller and/or more homogenous in geography as well as a larger sample size. The Barossa Grounds project is one such endeavor, which resulted in the identification of three main grounds (Northern, Central, Southern) with two further supplementary grounds (Eastern Edge and Western Ridge) in the Barossa Valley (Robinson and Sandercock 2014). The Scarce Earth program highlighted 19 wine districts in McLaren Vale (Bekkers 2012), and the Rocks project defined five subregions in Clare Valley (Werner and Roche 2016). Current research involving cross-national Australian viticulture and wine researchers are ongoing to establish the uniqueness of Australian Shiraz, Cabernet Sauvignon (Niimi et al. 2017), and Pinot Noir. These studies are using a combination of research wines and commercial wines as the former, which are typically young, mostly unoaked, and produced with standardized winemaking protocols, do not necessarily reflect the commercial wines and styles available in the market, but they do remove confounding factors introduced by human intervention.

In a recent study, consumers defined Australian fine wines as high quality, good value for money, easy to drink, which consistently show balance, plus diversity, fruity, and regional characteristics (Kustos et al. 2019). The importance of regional typicality has been recognized for some varieties such as Barossa Valley Shiraz, Coonawarra Cabernet Sauvignon, Margaret River Chardonnay, Hunter Valley Semillon, etc.; however research is yet to firmly establish sensory and chemical composition associated to GIs similarly to the old-world appellation system (Conduit et al. 2016; Van Caenegem et al. 2015). Whether from a marketing, consumer, or scientific perspective, the questions remain whether regional typicality is expressed more with less intervention and whether consumers can benefit from the research outcomes. Thus, the connection between Australian GIs, grape varieties, and regional typicality needs to be further explored.

Interest in Organic, Biodynamic, Preservative-Free Wine and a Sustainable Industry

The emerging alternative variety (plantings of grape varieties new to the Australian wine scape) and natural wine scenes have been growing trends in Australia over the past decade, but they represent smaller, niche markets sales-wise. Increased interest in alternative varieties is directed by a desire to ensure the sustainability of the Australian wine industry, particularly in the face of climate change and drought by planting varieties better adapted to hot climates and possibly as a point of differentiation for producers in a crowded wine market. The so-called natural wine movement is led by the momentum and voice of a newer generation of winemakers, who desire to intervene less. Of note for the reader, the term natural wine, if one consults the Australian and New Zealand food standards, is defined as one made from grapes. Although there is no definitive explanation of the term in a practical winemaking context, other than that the wine has to be made from grapes, the term "natural wine" has become more accepted within the Australian wine community as wine being made with less intervention in the winemaking process. Further to this, many wines are made in Australia with low intervention but do not claim to be "natural wine." Some of these natural wines are fermented with natural or wild yeasts (that naturally occur on the grapes) and are often unfiltered and sometimes darker or turbid in appearance. They are frequently unfined before bottling. Fining is a process involving addition of approved processing aids to wines for the purposes of reduction of unwanted compounds, often by precipitation, e.g., wine clarification. On the shelf, natural wines are often hand labelled with handwritten labels and wax-dipped closures. They include some of the so-called "orange" or "amber" wines; white wine made from extended skin contact, which is actually an old-world tradition; and lighter, less alcoholic style reds. This has infiltrated through the whole industry with more established producers making toned-down, less alcoholic wine styles. These new movements combine Australia's strong scientific wine knowledge with past local and international experience and have focused the industry's awareness on the production of wine that aligns with the country it is consumed in. Recently, Australia was renowned for powerful, lavishly, oaked, up-front fruit styles, which were winning many accolades in the important USA, UK, and Asian markets. Now, the dialed down tone of emergent wine styles better suits the Australian climatic drinking conditions, which is warm-to-hot for most of the year. Further to this, a number of producers have installed or converted their traditionally farmed vineyards over to organic or even biodynamic practices to enhance biodiversity in the fauna and flora of vineyards for sustainability and meet consumer demands for wines with lower chemical input. Small segments of vegetarian and vegan consumers have also shaped the Australian industry to take note of the use of certain winemaking aids. For example, research is being conducted and producers switching to vegetable as opposed to animal-derived protein fining agents to remove undesirable levels of tannins causing too much astringency (the roughing and drying textural, mouthfeel sensation) which at high levels lowers wine quality (Kang et al. 2018).

The majority of Australians reside in a concentrated strip around the coast, and drinking and eating are often outdoors, so the less opulent wines are likely to taste better on a hot day at the beach, picnic, or BBQ. Australian's BBQ anywhere, not just at home, and Australia's cuisine is now heavily Mediterranean and Asian influenced with grilled and barbequed meat (including "snags," what Australians call sausages), seafood, salad, garlic, chilli, and ginger. The richer, riper fruit and heavily new oak, oaked styles are less likely to fit this Australian wine and food lifestyle, with the exception during the cooler months. Australian wine consumers are part of the global premiumization trend in mature markets, with value growth exceeding volume growth as consumers turn to higher value products (Wine Australia Market Bulletin 2019), so these less opulent styles are suited to new segments of consumers wanting to reduce alcohol intake. Using different grape varieties that are infinitely more suited to Australia's often hot and harsh or at the other extreme, cool, growing regions, makes good sense for the sustainability of these rural agricultural areas and communities. Many of these varieties have origins in warm Mediterranean conditions and are well adapted to retain the acid and fruit flavor compounds necessary to produce fine wines. Examples include the white grapes Vermentino and Fiano and red Nero d'Avola and Montepulciano. This revival in the Australian wine scene positions drinkers of Australian wine for an extraordinary and interesting period. Recently, studies on the sensory and chemical profiles of wines made from the indigenous grape varieties of Cyprus, demonstrated Australian consumers found these wines acceptable (Copper et al. 2019). Consequently, the exciting opportunity exists to cultivate these grape varieties that may withstand tough Australian current and future conditions.

Australia's Unique Wine Styles

In the following section, the authors introduce you to four wine styles that are generally regarded as being unique to Australia (Iland et al. 2017). It discusses the grape varieties used, how the style developed, what to expect when tasting the wine, and how best to consume it.

Hunter Valley Semillon

The Hunter Valley wine region in New South Wales is approximately a 3.5 h drive North of Sydney. Hunter Valley Semillon is widely considered the iconic wine of the region, but good examples of wine from a variety of grapes including Shiraz, Chardonnay, and Cabernet Sauvignon are also produced there. The Semillon wines are unique, not just for their taste but for the fact that in some cases the wine company, and not the consumer, cellars the wines, sometimes for many years, before their release. Picking of the fruit occurs at relatively low sugar but high acidity levels. This compositional profile promotes the wine's cellaring potential. The fruit is crushed gently to reduce polyphenol extraction that can render the wine astringent and bitter (Jackson 2017) and the juice fermented cool to retain volatile flavor compounds (Jackson 2017) and also to ensure the wine's longevity. The finished wine is clarified, filtered, and bottled and then aged in the bottle for 6 years (or longer) prior to release.

The taste of Hunter Valley Semillon: Overtime the wine slowly develops a golden color, and the aroma develops from subtle grassy, apple, and lemon characters to toasty, vanilla, honey, honeysuckle, straw, and fig characters. As it ages, the wine builds in weight and richness. The best have a refreshing lingering acidity. These wines have great aging potential.

The acidity levels are crisp. It goes well with seafood and fresh chicken dishes. Slightly older, richer styles can handle more rustic flavors.

Riverina Botrytis Semillon

Most of the great sweet wines of the world, for example, those from Sauternes and Barsac of France; Beerenauslese and Trockenbeerenauslese wines of Germany and Austria; and the intricately complex Tokaji wines of Hungary, are made from grapes affected by the fungus *Botrytis cinerea* (Jackson 2017), often called "noble rot." Normally, noble rot and these wines are from cool, humid regions around the world. The climate of the Riverina region in New South Wales is hot and dry; yet wine companies produce world acclaimed examples of *Botrytis*-affected Semillon wines.

While the temperatures in the Riverina region can be high over summer, the climatic conditions later in the season are much milder due to the influence of late autumn rains. Fogs can cover the vineyards for most of the morning, and the humidity inside the vine canopy can reach about 80%, with mean daily temperatures in the order of 14 °C. About midday, the fog clears and bunches dry. The humid, misty mornings followed by drier afternoons are close to ideal conditions for infection and growth of the noble form of *Botrytis cinerea* without the presence of other molds. Even though *Botrytis cinerea* would have infected the vineyards of the Riverina region in various years during the history of the region, it was not until the 1980s that commercial production of botrytis-affected styles of Semillon wines began.

The taste of Riverina Botrytis affected Semillon: The aroma is a mix of fruit and botrytis-induced characters. The aroma characters include spice, floral, perfume, acacia, citrus, lime, pineapple, quince, peach, crab-apple jelly, passion fruit, lychee, orange, tropical fruit, apricot, dried apricot, nutmeg, almond, marzipan, butterscotch, marmalade, honeysuckle, honey, toffee, caramel, treacle, toast, and volatility (ethyl acetate; smell of nail polish remover and acetic acid; aromas of vinegar). These latter two compounds are normal components of wine and, although are referred to as off-aromas in some wine styles, in others, such as the botrytized wines, are considered part of the wine style (Jackson 2017). The taste and texture of these styles are described as sweet, viscous, luscious, soft, creamy, silky, velvety, rich, oily, sumptuous, opulent, and unctuous which may be due in part to higher amounts of glycerol formed from the presence of the microbes including the *Botrytis cinerea* (Iland et al. 2017) but should finish fresh, refreshing, and drying, not cloying or sickly sweet. These are wines that feel round in the mouth. They finish crisp, the sweetness balanced by refreshing acidity.

A beautiful sweet, dessert white wine to rival global counterparts. Pairs extremely well with cheeses including blue vein (Bastian et al. 2009), paté, foie gras and rich milk/dark chocolate. The dessert has to have rich caramel, citrus, or chocolate flavors and the same sweet power level of the wine. It is also good on its own as a dessert.

Sparkling Shiraz

Shiraz is Australia's major red grape variety and is produced in many styles ranging from rosé to fruit forward and generous flavored with full body to more savory, medium-bodied styles. However, it is also used for sparkling wine. These wines are made in a similar manner to white sparkling wines (Iland et al. 2017) – a primary fermentation followed by a second fermentation in the bottle in which it will be sold and served. Each batch of grapes is harvested and processed separately into a dry red wine. After the base wines are made, they are tasted and those with the right characters (normally rich flavor but soft tannins) are selected as base wines. The blend is then assembled. After the composition of the blend is decided, the selected wines are mixed with an amount of sugar solution and yeasts and then transferred to pressure-tested bottles; these are the bottles in which the secondary fermentation takes place and in which the wine is sold.

Most commercial styles remain on yeast lees for 1–3 years. Others may spend a much longer time on yeast lees, 8 or more years. During this time, complexity, the layers of interesting flavor, builds. The level of sugar addition at the dosage stage may range from about 8 to about 40 g/l of residual sugar. Also at this stage, there is an opportunity to add a touch of either younger or older wine to fine-tune the character of the finished wine.

For almost a century, Seppelt has been making Classic Sparkling Shiraz (previously called Sparkling Burgundy) at its cellars in Great Western, in the state of Victoria. Seppelt Show Sparkling Shiraz is a rich and complex wine. The extended time on yeast lees, often greater than 10 years, ensures a harmonious integration of aromas, tannins, and acidity.

The taste of Sparkling Shiraz: As young wines these wines are deep crimson red in color. With age garnet red and brown colors develop. The aroma spectrum can be made up of a mix of fruit and aged characters. Primary fruit characters include spice, pepper, cherry, violet, plum, prunes, plum pudding, mulberry, blackberry, sarsaparilla, licorice, fruit pastille, and jammy. Age brings earthy, sweet, barnyard, leather, mushroom, truffle, meaty, smoky, and chocolate. These wines are rich, full-flavored, and complex, with soft creamy-textured tannins.

Often a wine for celebration. Traditionally consumed chilled at Christmas time in Australia, midsummer and hot. Having a red wine base, it can complement roast meats, including turkey, pork, and beef.

Rutherglen Muscat

Rutherglen is a quaint historic town in the Northeastern part of the state of Victoria. Each year the grapes – Muscat a petits grains rouge – are harvested in batches according to their characteristics and quality and the resultant wines kept separate until their sensory features can be assessed and a decision made regarding which classification increasing in quality – Rutherglen, Classic Rutherglen, Grand Rutherglen, or Rare Rutherglen – they will join. In some years, very little or no wine may be considered good enough to be selected for the rare classification.

The grapes ripen and shrivel (raisin) on the vines, producing natural sugar levels in the range of 17–20°Baumé, sometimes in exceptional years of about 22–24°Baumé. The grapes are picked and crushed and yeasts are added. The mixture is allowed to stand for a few days, and extra sugar is leached from the raisins; the sugar level of the juice may increase to about 25°Baumé. During this time the yeasts slowly ferment the sugar. Just as the sugar level starts to drop, spirit is added to increase the alcohol level to about 18% v/v, and this results in the fermentation ceasing resulting in wines very high in sugar concentration, about 300 g or more of sugar per liter. This contributes to their luscious tastes.

The wine is stored and matured in puncheons (450 l) or larger oak casks for many years (sometimes 50 years or more), gaining complexity. Evaporation plays an important role in the concentration of flavors and other components of these wines. On average, the maturing casks of Muscat lose about 3–5% of their volume each year. The older wines are more complex and are often used in the very special blends.

The taste of Rutherglen Muscat: Expect a luscious, complex, intensely flavored wine. In the higher classifications, you are tasting the influence of many years of ageing in the maker's cellar. The aroma is a mix of marmalade, spice, walnut, fruitcake, toffee, and raisin. The palate is rich, viscous, concentrated, complex, and mellow. The sweetness is balanced with lingering acidity.

This is an after-dinner wine or nightcap. It melds beautifully with chocolate or rich chocolate-based desserts or is a dessert on its own. It can be used to macerate fruits to make special rich, moist fruitcakes or desserts.

Conclusion

While beer still narrowly dominates the consumption statistics as the most consumed alcoholic beverage, wine has made a significant impact on Australian culture, both as a social drink and particularly when eating at home and outdoors or dining in cafés and restaurants. This chapter has provided a brief introduction to the evolution of the wine culture in Australian society. It has traced the drinking and eating norms and evolution and preferences for wine styles of the Australian population across two centuries since the arrival of the British. This has been attributable to social and market forces, climate, Australia's multicultural society driven by various waves of immigration, and the advancement of wine knowledge stemming from cutting-edge grape and wine science research and education. It outlines the growth in confidence and knowledge, plus innovation and resilience of its grape growers and winemakers in a remote, and environmentally challenging, new-world wine nation, to produce value-for-money, good-quality, unique Australian wine styles that are globally renowned and more recently wines of provenance, to become one of the most successful wine-producing countries in the late twentieth and early twenty-first centuries.

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29 Wine Trends in China

Larry Lockshin and Justin Cohen

Contents

Abstract

China has become the second biggest economy in the world and growth in wine consumption has been part of the overall economic trend. This chapter provides an overview of wine consumption trends in China starting with an overview of alcohol consumption. The Chinese have always been alcohol consumers; what has changed is the move away from spirits into wine made from grapes. The reasons for this change over the last 50 years are provided as an introduction to the current market for wine in China. Very little consumption data is available from the Chinese government or from reliable data firms; so, much of this chapter is based on the two authors' research in China over the last 6 years. Overall, there has been a move from high-priced prestige wines to lower-priced wines for informal consumption. Even with all the news about online shopping in China, just over 29% is purchased through these channels. The chapter also provides

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information on the key countries selling wine to China, Chinese consumers' awareness of different countries of origin, and recommendations for growing wine sales and doing market research in China.

Introduction

In only 50 years, China has grown from a minor market for grape-based wine into the second largest market in the world. However, China has always been an alcohol-consuming country, but preferences have moved considerably in the last 10 years or so. This chapter will detail the current trends in wine consumption in mainland China in the latter part of 2019. In order to be clear and understood by various readers from different countries, we would like to set a few definitions and boundaries before we begin.

First, this chapter focuses almost entirely on grape-based wine. The character and word for wine in Chinese covers products made from rice, other grains, and from grapes. We will use the word wine to refer to an alcoholic beverage made from grapes. When speaking of other alcoholic beverages, such as when giving statistics for types of alcohol consumed, we will use adjectives such as rice wine or grape wine to make sure readers understand what we are referring to. The other clarification we want to make is that we are focusing on mainland China only.

This chapter will discuss the current trends in wine consumption in China. The first part of the chapter looks very briefly at the history of grape and wine production in China in order to dispel the myth that wine drinking is new in China. We then focus on more recent trends in alcohol consumption. This includes wine and provides recent estimates of wine production and wine consumption, to give more context to the current state of affairs. The next section of the chapter looks at the development of Western-style wine and food consumption as China opened its doors to both travel and major wine imports in the 1990s and into the twenty-first century. The following part looks at the role of government policy in the evolution of alcohol consumption from mainly beer and spirits (products over 20% alcohol by volume) and how these changes affected the growth of lower-priced table wines. The growth of wines below luxury level led to changes in the demographics of wine drinkers and to the development of new channels to buy and consume wine.

The main part will focus directly on current trends. Much of the data for this section comes from our own research in China mainly on behalf of the Australian wine industry. Thus, we will provide overall trends without providing much detail due to confidentiality agreements with the research funding organizations. We will also cover the rise of social media and online wine purchasing, noting, however, that our research shows still just over 29% of wine is purchased through online channels. We will describe the retail structure currently in place in China and how both brick and mortar and online selling have accompanied the movement from formal consumption occasions to much more informal consumption. We conclude the chapter with a summary and a few predictions for the future.

Brief History of Wine Production in China

There is evidence of grape and wine production in ancient China as far back as 9,000–7,000 years ago (Zhang and Pan 2002); however, these were native Vitis species and not the *Vitis vinifera* species that are now grown worldwide and the origin of the vast majority of the world's table wines. The first written mention of wine production in China is from the end of the Xia Dynasty about 1600 BC, where wine was made from fermented grain mash, which probably also contained grapes (Li et al. 2018). The first vinifera wine came after the opening of the Silk Road during the Han Dynasty about 135 BC and Marco Polo reported seeing vast vineyards around 1275 (Li et al. 2018). Some of this was made into wine; however, much of these grapes were grown for table use and not for wine (OIV 2017).

The first major commercial winery, Changyu Winery, was established in 1892 with the importation of 120 *Vitis vinifera* grape varieties. French Catholics and Japanese investors set up wineries through the 1920s and 1930s (Li et al. 2018) believing there would be growth and development of westernized wine consumption. But it was Chairman Mao who instructed China to put more effort into the wine industry to reduce the consumption of Baijiu (rice spirits) in 1956 that started the modern move to planting more vineyards and building more wineries (Su 2003). This led to foreign firms, such as Pernod Ricard, establishing grape growing and wine making as commercial operations, in this case Dragon Seal Winery (Li et al. 2018).

Current Wine Production and Alcohol Consumption

China is ranked in the top 10 of wine producing countries in the world (Table 1). This may seem surprising, but Mao's push to replace some of the spirits consumption with wine consumption began to take hold with major wine companies being established in the 1960s (Li et al. 2018). Then French and later Australian companies began to plant grapes and make wine in China, mainly in partnership with local government or private investors in the 1980s. China's production in 1996 was 9.5 million hectolitres, so it has increased about 10% in the 20 years recorded in the table. Domestic production is not increasing quickly due to a number of reasons not relevant to this chapter. There was a peak of about 13.5 million hectolitres in 2012, but production has fallen back to around 11.5 million since then, as it has in most wine producing countries. However, production in China fell to only ten million hectolitres in 2018 (IBIS World 2019). There was a lot of optimism and planting of wine grapes in the 1990s as Chinese wine consumption began to increase and more countries were beginning to consume wine, but there has not been a huge amount of planting recently. There are some premium vineyards being planted in some regions, such as Ningxia and in the northwest, but overall growth in planting has slowed.

The Chinese have always been consumers of alcohol, and as Table 2 shows, the largest categories by volume are spirits and beer. In value, beer and wine are about

Table 1 World Wine Production 1996 and 2016 in millions of hectolitres (Source OIV 2017)

Country	1996	2016
Italy	54.4	50.9
France	56.3	43.5
Spain	34.1	39.3
USA	21.4	23.9
Australia	7.4	13.0
China	9.6	11.4[a]
South Africa	7.8	10.5
Chile	5.1	10.1
Argentina	13.5	9.4
Germany	10.0	9.0

[a]Wine production was about ten million hectolitres in 2018 (IBIS World 2019)

Table 2 Alcohol sales in China in millions of liters (Passport 2018)

Alcohol type	2012	2013	2014	2015	2016	2017
Spirits	4,940	5,284	5,370	5,586	5,696	5,777
Beer	48,993	50,582	50,582	47,727	45,627	45,535
Wine	**4,218**	**4,208**	**4,108**	**4,350**	**4,581**	**4,777**
RTD's/High strength Premix	31.9	49.5	118.7	152.8	102.4	89.6
Cider/Perry	0.51	0.54	0.61	0.69	0.81	0.95
Alcohol drinks	**58,184**	**60,125**	**59,678**	**57,816**	**56,007**	**56,181**

Table 3 Alcohol sales in China by value in CNY millions (Passport 2018)

Alcohol type	2012	2013	2014	2015	2016	2017
Spirits	925,452	849,797	774,756	804,868	888,591	999,675
Beer	402,116	448.397	481.432	511.069	537,193	572,675
Wine	**396,126**	**375,576**	**368,008**	**405,380**	**441,641**	**480,823**
RTD's/High strength Premix	1,724	2,691	6,077	7,073	4,534	3,910
Cider/Perry	1.1	1.2	1.4	1.6	1.9	2.3
Alcohol drinks	**1,725,419**	**1,676,462**	**1,630,274**	**1,728,392**	**1,871,960**	**2,057,085**

equal, while spirits account for more than double the value of either of these (Table 3). Although the annual value of each beverage category varies, beer and wine have mostly been increasing while spirits have just returned to slightly above their 2012 value. Wine also has the highest value per liter of the alcoholic beverages.

Another way to look at the alcohol market in China is to look at penetration – the number or percent of unique consumers buying from each subcategory during a year. Previous research by the Ehrenberg-Bass Institute for Marketing Science has shown that most category buyers buy multiple brands (Sharp 2010), and for alcohol, multiple types of alcoholic drinks (Cohen et al. 2018). The data presented here and throughout this chapter were collected using online professional panel providers in cities across China as noted. Thus, only urban dwelling Chinese Internet users

Table 4 Penetration in percent of alcohol types in China by gender (Cohen et al. 2018; Driesener et al. 2018)

Alcohol type	Overall	Male	Female
Local beer	50	60	40
Local wine	**40**	**44**	**37**
Imported beer	30	36	24
Imported wine	**29**	**30**	**28**
Local spirits	28	41	15
Wine cooler	13	13	14
Imported spirits	12	13	11
Champagne	11	10	13
Alcoholic cider	10	9	10
Sparkling wine	9	9	10
Craft beer	9	9	8
RTDs (mixers)	6	6	6
Repertoire	**2.5**	**2.8**	**2.2**

were sampled, and no rural Chinese were included in the surveys. Table 4 shows beer is consumed at least once per year by 50% of urban Internet-using alcohol drinkers in China, with Chinese wine consumed at least once annually by 40% and imported wine by 29% of these alcohol drinkers. The average repertoire, or the number of different alcoholic subcategories consumed at least once in a year, is 2.5. Consumers do have favorite types of alcohol, but few would drink only one type in a year. Most consumers will drink two-three types.

Males and females differ in their preferences, although local wine and imported wine are consumed by a similar percentage of drinkers. Local spirits, mainly baijiu, is much more preferred by men than women.

Table 5 shows the breakdown of penetration for different alcohol types by age. We can see that younger consumers have a smaller repertoire than older ones and mainly consume beer plus one other beverage at least once per year. The alcoholic drinks repertoire, or number of different types of beverages consumed at least once per year, is calculated simply as the average of different subcategories consumed across all respondents. So, the average alcohol-drinking Chinese respondent under 25 years old drinks at least once annually from about two different subcategories, while those over 35 drink from about 2.7 different subcategories. The consumption of all alcohol types increases as consumers age, with the older consumers having larger repertoires than younger ones. More older consumers drink wine compared to other alcoholic beverages. We will go into more detail about current consumption trends for wine in the second part of this chapter.

These tables highlight that urban Chinese drink many different types of alcohol and, we will see in the later section that wine drinkers drink other types of alcohol as well. This is important to understand because there are very few "wine only drinkers" but mainly alcohol consumers who prefer wine but still drink other alcoholic beverages, as well as other beverage drinkers who drink wine once in a

Table 5 Penetration in percent of alcohol types in China by age (Driesener et al. 2018)

Alcohol type	<25	26–35	36–45	46–55	56+
Local beer	51	46	46	63	56
Local wine	**28**	**38**	**39**	**49**	**67**
Imported beer	21	27	35	37	36
Imported wine	**22**	**22**	**33**	**30**	**44**
Local spirits	22	26	25	43	33
Wine cooler	14	16	14	7	5
Imported spirits	11	11	15	12	14
Champagne	7	13	14	11	6
Alcoholic cider	7	11	13	6	5
Sparkling wine	8	11	11	8	3
Craft beer	7	9	12	6	3
RTDs (mixers)	5	6	10	5	3
Repertoire	**2.0**	**2.4**	**2.7**	**2.8**	**2.7**

while. Previous unpublished research from the University of South Australia showed Australian alcohol drinkers had favorite subcategories (such as wine), but over 80% drank other alcoholic beverages well, so this repertoire behavior is not unique to China.

Development of Western Grape Wine Culture in China

It is useful to have a brief description of the development of grape wine drinking in China in order to understand the current situation in context. As noted above, before the 1980s China mainly drank grain-based alcoholic drinks, mostly high alcoholic content baijiu and lower alcoholic content beer and moutai (distilled sorghum beverage). In 1987, the National Winemaking Conference proposed the Four Changes strategy to the alcoholic beverage industry. This was to change from high-strength alcoholic beverages to ones of lower strength and to move from distilled products to fermented grape wine instead of fermented grain wine (Zeng and Szolnoki 2017). Part of the reason was to reduce total alcohol consumption for health reasons, and part was to allow more grain to be used for food rather than drink.

Along with the political push to grape-based wine, China was also becoming wealthier as incomes grew and private consumption and gift giving were becoming the norm among the educated Chinese (Yang and Paladino 2015). Western wine, especially Bordeaux and Burgundy, were seen as hallmarks of sophistication and became prestigious gifts as well as regular accompaniments to corporate and government banquets. It was mainly the wealthier industrialists and communist party elite, who exhibited this behavior (Zeng and Szolnoki 2017). Contrary to popular myth there is not much evidence for expensive wines being mixed with soft drinks or lemonade to make it more palatable (Hunt 2014). However, in 2012, the then new president, Mr. Xi Jinping, made anticorruption and modest living part of his political platform. This action helped reduce the demand for high-priced luxury wines and increased the consumption of medium-priced wines for everyday consumption along with some special occasion consumption.

As more Chinese entered the middle class and more studied overseas, there was increasing demand for medium-priced imported wines along with imported beer (Zeng and Szolnoki 2017). By 2016, China began signing free trade agreements with wine producing countries: Chile, New Zealand, and Australia, which added to the availability and relatively low price of wines from these countries. At the same time, the advent and quick uptake of e-commerce in China also contributed to wine being more widely known and more widely accessible (Kuo et al. 2015). The current trends in wine consumption stem from this evolution, away from high-priced luxury wine seen as a status symbol and a very high-end gift. This included a focus on the most expensive wines typically among top political officials and wealthy businessmen, mainly consumed at official banquets or in expensive Western restaurants to a more informal alcoholic drink consumed more at home than in restaurants. The rest of this chapter details the current state of consumption: who is consuming, where they are buying and consuming, and motivations for drinking wine compared to other alcoholic beverages. As with most things in China, these developments carry a unique Chinese focus and do not mimic the development of wine drinking in Western countries, although some of the outcomes are similar. For example, in many Western countries, like the USA, UK, and Australia, about 80% of wine is consumed at home or at someone's home and only 20% consumed at bars and restaurants. China has moved from mainly restaurant consumption to a more Western-like pattern, but still has a greater percentage of wine consumed at bars and restaurants compared to Western countries.

Background to Consumer Research in China

The next part of the chapter is an amalgamation of research conducted by a team of researchers at the Ehrenberg-Bass Institute for Marketing Science from 2013 to 2019 funded by Wine Australia and other government wine bodies to understand the China wine market. Some key trade publications, which summarize the research findings, are listed in the references. We have integrated the findings into the rest of this chapter.

More recently, a research program has been initiated in order to create demand for Australian wine in China generously supported by Wine Australia. Until this research, there has been a lack of insight in terms of understanding the wine market in the broader context of alcohol consumption in general. There has not been any rigorous research conducted that identifies why current or potential buyers of wine enter the wine category in China. This is paramount knowledge to generate so that strategies can be developed to grow the number of wine buyers in China.

Current Trends in the China Wine Market

A survey was conducted in July of 2019 of 2871 Chinese people aged 18–65 who earn a minimum of 4,000RMB per month. In addition, they had to have purchased alcohol in the last 6 months. Purposeful sampling was utilized to reach different buying groups: approximately 60% imported wine buyers (the majority of these buyers also purchased Chinese wine), 25% Chinese wine buyers only (don't buy imported wine but do buy other alcohols in general), and 15% alcohol buyers who are non-wine buyers (imported or Chinese). Previous research by the same research group and by private consulting companies, such as Wine Intelligence (Hao and Halstead 2016), focused on imported wine drinkers only and therefore was not able to look at trends for domestic wine consumption or consumption of alcoholic beverages, which could lead to future wine consumption.

Data was collected in 15 Chinese cities representing a range of tier 1 and tier 2 cities. Tier 1 is defined as the largest and wealthiest cities: Beijing, Shanghai, Guangzhou, and Shenzhen, while Tier 2 is the next largest, such as Chengdu, Chongqing, and Wuhan (Wong 2019). The cities were selected for two reasons:

1. To achieve a geographic spread as there are many hypotheses made by industry pundits that China cannot be treated as one country and must be treated as individual city-states due to there being cultural differences across the country,
2. To generate insights that were of current value to wine brands and government wine bodies who are working to build the wine category in China, and these cities were nominated by stakeholders as being where resources are currently being directed.

Figure 1 below contains a map that shows the cities investigated.

As a starting point, it is useful to understand the buyer behavior for wine in the broader context of the alcohol category. Table 6 below shows self-reported market share of alcohol subcategories amongst alcohol category buyers over a 6-month period in 2019. These and the following tables are based on retrospective recall of the last alcohol purchase and/or consumption occasion.

Taking into consideration the sample for this research, there are several noteworthy patterns. Chinese beer is dominant. This accounts for 30% of alcohol buying even with the data skewed towards 85% of the buyers having had to purchase wine, as the research focus was on the wine category. Chinese and imported wine has an equal share of 15% each. This is interesting, as anecdotal reporting from actors in the wine industry as recently as 2016 stated that they believed 4 out of 5 bottles of wine sold in China were Chinese wine. The results from 2019, taking into consideration the sampling, indicate that the share of imported wine is increasing.

There is a prevalent assumption that alcohol consumption differs widely across China. Looking at the share of imported wine buying across the 15 cities shows only a few differences worth reporting. Market share for imported wine is elevated compared to the average of 15% in Chengdu, Fuzhou, Changsha, Wuxi, and Wenzhou; however, the difference is only 3–9% more. It is likely that imported

Fig. 1 Cities investigated in the Chinese Mainland

Table 6 Self-reported market share of alcohol subcategories in China (July, 2019)

Alcohol subcategory	Market share (%)
Chinese beer	29
Chinese wine	15
Imported wine	15
Imported beer	10
Chinese spirits	8
Champagne	4
Alcoholic cider	4
Craft beer	4
Imported spirits	4
Wine cooler	3
Sparkling wine	2
RTDs	2

wine performs better in Chengdu due to the digital wine platform 1919, a new specialty chain of wine stores, being based in Chengdu. The other cities are much smaller but still have populations over a million and Chinese wine brands are likely to have the same route to market issues that imported wine brands have. In addition, the data collected used online surveys and it is possible that panelists in the smaller cities have a stronger connection with Western culture because the pool of available respondents is smaller than in major cities where being part of survey panels is more common.

Imported beer has a 10% market share and Chinese spirits (i.e., distilled rice wine) only has an 8% share. The small share of rice wine is interesting to note on the back of industry reporting of the leading rice wine brand, Kweichow Moutai, being the most valuable liquor company in the world since 2017 and now being valued at over 200 billion USD in 2019 (Financial Times, 2019). This may be due to the consumers of Kweichow Moutai being older and more traditional and, therefore not represented adequately in the online panels used for data collection (Hancock 2019). There are a number of other small but growing subcategories of alcohol that are currently more prevalent in the Western World. These should not be ignored but for the moment the data indicate that purchase is mainly by young consumers, which suggests a trend in the future where alcohol buyers will have larger repertoires. Larger repertoires for older cohorts were already reported in Table 5.

These data provide context to the wine category in China. They show the Chinese wine and imported wine subcategories together account for roughly the same size of the market as Chinese beer.

Most of the investment in market development is by a few leading wine brands and by major wine exporting countries. It is useful to explore wine purchase by country of origin as the majority of investments in market development at the moment for small- and medium-sized brands come under the umbrella of government actions. Table 7 below reports on the market share of wine by country of origin in China amongst alcohol category buyers over a 6-month period in 2019.

Based on respondent self-reports, just under 25% of all wines purchased in the sample are French. China follows with about 20% market share. Italy, Australia, Spain, the United States, New Zealand, and Chile all have comparable market shares

Table 7 Self-reported market share of wine by country of origin in China (July, 2019)

Country of origin	Market share (%)
France	24
China	20
Italy	9
Australia	8
Portugal[a]	8
Spain	7
USA	6
New Zealand	6
Chile	5
Argentina	3
South Africa	3

[a]Note: Portugal consistently generates overclaimed data across studies executed in China using retrospective recall. This is likely due to the fact that the word for grape and the base of the word for Portugal in Chinese are the same

of 5–9%. Argentina and South Africa are the worst performers in the market with shares of 3% each.

There are mainly small share differences across the 15 cities when looking at buying by country of origin. There is more variability in shares across cities for French and Chinese wines. There is less variation in shares between cities for Italian or Australian wine. With countries like the United States, New Zealand and Chile there are 1 or 2 cities out of the 15 studied where market share is higher than the average. The deviations are mostly in the emerging cities which are gathering interest with the wine industry like Xian, Kunming, Xiamen, Wuxi, and Wenzhou. These differences are driven by distribution and market development activities. Certain countries are more active in particular Chinese submarkets as there is a tendency due to the influence of marketing by government wine bodies for group activities to consolidate human capital and funding for brand development.

France and China both have dominant positions in the wine market in China because they both have dramatically higher mental and physical availability amongst Chinese alcohol buyers. According to Sharp (2010), mental availability makes a brand easy to think of in a buying situation and physical availability makes the brand easy to buy. In the context of China, we explore this from a country of origin perspective. Figure 2 below shows the mental availability of wine by country of origin in China.

We use a construct called category entry points to measure mental market share as provided in Fig. 2. Category entry points are what comes to buyers' minds when they decide to enter a category or what generates the intent to buy from that category. Table 8 below shows a list of relevant category points obtained by conducting a text analysis of vignettes recorded from 300 wine buyers related to their wine consumption and purchase situations (Cohen et al. 2019). Mental market share is calculated based on the proportion of associations to category entry points that alcohol buyers

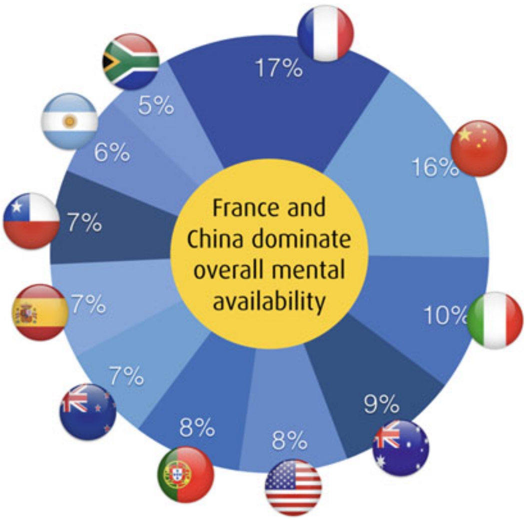

Fig. 2 Mental availability of wine by country of origin in China

Table 8 Category entry points for wine in China

Suitable for a business occasion	When I want to reward myself	Provides beauty benefits	Suitable for Western food
When I want to celebrate	When I want to try something different	Provides health benefits	When drinking/ socializing with foreigners
Suitable for gatherings with friends or family	At meal times	Helps me sleep better	Suitable for women
Suitable for a romantic occasion	Suitable for holidays and festivals	When I want something tasty or delicious	Suitable for men
When I need a gift for someone	When I am at entertainment places	When I want to express/project a high-class image	When I am drinking alone
Suitable for a formal occasion	When I am at friend's place	I want to ensure the wine I choose will not make me discourteous or lose face	When I need to host someone
When I want to improve my mood	When I am at home	When I want to create an atmosphere	When I want something cheap
When I am relaxing	When I am at a restaurant	Suitable for Chinese food	When I want to please others

have for each country of origin out of the total for the wine category. This is a useful way of understanding mental competition. To increase mental availability, brands need to increase their associations to relevant category entry points. The more category entry points related to a specific country, the higher the mental market share.

The above research focused on the occasions that bring Chinese people into the wine category and specifically result in them making a purchase. Purchase is a precursor to consumption. However, it is also useful to discuss the dynamics of consumption occasions. When exploring at home consumption, informal occasions are the majority (55%) followed by inviting guests (32%) and finally by special occasions (14%) (Corsi et al. 2017a). Table 9 below shows the frequency of occasions for at home consumption collected from imported wine buyers (Cohen et al. 2014).

Table 9 shows that roughly half the population of imported wine drinkers investigated in this research were consuming wine at home for a relaxing or informal occasion at least once per week. On the other hand, only 13% of wine consumers host people and only 8% of wine consumers celebrate special occasions at home once a week or more. This is a powerful insight and demonstrates the evolution of wine consumption in China. Wine is not simply a product to consume at special occasions or business functions. There is clearly a trend of regular consumption of wine. This means that marketing must focus on connecting wine brands and country of origin with the more relevant and frequently occurring consumption occasions which will result in increasing penetration and ultimately market share.

The other pillar that affects the purchase metrics reported in the tables above is the physical availability of each country of origin. This relates to the distribution of wine. There is limited industry understanding of the overall availability of wine across sales channels due to the lack of distribution metrics like numeric or weighted distribution that can be purchased from data providers like Nielsen or IRI for other markets. However, retail audits conducted across different cities in China by the authors indicate that brick and mortar retail shelf space is heavily occupied by Chinese and French wine brands. In order to increase physical availability, brands need to make sure their wines are available for purchase in relevant sales channels. Table 10 below reports the market share of sales channels for wine buying over a 6-month period in 2019 based on the self-reported last purchase of 2440 wine buyers across 15 cities.

Table 9 Frequency of consumption by occasion (%) for imported wine drinkers

Consumption Occasion	2–5 times per year (%)	About once every 2 months (%)	1–3 times per month (%)	Once a week or more often (%)
A relaxing drink at home	7	11	28	52
When inviting guest's home for dinner	12	23	48	13
With an informal meal at home	7	13	38	46
Celebrating special occasions at home	35	29	22	8

Table 10: Self-reported market share of wine buying across channels in China (July 2019)

Sales channel	Market share (%)
Wine/alcohol retailer	15
Wine distributor	12
Luxury supermarket	8
Alcohol ecommerce	7
Hypermarket	7
JD.com	6
Tmall	6
General ecommerce	5
Western restaurant	5
Warehouse stores	5
Supermarket	4
Chinese restaurant	4
TaoBao	4
Bar	4
Convenience	3
KTV	2
Traditional small retail	1
Weidian (WeChat)	1

The largest channel for wine purchase in China is specialty alcohol and wine stores, followed by purchasing direct from distributors. These distributor sales are fairly unique to China but have come to play a large role because of the relative security of the origin of the wines and their links with many business people, who buy wine as gifts and for their companies. About 43% of all wine purchased in China is coming out of physical retail: specialty wine and alcohol retailers, luxury supermarkets, hypermarkets, warehouse stores (e.g., Costco), supermarkets, convenience stores, and traditional small retail stores. Ecommerce or online channels account for 29% and on-premise outlets, such as restaurants, bars, and KTV (karaoke bars), add 15%.

What is most surprising is that on-premise consumption of wine is now a smaller percentage of purchasing compared to purchasing for consumption elsewhere – at home, friend's homes, or other private venues. This makes Chinese wine consumption much more similar to where wine is consumed in many Western countries. A major difference between China and most other countries is the relatively large percentage purchased online – almost 30%. We think this is mainly due to the much more developed online ecosystems in China and the crowded nature of the country where driving to shop is difficult and apartments are too small to store much.

Just over one-third of all purchases come from specialty alcohol/wine stores, distributors, and luxury supermarkets. If we add hypermarkets, we have 40%+ of all wine sales. Our interpretation of these figures is that channels which have wine focus as well as a focus on mid- to high-end quality are preferred. Distributors sell the wines these wholesalers represent, which come direct from the producer. Luxury supermarkets and hypermarkets are large chains owned and managed by major retailers, and again focus on high quality and assured sources. Anecdotally, Chinese buyers have spoken about their worry about the authenticity of wines purchased from local stores and restaurants.

Western and Chinese restaurants have a market share of 9%. This is surprising mainly because 10 years ago, the majority of wine seemed to be sold in Western-style restaurants or given as gifts. Convenience stores have a 3% share. Even with a small share there are thousands of convenience stores across major cities in China. This is an underutilized channel by most wine brands. This is also a channel where small format bottles are more common. KTV has a 2% share. This is a really complex channel to navigate for a foreign wine brand. KTV is a karaoke-based entertainment venue that is significant for males to frequent. There is little understanding of how to do business in this channel for foreign producers.

Online and digital channels play a large and seemingly growing role in the sales of wine in China. Aggregating all the digital channels together results in a 29% market share. This is obviously a valuable percentage of total wine sales, but far less than industry pundits claim. This has resulted in an alarming lack of investment in building traditional sales channels. Tmall, part of Alibaba and composed mainly of brand specific sites and leading platform JD.com each have 6% share with specialist alcohol eCommerce sites (where there is huge fragmentation) have 5%. TaoBao only has a 4% market share. This is represented more by individual sellers as opposed to brands. Many imported brands have trouble navigating the complex online environment, since there are so many options: own branded store within one of the big online channels, sold through a distributor's store online, sold through a retailer's store online, or sold by individual shops within a larger website. One sales channel which receives a lot of attention abroad but has a market share of less than 1% is Weidian. Weidian is the shopping component of WeChat where brands can have official sites that have eCommerce built in. WeChat is a very popular platform for communication and payment systems, but it has yet to effectively conquer eCommerce despite what the media would have one believe.

Predictions for the Future

Despite the rapid evolution of China both economically and culturally, it is unlikely that there will be rapid changes in the wine market for the foreseeable future despite China being a global leader in both social media and eCommerce. China is different to the rest of the world due to the great fire wall which results in major digital platforms such as Google, Twitter, and Facebook being blocked. This has given rise to comparable platforms such as Baidu, Weibo, and WeChat. Cohen and Lockshin (2018) discuss some opportunities for small brands with limited budgets to optimize their usage of social media channels such as these to reach consumers. There are also more advanced formats of blogging in China, such as vBloggers (video bloggers) who have enormous audiences. Technology creates opportunities; however, these social media channels still tend to reach current wine drinkers, who subscribe or are linked to wine relevant media. New tactics are required to reach potential and light/infrequent buyers rather than the heavy/frequent buyers already reached. Tables 4 and 5, which report on penetration of alcohol subcategories, justify the importance of thinking more broadly about alcohol overall rather than exclusively about imported wine.

It is not easy for a potential consumer to think about or locate a specific imported wine in a sales channel, whether they are looking for a country of origin or a particular brand. Because of this, the likelihood of being bought is diminished. This is reflected in the claimed purchase data reported in Table 7 and the mental availability data reported in Fig. 2. In order to increase sales, strategies that help build mental and physical availability are required. It costs money to build mental and physical availability. Collaboration between brands, government bodies, and distributors are essential. So, efforts to build mental availability must align with distribution efforts.

Future Research on Wine in China

China is a fascinating market. The more insights researchers uncover, the more it becomes apparent just how much is not actually known. Cohen and Lockshin (2017) provide the most comprehensive review to date on how to conduct research with impact in the China wine market. Good sampling of the population is an impediment to extending knowledge on the China wine market. Researchers must design their surveys to reach users of all alcohol categories, not just wine.

There is a tendency for research on wine in China to focus on the very affluent, highly educated, and worldly (i.e., have lived and studied overseas) and those with a passion for wine, which leads to surveying only those with heavy consumption and high involvement. While researchers can and should understand the behavior and preferences of this cohort of consumers, these types of consumers don't represent where growth in the wine category in China will come from. Acquisition of new customers is paramount. This means that research using current wine consumers in the major markets in China should be expanded to consider a competitive set of consumers of other alcohol subcategories. There are over 150 cities in China with populations over 1 million people. While the research in the 15 cities we report here does not show any major differences, we should not blindly assume that this is or always will be the case. As noted above, sampling is restricted to cities where panel providers can locate consumers, so the rural population has not been part of any market research the authors are aware of. Using online samples in small cities is risky until the size of the sampling pools increases. This will happen and when it does more research should be conducted to see if the patterns of wine buying behavior can be extended across China. In addition, there is a need for research to be conducted in rural areas to understand the role wine plays in alcohol consumption. At the moment, this is not of interest to imported wine brands, but the Chinese wine industry should be able to make inroads selling in rural areas and hence research is necessary to support their domestic industry.

Conclusion

This chapter discussed consumption trends for grape-based wine in China, which was current at the time of writing. It noted that the Chinese have always been alcohol consumers but have begun to grow and import wine over the last 25 years or so. The government encouraged its citizens to switch from high alcohol spirits to wine and at the same time, growing wealth and a consumer focus on the West resulted in such a rapid increase in wine consumption that China is one of the largest imported wine markets in the world. Wine has moved from a specialty drink to one consumed at home and in restaurants and bars, but still trails local beer and spirits as the alcoholic drink of choice for most consumers. Wine is widely available across brick and mortar and online retail outlets; however, knowledge of specific countries of origin and brands is still fairly low, and research has been conducted mainly with existing wine drinkers in major cities, so little is known about the potential for consumption growth in smaller cities and rural areas. It is predicted that major changes have already occurred and the next few years will bring slower growth in the consumption of grape-based wine in mainland China.

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Kosher and Halal: How They Affect Muslim and Jewish Dietary Practices

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Abstract

The Jewish kosher dietary laws and the Muslim halal dietary laws are an integral part of each religion as part of their larger legal frameworks. However, as food and drink are so central to people's daily life, these laws often taken on a greater significance. Therefore, it is useful to understand these laws and how they function to meet the daily needs of their adherents. The kosher (kashrus) dietary laws determine which foods are "fit or proper" for consumption by Jewish consumers who observe these laws. The halal dietary laws determine which foods are "lawful" or permitted for Muslims. For both religions, the food laws are a small part of a comprehensive system of religious laws that cover many aspects of daily life. However, these laws establish a framework, but how an individual Jew or Muslim will live their life is a personal matter often influenced by the standards of the local community and often not necessarily following all of the laws. And the laws themselves will vary as there is no central body currently in a position to harmonize these laws. Although these variations in practice may at times be frustrating for those making products to serve these markets, it is also a great strength internally to be able to respect differences within the group and to learn to celebrate this diversity.

Introduction

The Jewish kosher dietary laws and the Muslim halal dietary laws are an integral part of each religion as part of their larger legal frameworks. However, as food and drink are so central to people's daily life, these laws often taken on a greater significance both for adherents and for the larger society. Therefore, it is useful to understand these laws and see how they function in the broader society and also helpful to understand some of the dietary preferences/cultures that help these systems meet the daily needs of their adherents. (For a more detailed discussion of these laws, please see Regenstein et al. (2003).)

The Religious Significance of These Laws

Before looking into the laws in some detail and how they affect the foods eaten by Jews and Muslims, it is worth considering the religious significance of these dietary laws for Jews and Muslims, in the broader context of these two Abrahamic faiths. The kosher (kashrus) dietary laws determine which foods are "fit or proper" for consumption by Jewish consumers who observe these laws. The halal dietary laws determine which foods are "lawful" or permitted for Muslims. For both religions, the food laws are a small part of a comprehensive system of religious laws that cover many aspects of daily life. Thus, almost no question about how to lead one's life is beyond the scope of these religions legal systems. This is probably the biggest distinction between the Jewish and Muslim religion in comparison to the third Abrahamic faith of Christianity broadly defined. However, these laws establish a framework, but how an individual Jew or Muslim will live their life is a personal matter often influenced by the standards of the local community and often not necessarily following all of the laws. And the laws themselves will vary as there is no central body currently in a position to harmonize these laws, and their probably is no real noncommercial driving force for such harmonization. Although these variations in practice may at times be frustrating for those making products to serve these markets, it is also a great strength internally to be able to respect differences within the group and to learn to celebrate this diversity.

Why do Jews and Muslims follow dietary laws? The explanation by Rabbi I. Grunfeld provides an explanation that really speaks on behalf of both religions although it is clearly of Jewish origin (Grunfeld 1972) but similar thoughts can be found in Muslim documents. (It is also a very traditional document and framed in the male voice.)

> And ye shall be men of a holy calling unto Me, and ye shall not eat any meat that is torn in the field (Exodus XXII:30).
>
> Holiness or self-sanctification is a moral term; it is identical with. . .moral freedom or moral autonomy. Its aim is the complete self-mastery of man.
>
> To the superficial observer it seems that men who do not obey the law are freer than law-abiding men, because they can follow their own inclinations. In reality, however, such men are subject to the most cruel bondage; they are slaves of their own instincts, impulses and desires. The first step towards emancipation from the tyranny of animal inclinations in man is, therefore, a voluntary submission to the moral law. The constraint of law is the beginning of human freedom.
>
> The three strongest natural instincts in man are the impulses of food, sex, and acquisition. Judaism does not aim at the destruction of these impulses, but at their control and indeed their sanctification. It is the law which spiritualizes these instincts and transfigures them into legitimate joys of life.

The Kosher and Halal Markets

Both kosher and halal are important specialty markets in many countries. This section will focus on the USA with a mention of other markets. Briefly, the deliberate consumers of kosher food, i.e., those people who specifically look for the kosher mark, are estimated to be over 12 million Americans (of which 2/3 are not Jewish), and they are purchasing almost 15 billion dollars of kosher products (Lubicom 2012). Other users include consumers who may find kosher products helpful in meeting their own dietary needs such as Muslims; Seventh-Day Adventists; vegetarians; vegans; people with various types of allergies – particularly to dairy, grains, and legumes – and general consumers who for one reason or another prefer kosher products. By undertaking kosher certification, companies incrementally expand their market, i.e., increased incremental sales. In the USA, this means that about 40% of packaged goods in a typical supermarket in the northeastern USA are kosher. Thus, most US consumers will have kosher products in their home, even though they do not realize that they do. In Europe more and more products are taking on kosher markings although the numbers are much smaller than in the USA. Traditionally, Europe has used a different system. The local rabbi inspects the plant and then tells the community which products are acceptable. Unlike the system using markings, there is no fee for service with this arrangement. But that also means there is no legal commitment from the plant to let the rabbi know when they are making changes.

On a global scale, the halal market is a significant component of trade in foods. The number of Muslims is estimated to be between 1.3 and 1.8 billion people (i.e., 20 to 25% of the world's population!), and inter-country trade in halal products continues to grow. In many countries halal certifications acceptable to the national government have become necessary for products to be allowed to be imported. Thus, the religious needs have become part of the secular environment of everyone within these countries. In the USA, this market is now emerging and slowly increasing the number of domestic products. In Europe, because of immigration, the halal market is expanding rapidly, but hard numbers are difficult to obtain. But simply the number of Muslims in many of these countries assures that there is a viable market for halal products.

The products covered by these markings may be traditional foods that have no relationship to kosher or halal, but, on the other hand, some companies and some products are directly associated with the culture and food preferences of each of these communities. One of the challenges for adherents in Western countries is the tension between traditional religious and cultural food habits and the desire of the younger generation to go more mainstream. Thus, products in both categories, i.e., traditional and "secular," are needed that are also religiously acceptable.

The Kosher Dietary Laws with References to the Halal Dietary Laws

The Jewish dietary laws predominantly deal with three issues, all focused on the animal kingdom with a fourth set of laws dealing with the holiday of Passover that are added to the regular laws but focus more on the plant kingdom.

There are also many additional laws dealing with special issues such as grape juice, wine, and alcohol derived from grape products; Jewish supervision of milk; Jewish cooking, cheese making, and baking; equipment kosherization; purchasing new equipment from non-Jews; and old and new flour.

The Muslim dietary laws cover much of the same territory as the first two kosher issues but not the last two, and they bring in issues such as alcohol and live animal feed. On the other hand, their dietary laws remain constant throughout the year.

Allowed Animals

Ruminants with split hoofs that chew their cud (ruminants), the traditional domestic birds (e.g., chicken, turkey, duck, and geese), and fish with fins and removable scales (i.e., visible and they do not tear the skin; cycloid and ctenoid scales are permitted, while ganoid and placoid scales are not permitted; all fish with scales have fins) are generally permitted. The most controversial fish is the swordfish (Govoni et al. 2004).

Pigs (which have often become the symbol of both kosher and halal observance) and camels (a ruminant without a complete split hoof) are not permitted although the latter is halal. The rabbit among commercial food animals is also permitted in halal as are other generally "vegetarian" animals. The list of allowed animals is definitely greater for halal than kosher.

Among commercially available birds, the ostrich family is prohibited for kosher but is accepted as halal. Determining which birds are kosher and halal is a bit more complicated because the original scriptures (i.e., Hebrew Scriptures and Quran) are not as specific.

Animals that spend their entire life in the water are permitted according to the Quran. However, subsequent writings by Muslim scholars in the various sects and schools of Islam have led to a great deal of divergence with respect to the acceptability of marine life. A few fish are controversial in the kosher community because of the question as to whether their scales meet the Jewish requirements. The biological definition of scales is broader than the Jewish definition!

Most insects are not kosher. A few types of grasshoppers/locust are kosher and halal. Modern IPM (integrated pest management) programs that increase the level of insect infestation in fruits and vegetables can cause problems for the kosher consumer, who must inspect produce suspected of having insects and then remove any insects found. The red pigments carmine and cochineal are not permitted by most rabbinical supervisors, although a few do permit it because it comes from the inedible shell. The Muslim community also debates this topic although many of the Muslim schools of thought again prohibit most insects other than locust. However, bee's honey and shellac (lac resin), an insect exudate are permitted by most kosher and halal authorities. As the food industry moves to more and more use of insects, each of the communities will need to address some key issues. For both, the question of what may be eaten will need to be addressed. It is unlikely that the Orthodox Jewish community will accept any insect products since for most Jews the tradition of eating insects has been lost. However, their use in animal feed will probably not be a problem. For Muslims, on the other hand, the use of insects that might be considered filth (i.e., najis) may present difficulties.

Obviously any ingredients coming from a prohibited animal or an animal not properly slaughtered religiously (see below) also present problems. As a practical matter, many ingredients that can come from both animal and plant sources are cheaper coming from an animal, so proper supervision of food companies is needed.

Prohibition of Blood

Ruminants and fowl must be slaughtered according to Jewish law by a specially trained religious slaughterman (shochet) using a special knife designed for the purpose (chalef). Before starting to slaughter animals, the shochet does say a prayer.

The knife must be razor sharp and totally free of nicks. It must have a very straight blade that is at least twice the diameter of the neck of the animal to be slaughtered. This knife is checked after each slaughter. The cut is done horizontally across the neck in a specifically designated region. Both carotid arteries and both jugular veins along with the windpipe and esophagus are cut. When done right on calm animals, this leads to strong bleeding which leads to rapid unconsciousness of the animal in a calm fashion. A key animal welfare aspect of this process is the absence of nicks, which if present would activate the pain receptors in the skin region of the cut.

The Muslim community uses a similar slaughter along with a blessing over each animal or bird. They highlight sharpening the knife properly but not sharpening the knife in front of the animal, not allowing another animal see the slaughter, and having the animal facing Mecca. However, the emphasis on avoiding nicks is not part of their training. The design of the knife is also not specified although work by Dr. Temple Grandin at Colorado State University (personal communication) has suggested that the long straight blade has definite advantages, and both she and her disciples are recommended such a knife for halal slaughter of animals. Recently an instrument to measure the sharpness of knives and to show that the knife is nick free has been developed by the Anago Company in New Zealand (anago.co.nz). The hope is that these improvements will be adopted by the Muslim community.

Both communities are concerned with animal welfare. Again a traditional Muslim text summarizes this nicely: "Allah has decreed that whatever is to be done should be perfect and sublime. Hence, when you kill, kill well; and when you slaughter, slaughter well: sharpen your blade and handle with kindness, that which you slaughter."

Some Muslim scholars permit pre-slaughter stunning of an animal, and some rabbis permit post-slaughter stunning. Both of these are controversial, and many more traditional Muslim and Jewish consumers reject these processes.

Slaughtered animals for kosher are subsequently inspected for visible internal organ defects by rabbinically trained inspectors, with a special emphasis on the lungs. Both discolorations and connective tissue adhesions between lung lobes and/or with the lung cavity (sirchas) must be examined carefully to determine if the meat is acceptable. This involves both an internal inspection with the lungs in place and further work after the lungs are removed from the rest of the carcass. The failure rate can be significant and impacts the cost of kosher meat as if rejected, the entire carcass is moved to the secular supply, often with a price discount. In modern times, starting in the USA, the rabbis ruled that only a few sirchas are permitted for the strictest meat. This is referred to as "glatt" meat and the term "glatt" can really only refer to mammals. The Jews living in the Muslim world during the dark ages (Sephardim) were stricter and required that there be no lung adhesions. This meat is referred to as "Beit Yosef" meat.

Meat and poultry must be further prepared by properly removing certain veins, arteries, prohibited fats, blood, and the sciatic nerve. The removal of the sciatic nerve is difficult in some animals, e.g., cattle and sheep, while much easier in deer, so as a practical matter in most countries, the hindquarters (which contain the sciatic nerve) are moved to the secular trade. Again in the Sephardic tradition, the hindquarter was used, and as Israel is a Sephardic country, such meat is available there although most practicing Jews of European origin (Ashkenazic) will not use such meat.

To further remove the prohibited blood, red meat and poultry must then be soaked, salted, and rinsed within 72 h of slaughter. Livers and hearts will be handled separately. The heart must be opened and any coagulated blood removed. The liver must be broiled in a dedicated broiler until it is at least half cooked. If more than 72 h are needed, then according to some rabbis, meat may be specially washed (begissing, a real wash and not just a light spray), and this wash procedure may be repeated for up to two more times, each time within 72 h of the previous washing. This is done to make sure the blood and meat surfaces remain moist. However, this process of begissing has been rejected by most consumers who require glatt or Beit Yosef meat.

The soaking is done for half an hour in cool water (not cold); thereafter, the salting is done for 1 h with all surfaces, including cut surfaces and the inside the cavity of a chicken or turkey. After the hour of salting, the meat is then rinsed three times. The salted meat must be able to drain throughout, and all the blood being removed must flow away freely. The special crystal size used for this process is called kosher salt (crystals large enough to not dissolve in an hour, but small enough to adhere and totally cover surfaces). Most salt is actually kosher, so in this case, the word kosher refers to the crystal size, which has become very popular with many secular chefs, especially those on TV and various social media!

Some concern has been raised about the salt level in kosher meat. Note that only the surfaces are salted, generally using primal cuts (i.e., 20–40 pound pieces of meat), and that the penetration of the salt is less than a half centimeter in red meat (NY Department of Agriculture and Markets, personal communication). Many pieces of meat, as consumed, have therefore not been directly subjected to the salt treatment. If salt content in a diet is a very important consideration, then one should cut off all surfaces and not use any of the drippings that come out during cooking as much of the salt that goes into the meat at the surface is cooked out with the drippings.

Any ingredients or materials that might be derived from animal sources are generally are available in a kosher and/or halal form derived from plant oils. A possible exception might be normative mainstream gelatin, which is now being produced from kosher beef hides or fish. Also some kosher rennet, the cheese-coagulating enzyme, is obtained from the dried fourth stomach of a kosher-slaughtered milk-fed calf although most commercial cheese today is made using microbial enzymes that come either from genetically modified bacteria or other microbes whose coagulating enzyme(s) can be successfully used. Microorganisms must be produced in kosher or halal systems (i.e., all ingredients and the equipment are kosher or halal).

Because of the need for the lung inspection, it is rare to have dairy cows even brought to kosher slaughter as they generally cannot pass the lung inspection. So all processed kosher meat products unlike most secular processed meat products, which use dairy cow meat, need to be made from the same meat that would be served at the table.

The Muslim community is concerned with the slaughter of the animal; thereafter, the product is turned over to the secular authorities for the necessary health inspections although it should be noted that both religions require an anti-mortem inspection, i.e., before the slaughter of the animal to determine that it is healthy and not show signs of visible injuries.

Prohibition of Mixing of Milk and Meat

Thou shalt not seeth the kid in its mother's milk. (Exodus XXIII:19, Exodus XXXIV:26, Deuteronomy XIV:21).

This passage appears three times in the Torah (the first five books of the Hebrew Scripture) and is therefore considered a very serious admonition for kosher practice. As a result, the law cannot be violated even for nonfood uses of such mixtures such as pet food. Neither can one derive benefit from such a mixture. The meat side of the equation has been rabbinically extended to include poultry (but not fish) as both meat and poultry need to be inspected, deveined, salted, and soaked. The dairy side includes all milk derivatives.

Keeping meat and milk separate in accordance with kosher law requires that the processing and handling of all materials and products fall into one of three categories:

1. A meat product
2. A dairy product
3. A neutral product called "pareve"

The pareve category includes all nonmeat or nondairy products and includes all plant products along with eggs, fish, honey, and lac resin (shellac). To assure the complete separation of milk and meat, all equipment, utensils, pipes, steam, etc. must be kept in the properly designated category.

Pareve ingredient or product must be produce on equipment that has undergone equipment kosherization (see section on "Equipment Kosherization"). This separation of products into these three categories including during production makes kosher products of interest to people with other lifestyle choices, e.g., vegetarian (dairy and pareve) or vegan (pareve – although clearly the few animal products need to be checked).

Other Kosher Issues

Grape Products

To be kosher, all grape juice-based products can only be handled by observant Jews from grape-pressing to final processing. If the juice is heated (mevushal) to at least 140 °F (or 60 °C, some rabbis require a higher temperature), then it can be handled by any worker, as an ordinary kosher ingredient. Thus, preparing a quality wine is more difficult after heating. In recent years, such wines have been produced successfully, and the author has seen news articles indicating that this or that wine had even won a wine tasting award when competing with non-heated (non-mevushal) wines. Technically, a non-mevushal wine may only be handled by a Sabbath observant Jew when being served to other such observant Jews. (Note: the term "Sabbath observant Jew" is used to denote someone who is Orthodox and tries to observe most traditional Jewish laws.)

The traditional kosher wine is made with Concord grapes and added sugar. It is a totally different product from the normal wines and is more closely related to a very sweet dessert wine. It can be enjoyed in its own right. For religious purposes, the wine can be either this sweet Concord grape wine or any other wine that has been properly supervised during its preparation.

Jewish Cheese (Gevinas Yisroel)

Most normative mainstream kosher supervision organizations require that a Sabbath-observing Jew add the coagulating agent, i.e., the agent such as chymosin that causes curd formation. Any ripened cheese that does not meet this requirement is unacceptable. This rule does not apply to fresh cheeses.

Kosher whey can be created more easily than kosher cheese. If all the ingredients and equipment used during cheese making are kosher, then the whey will be kosher as long as the curds and whey have not been heated together above 120 °F (49 °C) before the whey is drained off. This is true even if a rabbi has not added the coagulant. So the cheese is not kosher, while the whey is. This has led in the USA to the situation where human grade whey is kosher. If it is not kosher, it generally is used as animal feed at a price discount. Generally, whey is dried by spray-drying. This is a difficult piece of equipment to kosherize (see below), so the equipment is kept kosher all the time. (For more information, please see Regenstein and Regenstein (2002a, b).)

Cholev Yisroel

Some kosher-observant Jews are concerned about possible adulteration of milk with the milk of nonkosher animals, such as mare's milk or camel's milk, and therefore require that the milk be watched from the time of milking (i.e., on the farm). "Cholev yisroel" milk is required by some of the stricter kosher supervision agencies for all dairy ingredients. Rabbis who accept non-"cholev yisroel" milk in the USA do so for two reasons. First, they believe that the laws in the USA and many other developed countries are strong enough to assure that adulteration does not occur. Second, the nonkosher milks are worth more money than kosher milks, so there is no incentive to add the nonkosher milk.

Passover

The Passover holiday occurs in spring and requires observant Jews to avoid eating the usual products made from the five Biblically prohibited grains: wheat, rye, oats, barley, and spelt (Hebrew, chometz). One can only eat the special unleavened holiday bread from wheat (Hebrew, matzos). Some matzos are made to a stricter standard with rabbinical inspection beginning in the field. For others supervision does not start until flour milling. Matzo made from oats and spelt are now available for consumers with wheat allergies.

In the middle ages, the rabbis of Europe noted that people also made flour products derived from corn, rice, legumes, mustard seed, buckwheat, and some other plants (Hebrew, kitnyos), so they prohibited these for Passover as they might be mistaken for chometz. In addition to the actual "flours" of these materials, many contemporary rabbis also prohibit derivatives such as corn syrup, corn starch, and corn starch derivatives such as citric acid. A small number of rabbis permit the oil from kitnyos materials, or liquid kitnyos products and their derivatives such as corn syrup. The major source of sweeteners and starches used for production of "sweet" Passover items are either real sugar or potato or cassava (tapioca) starches. These starches have different properties, which affects the end product. The matzos can be ground into either a course meal (matzos meal) or a very fine meal (matzos flour). However, these like bread crumbs are already baked, and so baked goods and other products using them will have a different outcome. (Note: Matzos for year-round use does not need to meet the special rules for Passover matzos, so regular wheat flour can be used and the time to process it and bake it is not an issue.)

Kosher: Other Processing Issues

Equipment Kosherization

There are three ways to make equipment kosher or to change its status back to pareve. Rabbis generally frown on regularly going from meat to dairy or vice versa. Most conversions are from dairy to pareve or from treife (nonkosher) to one of the categories of kosher. There is a range of processing procedures to be considered, depending on the equipment's prior production history.

After a plant, or a processing line, has been used to produce kosher pareve products, it can be switched to either kosher dairy or kosher meat without a special equipment kosherization step. It can also subsequently be used for halal production (from pareve or dairy lines, not always from meat lines) and then, finally, for nonkosher products. In many cases, a mashgiach (the rabbinically approved kosher supervisor) is needed on-site for equipment kosherization, so it normally is beneficial to minimize the number of changeovers from one status to another. Muslims also have a procedure for changing equipment that generally involves a supervised washing. In a few cases, when pork was used, they might require that contact surfaces be sandpapered.

The simplest equipment kosherization occurs with equipment that has only been used for cold products. This requires a good liquid caustic/soap cleaning – i.e., the type of cleaning done normally in most food plants. Some plants do not normally do a wet cleanup between runs (e.g., a dry powder packing plant or a chocolate line), and these would need to seek specific rabbinical guidance for the changeover if permitted. Materials such as ceramics, rubber, earthenware, and porcelain cannot be koshered.

Most food processing equipment is operated at cooking temperatures, generally above 120 °F (49 °C), the temperature that is usually rabbinically defined as "cooking." However, the exact temperature for "cooking" depends on the individual rabbi and may also be product specific (range 110 to 140 °F (~43 to 60 °C)) with 120 °F (49 °C) being agreed upon in the USA for dairy products. Such equipment must be thoroughly cleaned with liquid caustic/soap. The equipment must then be left idle for 24 h, after which it is "flooded" with boiling water in the presence of a kosher supervisor. The details depend on the equipment being kosherized. In some cases, particularly foodservice establishments, a "pogem" (bittering agent, oftentimes ammonia) is used in the boiling water in lieu of the 24 h wait. The absolutely clean equipment (e.g., silverware) is put into the pogem containing boiling water followed by a second boiling with clean water.

In the case of ovens or other equipment that uses "fire," or dry heat, kosherization involves heating the metal until it glows. Again, the supervising rabbi is generally present while this process is taking place. Sometimes the same oven can be used sequentially for pareve and dairy baking. The details are beyond the scope of this chapter and require a sophisticated rabbinical analysis. If kosherization of an oven is needed, this often requires the use of a blow torch to heat surfaces to "red hot."

Kosher and Allergies

Many consumers use the kosher markings as a guideline to determine whether food products might meet their special needs including allergies. There are, however, limitations that the particularly sensitive allergic consumer needs to keep in mind. The kosherization procedure may not yield 100% removal of previous materials run on the equipment.

In a few instances, where pareve products contain small amounts of fish (such as anchovies in Worcestershire sauce), this ingredient may (but not always) be marked as part of the kosher supervision symbol as fish cannot be used directly with meat. Many certifications do not specifically mark this if the fish in the initial material is less than 1/60 by volume (a special amount used). Although a number of these issues have already been discussed, it may be helpful to also bring a few of them together here, only for a first screening of products.

Blessings

There are many blessings for food along with many other blessings. So to say the right blessing, one needs to know something about the food you are eating. Some blessings are specific, e.g., tree fruit versus ground fruit. Some can cover the whole meal, e.g., the blessing over bread, which follows the blessing for washing the hands, and are said without interruption between them. Sometimes a single product requires more than one blessing, e.g., one of the "Chex" products is corn on one side and wheat on the other side. Those have different blessings and so you start with the wheat facing up and say its blessing. Then one turns the product over and says the blessing for corn.

Additional Information About the Halal Dietary Laws

Although a number of these issues have already been discussed, it may be helpful to also bring a few of them together here. It is also clear that the amount of detail for halal is less than kosher. This is consistent with the idea that the distinction of halal and haram is for human *ease*, goodness, guidance, and mercy.

Halal Dietary Laws

The halal dietary laws define food products as halal (permitted) and haram (prohibited) and put a few items to go into the category of makrooh (questionable to detestable), which is often the most controversial area. The law deals with the following five issues; all but the last are in the animal kingdom.

Prohibited and Permitted Animals

As previously mentioned, pork is prohibited, as are the carnivorous animals and birds of prey. However, most Muslims consider horsemeat to be makrooh. Birds are specifically those that do not use their claws to hold down food.

The animals fed unclean or filthy feed (e.g., formulated with biosolids (sewage) or protein from tankage) and must be quarantined and placed on clean feed for a period varying from 3 to 40 days before slaughter to cleanse their systems. This is an area where Muslim needs are not being met in some cases although many Muslims would like to have more meat and poultry available from animals that have met this requirement.

Food from the sea, namely, fish and seafood, are the most controversial among the various denominations of Muslims. Certain groups, particularly Shiia, only accept the kosher fish, i.e., with fins and scales although many also accept shrimp, while others consider as halal everything that lives in the water all the time. But others may consider some of these makrooh and avoid them. Animals that live both in water and on land (amphibians) are not consumed by the majority of observant Muslims.

The status of insects is uncertain except that locust is specifically mentioned as halal. However, from legal discussions, it seems that both helpful insects, like bees, ants, and spiders, and harmful or dirty creatures like lice, flies, and mosquitoes are all haram.

Eggs and milk from permitted animals are also permitted for Muslim consumption. Unlike kosher, there is no restriction on mixing meat and milk.

Prohibition of Blood

According to the Quranic verses, blood that pours forth is prohibited for consumption. There is general agreement among Muslim scholars that anything made from blood is unacceptable.

Proper Slaughtering of Permitted Animals

In addition to those discussed earlier, there is the rule that only after the blood is allowed to drain completely from the animal and the animal has become lifeless can the dismemberment begin.

Prohibition of Alcohol and Intoxicants

Consumption of alcoholic drinks and other intoxicants is prohibited. One of the scholarly passages on alcohol is particular interesting in terms of food science. It actually talks about the entire production cycle: “Allah’s curse falls on ten groups of people who deal with alcohol. The one who distills it, the one for whom it has been distilled, the one who drinks it, the one who transports it, the one to whom it has been brought, the one who serves it, the one who sells it, the one who utilizes the money from it, the one who buys it, and the one who buys it for someone else.”

Although there is no allowance for added alcohol in any beverage like soft drinks, small amounts of alcohol contributed naturally from food ingredients may be considered an impurity and hence ignored. Synthetic or grain alcohol may be used in food processing for extraction, precipitation, dissolving, and other reasons, as long as the amount of alcohol remaining in the final product is very small, generally below 0.1%. Each importing country may have its own guidelines for both natural and other alcohol. Generally beverage alcohol is most frowned upon. Some will suggest that in food products that are cooked, the alcohol is vaporized. This has been shown not to be the case through research done by the USDA (Larsen 1995). Among the foods that are often not thought about as containing alcohol are breads. They can have up to 0.2 to 0.3% or so alcohol.

In addition both communities also have rules about blessings for food. However, the Muslim religion also tries to guide its adherents, and their particular guidelines for eating and for table manners are particularly interesting.

For eating:

1. Never criticize any food.
2. Du’a (say a supplication) before each meal.

3. Du'a after each meal.
4. Eating less.

> Nothing is worse than a person who fills his stomach. It should be enough for the son of Adam to have a few bites to satisfy his hunger. If he wishes more, it should be: One-third for his food, one-third for his liquids, and one-third for his breath. (Tirmidhi and Ibn Majah)

5. Eating slowly.
6. Moderation.

> Eat of the good things. We have provided for your sustenance, but commit no excess therein.... (Al-Qur'an 20:81)

7. Sharing.
8. Eating together.

> Eat together and not separately, for the blessing is associated with the company. (Ibn Majah)

And for table manners:

1. Sit down while eating and/or drinking.
2. Eat together and share food.
3. Serve others first, especially guests.
4. The host is the first to start eating and the last to finish.
5. Take smaller portions of food on the plate.
6. Eat from one's own side of the plate and not from the middle.
7. Finish the plate of food without leftovers.
8. Eat with the right hand.
9. Wait for everyone to finish before finally leaving the table.

Both Kosher and Halal

Biotechnology

Rabbis and Islamic scholars currently accept products made by simple genetic engineering; e.g., chymosin (rennin) was accepted by the rabbis about half a year before it was accepted by the US Food and Drug Administration. The basis for this decision involves the idea that the gene isolated from a nonkosher source was not "visible." Subsequently, it is copied many times in vitro and then eventually injected into a host where it is then reproduced many times. Thus, the original source of the "gene" is essentially totally lost by the time the food product appears. The production conditions in the fermenters must still be kosher or halal, i.e., the ingredients and the fermenter, and any subsequent processing must use kosher or halal equipment and ingredients. A product produced in a dairy medium would be kosher dairy. Mainstream rabbis may approve porcine lipase made through biotechnology when it becomes available, if all the other conditions are kosher. Islamic scholars are still considering the issue of products with a porcine gene; although a final ruling has not been established, the leaning seems to be toward rejecting such materials.

If the gene for a porcine product were synthesized (i.e., it did not come directly from the pig), Islamic scholars still need to determine if they will accept it. Again, the leaning seems to be negative. Because the religious leaders of both communities have not yet determined the status of more complex genetic manipulations; such a discussion is premature. (For more details, please see Chaudry and Regenstein (1994).)

Kosher and Halal Foods

A key consideration is that which is called Jewish food and what is called kosher food need to be distinguished. Kosher food is food that meets the technical requirements of the Jewish religious laws as interpreted by the consumer and/or the person's religious advisor. The same is true for halal for Muslims. But what is religiously acceptable does not mean it is what most people of these two faiths actually eat and especially what they might have eaten in the recent past.

Many Muslims live in countries where they are a majority, there are 57 countries that are part of the OIC (the Organization of the Islamic Conference) that wish to be identified as Muslim majority or have a sufficiently large Muslim population that their government wants to recognize this unique aspect of their country. In these cases, the food of the population tends to reflect the dominant food style. So, for example, Pakistani, Malaysian, Moroccan, Egyptian, and such countries have their own cuisines, and the halal interaction is real but has a limited impact on the cuisine for those who are or are not practicing Muslims. The biggest difference is probably in whether alcohol is or is not incorporated into the meal. Therefore, it seems that discussing in detail these foods would be redundant with material already available.

On the other hand, Jews, as a wandering people, have incorporated the foods of many countries and have adopted them to their religious requirements, their culture of holidays with different meanings, and the fact that overall they were poor. Only in modern times has this food of poverty become celebrated. Again, in Christian countries, with their heavy emphasis on pork and often the mixing of milk and meat, the food of Jews both daily and on holidays was different from others. In the Muslim countries, the distinction was much less. The absence of dairy and pork in most of these countries meant the Jews and Muslim diets could be similar although as seen earlier, the meat would have to be different, most Muslim neighbors would eat in the Jewish home and, other than meat, the religious Jew might even eat in a Muslim home.

So, this section will focus on the diet and eating habits of the Jew in Europe. The rules for baking and the absence of dairy breads meant that bakeries had to be supervised. This was often a part of the job of the local rabbi. This would certainly require at least a daily visit if the bakery was owned by a Gentile and had no Sabbath-observing Jewish employees. And if Jewish owned, it might be required to take challah. This is a small portion of large amounts of dough that must be removed, a prayer said, and the material burned – again the details are beyond this chapter. And the rules for working with ovens going back and forth between dairy for cakes and other items versus pareve for bread and pareve cakes would require all involved to have a basic understanding of that component of the law.

Breakfast and lunch would generally be dairy or pareve with no meat eating until evening, if there was enough money to buy some meat. This is also due to the customs that developed in switching from meat to dairy or vice versa. The custom in going from meat to dairy is to wait a fixed period of time which was most often 6 h but in a few cultures was 3 or 4 h (e.g., Germany) or even 1 h (e.g., Holland). On the other hand, going from dairy to meat was much shorter, with some accepting a good rinsing of the mouth, while others waited 1 h. (Note: Some dairy products like some dry cheeses were considered meat like and then required the same wait to switch as meat.) Thus, timing of meals became important. If one had a pareve meal, regardless of whether one used meat dishes or dairy dishes, the quick mouth rinse is all that is required to switch.

For example, like many other cultures, the meals were heavy on starch, and a meat meal would also often be a stretch of the little meat available, i.e., a dough-filled food like kreplach, which is the Jewish version of a wonton or a ravioli, is popular. A relatively unusual grain popular with European Jews has been buckwheat, which is known as kasha. It would often be served with traditional pasta. In America buckwheat is grown in the region around Penn Yan in upstate New York along Seneca Lake in the Finger Lakes region, which calls itself the buckwheat capital of the USA. The kasha is also a filling for another traditional "double starch" food, the knish, a larger dough-filled food. The most common filling is potato although other fillings were common, while in modern times, the fillings have become more varied. So, other traditional fillings might be kasha, cabbage, and liver. Other fillings now include sweet potato, spinach, and cheese with fruit. Obviously, the kosher versions need to carefully separate the meat, dairy, and pareve items.

The use of liver has been the focus for the use of edible offal. Because the liver is one of the few front quarter offal meats, its use in Jewish cooking has almost become symbolic. It does have to have some forbidden fat removed, and because of the high level of blood, it needs to broiled, at least to halfway done. Chopped liver, much coarser chopped than a classical pate, becomes an important appetizer in modern times.

The heart of the weekly cycle of the Jewish week is the Sabbath. As all Jewish days start at sundown, dinner on Friday night is accompanied by special prayers including the wine and special bread, i.e., challah, an egg-based "rich" bread. (The term challah does have two meanings, a type of bread and the removal religiously of a piece of dough.) So the focus of Jewish culinary has been on this weekly festival, but that means that there are a whole bunch of special rules that have to be followed as work is prohibited on the Sabbath. What does “work” mean? It is all of the activities associated with the building of the Temple in Jerusalem.

So cooking on the Sabbath, a day of joy and celebration, becomes a little tricky, given that to celebrate you want hot meals for the official meals. The traditional solution is the “Blech,” a metal covering of the stoves, so the fire can be left on for the entire Sabbath. The oven may also be left on the whole night and day. Changing settings on the Sabbath is very complicated. In modern times, especially with electric stoves, special Shabbos stoves have been developed to deal with the complex requirements. Other household appliances also have to be adjusted, e.g., the light in the refrigerator needs to be turned off. No electricity can be turned on or off, so the use of timers has become fairly common. A key is that all food must be at least half cooked when the Sabbath begins or in practice when the homemaker accepts the beginning of Shabbos within the allowed window. There is some discretion in Jewish law as to when a person can begin following the Sabbath rules. Because it is such a special holiday, some people might want to start earlier than the last possible time – it is a sign of respect for the holiday to start early.

The Friday night dinner is fairly easy. And brisket and chicken are probably the most traditional meats for Friday night in the USA. But, the two meals on Saturday are more of a challenge. The traditional solution is cholent, a bean, potato, and cheap meat dish, e.g., flanken (rib bones) that is fatty and needs long cooking. So, Jews developed some of the early slow cooker foods, put in the oven on Friday afternoon, and held until needed. Another such slow cooking dish is tsimmes, usually based on carrots, often with sweet potatoes and even dried plums (prunes) and other sweets (e.g., pineapple) to celebrate the sweetness of the day. This can be made with meat, a tradition that is also found in the foods of many Muslim countries, e.g., Malaysia and Morocco.

Another traditional appetizer for Shabbos dinner is gefilte fish. A lot of traditions surround this interesting fish dish. It traditionally was made from carp, a very tasty fish with two challenges. The first is that if it comes out of a muddy river, so it may have a muddy flavor. This flavor is water soluble and the live fish can be purged. So when and how does one do that? In the bathtub of course. The homemaker would buy the fish on Wednesday and bring it home and put it in the bathtub. Thankfully, carp are pretty hardy and survive the trip home. Obviously, the young people in the household would enjoy this temporary pet as most Jews did not generally have pets (which are subject to some of the kosher laws). So Jewish children’s literature is filled with stories involving this fish in the home, both realistic and sometimes more fanciful outcomes. On Friday morning the fish would be killed, often by the senior female in the household. This worked out fine in traditional homes where one took a hot bath once a week and in a Jewish home that meant on Friday in preparation for the Shabbos. Originally, the carp was just cooked, but it has a lot of “flying Y bones” which are a nuisance for many, especially children. So a chopped form was developed and put in the belly cavity of a second carp for cooking (baking). But after a while it became its own dish. Grandma would then prepare the traditional gefilte fish by adding the other ingredients that would include fat (often a bird fat, i.e., schmaltz, the Jewish meat spread in place of butter); egg; matzo meal, the ground matzos associated with Passover; and, of course, salt and pepper. And, of course, that meant grandma tasted the mixture to be sure it was "right." But carp have worms. Therefore, grandma would be the only one with intestinal worms! (If the worm cannot be seen, it cannot be a kosher issue. There are also other more complex interpretations that suggest that fish worms are not an issue but that is beyond the scope of this chapter.) The fish in some form would then be boiled for an hour or more and that both killed the worms and softened the bones. This was then served with horseradish to give more flavor, but often with beets added to give a nice contrast and to cut down the sharpness of the horseradish.

The many Jewish holidays throughout the year also developed special foods. If the holiday came on the Sabbath, the Sabbath rules dominated. Depending on the holiday, the degree of rules varied somewhere between everyday rules and almost Sabbath rules. And the challenge sometimes is that the holiday comes on Sunday and one cannot prepare meals for another day on the Sabbath or it came on Friday and one had to prepare the Sabbath meals but not violate the holiday rules.

So working through the Jewish calendar, the special holidays and their foods will be discussed briefly.

Rosh Hashanah. The Jewish New Year is a serious religious holiday. It is also a time of hope for a sweet new year. One would like to dip a new fruit in honey and say the special prayer for getting to this time. So apples or another fruit that one had not eaten in a while, preferably from the fall harvest would be used. Taglich are baked goods with lots of honey. Honey cake is another favorite. Plums were also often available around this time in Europe, so various forms of plum cakes are also associated with Rosh Hashanah.

Yom Kippur. This is the major fast day in the Jewish calendar. It is a day of atonement and completes the 10 days of the New Year holiday. During the 10 days, a Jew is supposed to seek atonement from others that he/she might have harmed during the year. Only then can one seek atonement from G-d. Obviously, the meal going into the fast is relatively bland. The hard part is breaking the fast, where eating too much or too fast is a challenge to avoid. Herring in wine sauce and herring in cream sauce are two pickled fish favorites. Note that the cream sauce is based on sour cream, a tie to Central Europe where sour cream was a way to preserve milk and was not as complicated religiously as cheese. Sour cream is also used to sweeten the strongly acidic (sour salt, citric acid) taste of borscht (beet soup that could be made pareve or with meat) or Schav (sorrel grass with sour salt – a specialty dish that even most Jews would have to admit that they never tried it!).

Succoth. This is the festival of the booths/huts commemorating the wanderings in the desert after the exodus from Egypt. Meals are supposed to be eaten in the Succah and many observant Jews will even sleep in these huts. Even beyond the observant Jewish community, this holiday is very popular as more and more people build their own Succah at home rather than use the communal Sukkah that is usually at the synagogue. Young people in particular seem to enjoy the "camping out at home" experience. The Succah are often decorated with foods including strings of cranberries, apples, various squashes, and other fall fruits and vegetables.

Hanukkah. This is the holiday closest to Christmas, so despite being a minor holiday in the Jewish calendar, it has become a part of the winter celebrations in the USA. It commemorates the military victory over the Romans and the restitution of the Temple in Jerusalem. The miracle was that the oil needed for the holy light at the top of the ark holding the five books of the law (Torah) was enough for 1 day, but it lasted for the 8 days needed to make new oil. So the goal is to eat oil. European Jewry general uses latkes, potato pancakes, as the major holiday food, while Sephardic Jews from the Muslim countries often use long jelly-filled fried doughnuts called sugganiot. And the highly debated point is whether latkes should be covered with sour cream or applesauce. Some solve the problem by doing both. Note: A brief summary of many Jewish holidays center around celebrating persecutions of Jews, where the Jews were victorious and then choose to celebrate the holiday, with food often being central.

Tu B'Shevat. This is a very minor holiday, but it is very food related. It is a celebration of the trees and plants. It has a formal meal with a set order, i.e., a Seder, that requires fruits not eaten for a while. For many the tradition is at least a month for it to be new food. This Seder is also accompanied with wine, starting with white and adding a little red followed by red with a little white followed by red wine. Thus four glasses are drunk along with at least four new fruits, with the blessing of the wine and the fruit and having reached this season. A more traditional meal may be served after the Seder, but at other times, the meal is essentially fruit and wine.

Purim. This is in some ways the Jewish Halloween. It is celebrated by wearing costumes, including adults. The villain is a government official named Hamen. He apparently wore a triangular hat or at least that is the rumor. A sweet-filled triangle cookie, called a Hamentaschen, literally a Hamen's pocket, is eaten. The traditional fillings were prune butter and mohn, a poppy seed paste. In modern times many of the sweet flavored jams are used along with chocolate. There is also a tradition of sending food baskets to friends with at least two different items.

Passover has generally been the most celebrated Jewish holiday, possibly because it is centered around a large family gathering the first two nights called the Seder (when used alone it means the Passover meal and not the Tu B'Shevat meal), which retells the story of the exodus from Egypt without ever using the name of Moses in the Hebrew text. The Seder plate has a number of symbolic foods that are also used for various ceremonies during the prayers before the meal. The parsley or greens are dipped in salt water to commemorate slavery in Egypt. A piece of unleavened matzos (afikomen) is put away as the official desert. The matzos are eaten with both bitter herbs and charoses, the mortar used to build the pyramids. In the Ashkenazic world, charoses is made with apples, nuts, and wine. In the Sephardic world, dates are often the base for the charoses. Again four cups of wine are drunk. Some newer traditions such as including a cup of water for the role of Miriam (the sister of Moses and a key player in the story of the exodus) have been added in some homes. The special meal requires that all the plant materials be acceptable, i.e., no chometz or kitnyos and no insects.

A Word About Matzos. The wheat may be watched from the harvest in the field (Schmura) or only from grinding. The water, the only other ingredient in the matzos of the poor, which is the only matzos that can be used for the ceremonies, must be lukewarm and held overnight. The matzos must be baked within 18 min. Modern factories use continuous vibrations to prevent any rising so can use a continuous process. Handmade matzos are made in 18-min cycles with a full cleanup before continuing. Richer matzos using fruit juices or eggs are only permitted by Ashkenazim for children, the elderly, and the sick. Sephardim are more liberal about this and also allow most kitnyos.

Shavuot. The final holiday of the yearly cycle is the festival of the giving of the law. It is tied directly to Passover by the counting each day of the Omer, originally the grain offering on the three pilgrimage festivals. It is traditional that meals on this day be dairy. So various puddings, e.g., kugels, are made. Noodle, matzos, and potatoes along with eggs can all be used for the kugels. These often will have cheese (e.g., cottage, pot or farmers cheese, i.e., fresh cheeses added). (A kugel for a meat meal will generally have fruit added, the most common being apples.)

A Word About the Issue of Whether a Holiday Is 1 or 2 Days. Many of these holidays are 1 day in Israel, but when Jews worried about getting the “timing” right, the rabbis instituted 2 days in the diaspora.

The Muslim calendar has a few key holidays. And obviously different Muslim countries have country focused holidays; some may also be tied to the country’s Muslim religious history.

Ramadan is certainly the most widely known holiday. It is a whole lunar month. And it is a month of fasting. This means that fasting and other restrictions are observed during daylight hours. A predawn breakfast (Arabic, Suhur) and a celebratory meal in the evening (Iftar) are eaten. The normal pattern is to break the fast at sundown with dates, other fruit, and rose water. Then the evening prayers are said before the big meal. Often this meal is eaten communally, and the night prayers said thereafter.

It should also be noted that fasting in Islam is fairly common and many Muslims fast once or twice a week regularly. It should also be pointed out that Muslims pray five times a day with the major communal prayer being on Friday early afternoon. Jews, on the other hand, pray three times a day. Those who are observant often do actually pray this regularly.

Note that the Muslim calendar is a lunar calendar, so each year the calendar moves up about 10 days. Ramadan can occur at any season. On the other hand, the Jewish calendar is also a lunar calendar, but it has a leap month (seven times every 19 years) so that holidays retain their relationship to the seasons as many are tied to the harvest cycle in Israel.

At the end of Ramadan, the first few days of the new month are the first of the two Eid festivals (Eid al-Fitr). The second Eid (Eid al-Adah) is about 3 months later and commemorates the almost sacrifice of his son Ishmael by Ibrahim as told in the Quran. (Some may recognize this as a different version of the Abraham and Isaac story.) On both occasions there is usually a desire for every family to formally sacrifice an animal, generally a sheep or goat, for the holiday. This presents a logistical and animal welfare challenge. It should also be noted that Muslim practice is to consider that one-third of the animal is for the family. The second third is for relatives and friends, and the final third is for the poor.

The second Eid occurs when many Muslims are meeting one of the five pillars of Islam, which is the Haj, the pilgrimage trip to Mecca, and Medina in the Kingdom of Saudi Arabia. That means that the many millions of people on Haj all need to have an animal sacrificed in a short period of time. In this case most of the animals will be going to the poor. Based on discussions with some Muslim leaders in the UK, the author believes that Saudi Arabia should be complimented for working hard to improve animal welfare and work out systems to get this meat to people in other countries where it is needed. The transport of the many live sheep needed from other countries is an area where more work is needed to meet the highest modern animal welfare standards.

Thus, both communities have worked out the integration of their religion with their daily life, where food and drink and socializing all need to work together for a meaningful life of each Muslim or Jew with a full range of actual religiosity.

Conclusion

The kosher and halal food laws serve as the framework for the eating habits of Jews and Muslims, respectively. These rules limit food choices, but still allow for a very varied diet. In many cases, the foods of both religions represent the foods of many countries and often, particularly for Jewish food, the adaptation of economical foods to their dietary requirements. To be successful, a global food supply will need to take into consideration the food needs of the various religions around the world.

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Additional Resources

Food Marketing Institute: http://www.fmi.org
Kashrus Magazine – The Online Source for Kosher Information: http://www.kashrusmagazine.com
Kashrut.com – The Premier Kosher Information Source on the Internet: http://www.kashrut.com. North American Meat Institute: http://www.meatinstitute.org
Salaam Gateway: www.info.salaamgateway@thomsonreuters.com

Part VII

Nutrition and Health Sciences

Public Health Nutrition Communication in the Netherlands: From Information Provision to Behavior Change

31

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Contents

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Abstract

Public health nutrition is concerned with the promotion and maintenance of good health through nutrition and the prevention of nutrition-related illness in humans. Nutrition communication plays an important role in the dissemination of credible and practical dietary advice and promoting healthful dietary behaviors. The purpose of this chapter is to provide insight in the changes in public health nutrition communication, by addressing the history, key themes, concepts, and approaches of nutrition communication in the Netherlands. The chapter concludes with a broader view of the challenges of public health nutrition communication and presents potential future directions for this field.

Introduction

Malnutrition is one of the greatest health issues of our time, affecting at least one in three people in the world (WHO 2017). To date, many countries face a double burden of malnutrition, with high rates of undernutrition co-existing alongside overweight, obesity, and diet-related noncommunicable diseases (Willett et al. 2019). Good nutrition is fundamental to prevent malnutrition in all its forms. Changes in the global food system, increased food-related marketing and changing lifestyles, however, have led to a global dietary intake pattern in which people often consume too little nutrient-dense foods and too much high-energy dense foods (James 2008; Popkin 2001). Over the past decades, the food system and food environment have changed in such a way that it is simple to get access to a surplus of inexpensive, highly palatable, energy-dense foods that are heavily marketed (Steeves et al. 2014). This type of environment stimulates people to consume more energy than required, and therefore it is concluded that the global rise in overweight and diet-related noncommunicable diseases is a natural response to the current food environment (Swinburn et al. 2011). Current trends in food production and food consumption also impose an undue burden on sustainability. Food production, for instance, is an important driver of ecosystem degradation (Millennium Ecosystem Assessment 2005), with food responsible for 20–30% of the environmental impacts (Tukker et al. 2011). This implies that providing a global population with healthy diets from sustainable food systems is an immediate challenge that requires large reductions in food losses and waste and major improvements in food production practices (Willett et al. 2019). Furthermore, it asks for consumers' willingness and ability to change their (current) behavior (Van Loo et al. 2017). Altogether, it is not surprising that health and sustainability goals have found their way into public health nutrition communication.

Healthy eating habits make an essential contribution to a healthy lifestyle. The context for public health nutrition communication in the Netherlands, however, is comparable to other Western countries: many people do not eat according to current dietary guidelines. Compared to other Europeans, Dutch adults consume more alcoholic and nonalcoholic beverages, dairy products, and snacks and desserts. In contrast, consumption of vegetables and fruit are among the lowest in Europe (Geurts et al. 2017). Additionally, the prevalence of overweight and obesity is on the rise in the Netherlands. To date, one out of two Dutch adults has overweight (National Institute for Public Health and the Environment 2018). This has important implications for health, contributing to the increased prevalence of diabetes, cardiovascular diseases, and selected cancers (Wyatt et al. 2006). As a result, different national and local authorities, schools, civil society organizations, and private parties have set up preventive and interventive initiatives to reduce the prevalence of overweight and obesity in the Netherlands. Although the solution to this public health problem often requires actions and policies that reside outside the individual consumer, it is nevertheless important to increase the personal significance of these issues for individuals, increase nutritional knowledge, change norms and beliefs about healthy eating, and motivate people to improve current dietary behaviors. The Netherlands Nutrition Centre is the organization primarily responsible for behavior-focused public health nutrition communication in the Netherlands. The Centre provides consumers and professionals with scientific and independent information about healthy, safe, and sustainable food choices and encourages consumers to develop and maintain healthy and more sustainable eating habits. The Centre is funded by the Ministry of Public Health, Welfare and Sport and the Ministry of Agriculture, Nature and Food Quality.

The focus of this chapter is to illustrate the challenges of public health nutrition communication, thereby taking the Dutch context as a case study. In this chapter, the key themes, concepts, approaches, and challenges of public health nutrition communication are described. Firstly, the history of public health nutrition communication in the Netherlands and the current mission and vision of the Netherlands Nutrition Centre are outlined. Then, the primary nutrition education tool that is used in the Netherlands is introduced, after which the main concepts that are included in the health-promoting activities of the Netherlands Nutrition Centre are described. On the basis of these concepts, several approaches that have been developed throughout the years are reported, together with their reach and (potential) impact on the general population. Finally, this chapter describes the general challenges of public health nutrition communication and presents potential future directions for this field.

The History of Public Health Nutrition Communication in the Netherlands

It is 1941. The Netherlands are at war, and professor Cees den Hartog is asked to become the director of the precursor of the Netherlands Nutrition Centre (hereafter referred to as “the Centre”): a nutrition education center fully funded by the government that aims to provide housewives with information about how to survive in times of food scarcity. Basic sustenance products such as milk and sugar are no longer available, and people have to resort to new and unusual products such as pea flour, sugar beet, and flower bulbs. The first activity of the Centre, therefore, is to organize food courses and cooking demonstrations to provide housewives with the practical skills to prepare these foods without food waste. This is urgently needed, because the total daily energy intake of inhabitants in cities such as Amsterdam dropped to less than 580 calories per day (Stein et al. 1975). In addition, the Centre also launches its first edition of the "Guidelines for Contemporary Nutrition." This booklet not only contains an explanation about the functioning of the human body, down to the cell level, but also provides information on the main function of the different macronutrients (i.e., carbohydrates, fat, and proteins) and micronutrients (i.e., vitamins and minerals). Finally, the booklet contains reference tables showing how many grams are needed of a particular nutrient in order to "close the gap between theory and practice." Throughout the years, this booklet is distributed among 100,000 housewives – a huge print run during that time (Bast 2014).

After World War II had ended in 1945, the context for public health nutrition changed rapidly. The country had gone through a period of reconstruction, and the food landscape transformed quickly under the influence of growing prosperity. Fat, salt, and sugar consumption were on the rise, and people started to adopt an eating pattern that was completely different compared to that of the beginning days of the Centre. The proportion of fat in people's daily dietary intake, for instance, increased from 30% to 40% between 1945 and 1960 (Bast 2014). Consequently, nutritional deficiencies were replaced with dental problems and overweight, and professor den Hartog concluded that something different was needed to convey nutritional guidelines in such a way that they were actually understood and used. After being exposed to the "basic seven food groups" developed by the US Department of Agriculture, he decided that a similar method was needed in the Netherlands, and in 1953 the first version of the "Wheel of Five," the primary nutrition education tool in the Netherlands, was launched. During these years, the Centre primarily educated the general population through leaflets, public lectures, movie nights, and radio spots, and the tone of the message was often didactic. One of the brochures of this time, for example, said: "we especially encourage those women living alone to no longer neglect one's nutrition as too many of you are still doing" (Bast 2014). In addition, fear-arousing communications consisting of a fear appeal that stressed the severity and personal risks of unhealthy eating were used. Between 1960 and 1970, the Centre started, for instance, to focus on the health risks of excessive sugar consumption, thereby showing images of rotten teeth with the message "exposure to sugar is harmful for your teeth" (Bast 2014).

In the early 1990s, the Centre changed its tone of voice. The idea of "good" and "wrong" foods was abandoned, and particular food products were no longer banned from current diets. Instead, the Centre started to communicate clearly that everyone was free to make their own choice and included the importance of consumers' total eating pattern, instead of focusing on specific choices, in its nutrition education communication. In 2000, the Centre and three other organizations merged into what is now still known as the Netherlands Nutrition Centre. Although the precursors of the Centre always called on the general population to change their behavior, this behavioral aspect – in addition to providing information and education – became more and more important in the next years. In line with this, the Centre's communication style changed from "sending the message" to a more stimulating and motivating way of communication. This shift is inspired by rapid advances in the research on the nonphysiological factors that might influence when, what, and how much people eat (Nestle et al. 1998; Story et al. 2002) and the rise of psychological health behavior models that focus on understanding and changing behavior, such as the transtheoretical model (Prochaska et al. 2002) and dual-process models of human behavior (e.g., Strack and Deutsch 2004). On the basis of these models, consumers are now inspired and motivated to eat healthily, safely, and sustainably, thereby taking into account the impact and role of the social and physical environment on their behavior.

Mission and Vision of the Netherlands Nutrition Centre

As of the "relaunch" in 2000, the Centre acknowledges that promoting health behavior can take place at different levels, including the micro level (the personal level), the meso level (the organizational and community level), and the macro level (the policy level) (cf. de Vries et al. 2018). The main aim of the Centre, therefore, is to encourage changes on all levels in order to support consumers to develop and maintain healthy and sustainable dietary intake patterns. At the micro level, the goal of the Centre is that people in the Netherlands are motivated to eat in accordance with the Wheel of Five and that they have the knowledge and skills to make healthy and sustainable food choices. In this context, health education is used as one of the strategies to inform and educate people about healthy and sustainable eating. At the meso level, the Centre strives toward a food environment that is arranged in such a way that healthy and sustainable food choices are available and accessible to everyone, thereby focusing on both the family context and schools, work sites, and other food environments. Further, the Centre supports health professionals (e.g., dietitians, physicians, teachers) with tools and advice regarding healthy and sustainable dietary intake patterns. Also at this organizational level, the retail sector, catering industry, food industry, and trade associations are advised on how to implement measures to reformulate foods and how to change the direct food environment to make it easier for consumers to adopt healthy dietary intake patterns. Finally, at the macro level, the Centre informs policy makers on strategies and approaches that governments can use to encourage consumers to change their dietary behaviors, including the implementation of front-of-pack labeling and bans on food-related marketing to children (cf. Mozaffarian et al. 2018)

The Wheel of Five: A Point of Reference for Healthy Eating in the Netherlands

As said, healthy dietary habits are important for maintaining good health and preventing diet-related chronic diseases. Strategies to promote a healthy diet include the development of food-based dietary guidelines. These guidelines provide practical advice to consumers on foods, food groups, and dietary patterns to provide the required nutrients, prevent chronic diseases, and promote overall health while considering culture-specific food preferences (EFSA 2010).

Based on an optimization model, scientific evidence, information on dietary patterns, and expert knowledge, the Netherlands Nutrition Centre and the National Institute for Public Health have derived specific food-based dietary guidelines for different target groups, visualized in the Wheel of Five (see Brink et al. 2019 for a detailed description of this development process). This model visualizes a recommended dietary pattern that offers the best possible combination of health benefits and nutrient provision, based on Dutch foods habits (Brink et al. 2017; see Fig. 1 for a visual illustration of the Wheel of Five).

This tool is the foundation for all nutrition education in the Netherlands. By now, the model has been updated six times after its first launch in 1953, and its most recent update is from 2016.

The Centre advises consumers to mainly eat foods from the Wheel of Five, to eat the right amounts from each segment (each day), to vary the consumption within the different food groups, and to limit the consumption of foods that are not part of the Wheel of Five (no more than 15% of the total energy involved). Foods that are not in of the Wheel of Five are divided in two categories: daily and weekly choices. The

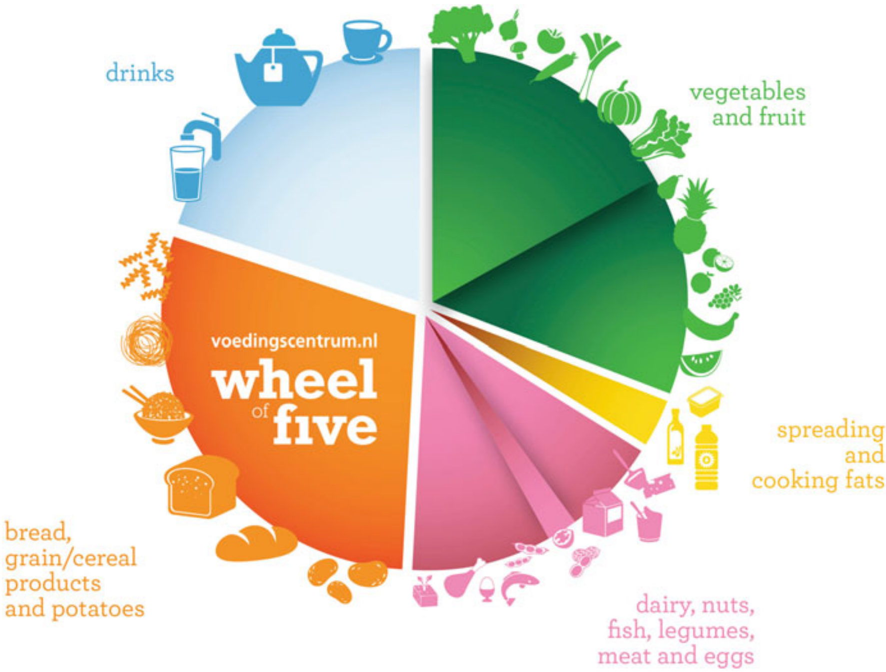

Fig. 1 The Wheel of Five: the practical information tool used by the Netherlands Nutrition Centre to give examples of healthy dietary patterns

advice is to consume no more than three to five foods or drinks from the daily food choices (e.g., light soda, small biscuit, a piece of chocolate) and no more than three foods or drinks per week from the weekly food choices (e.g., regular soda, sugary desserts, cakes, or large biscuits) (Brink et al. 2017). By alternating between food groups in the segment containing fish, pulses, meat, eggs, nuts, and dairy products, consumers can comply with the recommendation that they eat "more plant-based foods and fewer animal products."

A specific example of a recent change in Dutch dietary guidelines is that the fish recommendation has been reduced from two to one servings per week, with the explicit recommendation to consume only sustainably caught or cultivated types of fish. In the Netherlands, two out of three people consume less than one serving of fish per week (National Institute for Public Health and the Environment 2019). For health purposes, one serving per week versus no serving makes a big difference, but adding a second serving does not lead to significant additional health gains. Increasing to two servings, however, would place a heavy burden on sustainability. Thus, this updated recommendation gives sufficient health benefit and also contributes to sustainability.

The Main Concepts Involved in Public Health Nutrition Communication in the Netherlands

To address the public health issues related to poor dietary intake and to provide people with knowledge and skills to make healthy and sustainable food choices, the Centre employs different strategies and approaches. Firstly, elements of the intervention mapping protocol are used to gain insight into the main issues involved around eating and drinking and to outline the steps that can be taken to tackle the issues raised. Further, this approach makes it possible to identify the personal and environmental factors that determine individuals' dietary intake patterns (Kok et al. 2016) and translate theory into actual program materials and activities, following specific intervention matrices (Bartholomew et al. 1998). Following this protocol, the main concepts are explored to understand the target group's existing knowledge, awareness and risk perception, habits and impulsive behaviors, attitudes and beliefs, capabilities, self-efficacy, and intentions. Finally, it is explored whether and how social influences (i.e., social norms, social networks, and social support) may stimulate or impede behavior. Knowing the target audience and understanding their barriers to change also helps to develop messages and strategies that are personally relevant and that will resonate in ways that may lead to behavior change (Fitzgibbon et al. 2007; Viswanath and Bond 2007).

The past decade has seen a rapid increase in the use of storytelling to enhance health communication and promote behavior change (Robin 2006). In addition to more traditional approaches of information provision, the Centre also employs an information approach that is built on narrative storytelling. Within this context, the Centre uses the "touch-tell-sell" method. In the touch layer, the goal is to increase awareness by "touching" emotion. It is assumed that content that provides an emotional connection becomes more personally relevant. A mood-inducing film that touches upon the barriers people encounter when trying to eat healthier and the feelings that go along with this is an example of a "touching story." In the tell layer, it is about informing and inspiring people. Providing people with concrete advice which food choices they could make to improve their current dietary behavior is an example of this. In the sell layer, it is about motivating and seducing people to undertake real action, e.g., switching from sugar-sweetened beverage to water or from cake to banana. The use of engaging and transporting stories in health communication may be effective for various reasons: they may reduce resistance against behavioral change, facilitate processing of new and/or difficult information, produce cognitive and emotional effects that create stronger attitudes and intentions, and provide social connections and role models for behavior change (Green 2006; Kreuter et al. 2007).

Although public health nutrition education and communication have the potential to change individuals' behavior, it is also known that they can only have their impact if their message reaches the target population. Therefore, the Netherlands Nutrition Centre uses different communication channels to reach its target group. In the next section, the different communication channels that are used are described.

Communication Channels

Website

The Centre seeks to explain the relevance of scientific knowledge and translate it into easily understandable, balanced, and practical guidelines and advice. The website provides all the information and advice that is collected throughout the years and helps people the find the right information about healthy, safe, and sustainable eating. The website is updated daily and attracts more than 20 million visits a year, which is considerable for a country with 17 million inhabitants. The information that is available at the website focuses largely on the concepts of knowledge, awareness and risk perception, and capabilities and use strategies such as providing information, risk personalization, self-monitoring of behavior, guided practice, and action perspective.

Brochures, Books, and Leaflets

Since the early days of the Centre, books and brochures are important promotional documents that are used to inform people about healthy, safe, and sustainable eating. On average, more than 1.3 million brochures are distributed per year. These brochures contain specific information for specific target groups, such as (expectant) parents or people with overweight or diabetes. Although all brochures, books and leaflets can be ordered by consumers directly, the majority of brochures and leaflets are distributed through healthcare organizations or by health professionals, such as dieticians. The concepts that are most often targeted in these brochures and leaflets are existing knowledge and awareness, by providing readers with (new) information and action perspective. Finally, consumers are assisted through several books to eat more healthy and sustainable and develop and maintain a healthy weight.

Mass Media Campaigns

Mass media campaigns have long been used in the journey to improve public health. Although mass media campaigns are often not sufficient to initiate direct behavior change, they have shown to be effective in influencing potential mediators of change such as knowledge, attitude, risk perception, or social norms (Reid 1996). Further, they have the potential to promote public health by agenda setting and can be used as a powerful tool in broader health promotion strategies (de Vries et al. 2018). Throughout the years, the Centre has launched different media campaigns with the aim of agenda setting and creating awareness of a need to act (i.e., change). In 2002, for example, the Centre launched the "Maak je Niet Dik!" campaign: an initiative to promote prevention action on weight gain. This specific campaign had the goal to put weight-gain prevention on the public agenda and to induce more positive attitudes and intentions toward prevention of weight gain among consumers. An independent evaluation of this campaign showed that this campaign reached a large proportion of the population (i.e., 65% of the respondents was able to recall at least one campaign message) and led to more positive attitudes toward the prevention of weight gain, but was not strong enough to induce substantial changes in other predictors of behavior change, such as awareness of personal body-weight status or overweight-related risk perceptions (Wammes et al. 2005). This finding may be explained by the finding that respondents did not perceive a personal susceptibility to gain weight and therefore may not have experienced a personal need to change. One of the specific learnings after this campaign, therefore, was to improve the Centre's planning and testing of campaign content and format with the target audience.

Most recently, the Centre initiated the nationwide campaign "De Eetwissel," a campaign aimed at inspiring people to make small improvements in their current diet by switching from an energy-dense food product to a nutrient-dense product (i.e., from white bread to whole grain bread) and subsequently to eat more in accordance with the Wheel of Five. The campaign was launched in the first week of January, a period during which consumers are naturally inclined to form New Year's resolutions. These resolutions involve the development of self-initiated plans at the first day of a new year, which fitted well with the campaign aims. Behavioral determinants that were targeted in this campaign were knowledge, attitude, self-efficacy, and action planning. This campaign secured significant funding to enable frequent and widespread exposure to campaign messages on national television. The first two flights of the campaign reached 6.2 million people, including 4.2 million individuals with a lower education. Online and on social media, the campaign received a stunning number of 12.7 million views, once again indicating that the campaign had sufficient reach across the population. More importantly, however, campaign evaluations showed that a large part of the population had seen or heard and remembered the campaign message and reported an increased intention to make a daily "food switch" in line with the Wheel of Five. There is no information available on the impact of this specific campaign on actual consumption behavior. As yet, campaign effectiveness with regard to behavior change is unclear. Although isolation of the independent effects of mass media campaigns is difficult (Wakefield et al. 2010), the Centre has plans to carry out a yearly evaluation of the specific behavioral determinants (e.g., awareness, knowledge, and attitude) that are involved in consumption behavior (see also "Future Directions").

Social Media

In addition to more traditional communication channels, such as radio and television, social media channels are used as a mechanism for mass information dissemination and engaging audiences in conversations and interaction. Through social media, the Centre can target and reach a broader variety of audiences, in particular those who may prefer to receive nutrition information through these channels. Social media monitoring tools further allow the Centre to learn more about what diverse audiences are saying about health and nutrition and help to identify information gaps and adjust messaging accordingly. Likewise, by answering health-related questions and responding to comments, social media are a powerful tool for customer service. Finally, social media influencers help the Centre to drive online conversations on healthy and sustainable eating and increase social media engagement. In addition, these influencers help to promote messages and increase the Centre's reach of public health nutrition communication.

The Centre uses different social media channels to engage with consumers and professionals. Firstly, Facebook is used to inform and interact with professionals and consumers about (new) activities (102k followers). Secondly, Twitter is used to inform the general population about new activities and to interact with professionals and media (25 k followers). This is done by the corporate account but also by the individual accounts of the Centre's experts on health, food safety, sustainability, and behavior change (together more than 6k followers). Thirdly, Instagram is used to share food recipes and short videos with consumers (37k followers), whereas LinkedIn is used to update and interact with professionals (13k followers). Finally, the Centre has started a YouTube channel to produce and distribute video content (8k followers). This is important considering that a large percentage of the internet traffic will be for video in the near future. By now, the videos on this channel have more than seven million views.

mHealth: Mobile Applications

The quick growth of smartphones has led to a proliferation of smartphone software applications ("apps"). From a public health perspective, these apps can potentially enhance the delivery of health behavior change interventions to individuals (Hebden et al. 2012) and increase nutrition knowledge and support individuals in making healthy, safe, and sustainable food choices. The Centre has therefore developed and launched different applications that may support behavior change. These apps are often built on the concepts of self-monitoring of behavior, goal setting, and planning coping responses. The "Eetmeter" app (translated as "measure what you eat"), for instance, is a self-monitoring tool with which consumers can monitor their daily eating patterns. See Fig. 2 for a visual illustration of this application.

There are three monitoring elements: actual food intake, exercise behavior, and weight status (i.e., body mass index). Users receive feedback and advice on the nutrient and energy content of their tracked foods and the extent to which they eat in accordance with the Wheel of Five. Further, users receive personalized advice about how they could improve their eating pattern. By now, this app has been downloaded more than 1.5 million times and has more than 800 k regular users.

The "Eetmeter" app has recently been linked to an application with which consumers can compare products (i.e., branded items) on nutrients such as salt, sugar or saturated fat, or allergens, by scanning the barcode of the different products. This application is titled the "Kies Ik Gezond?" app (translated as "Do I choose Healthy Choice?" app). See Fig. 3 for a visual illustration of this application.

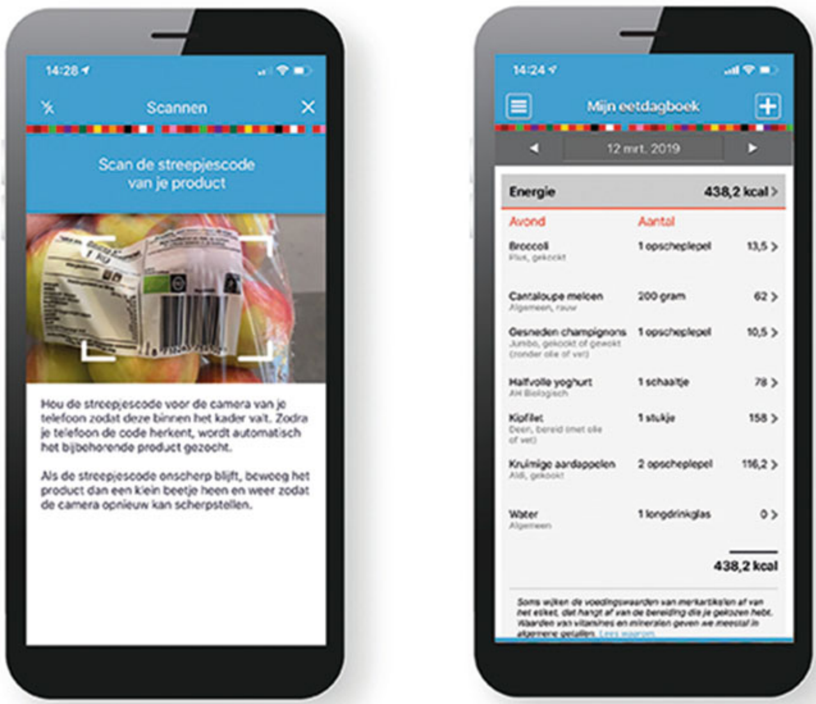

Fig. 2 A screenshot of the "Eetmeter" app.

Fig. 3 A screenshot of the "Kies Ik Gezond?" app.

With this app consumers can also search a food database that covers 90% of the product portfolio available in Dutch supermarkets and receive information on whether or not the product is included in the Wheel of Five. One year after its release, the app has now more than 200,000 downloads, with increased downloads every month.

Schools

One important setting to educate children, adolescents, and young adults about healthy and sustainable eating is the school context. The Centre is, therefore, involved in different initiatives that aim to positively influence children's nutrition knowledge and health behavior at school. First of all, the Centre contributes to the "Healthy Daycare" program: a practical method that supports childcare organizations to make a structural and integral contribution to good health and a healthy lifestyle in young children. Along the same line, the Centre plays an important role within "The Healthy School" approach: a national program that supports schools for primary, secondary, and vocational education in the education and monitoring of healthy behaviors in children. The materials and advice of the Centre help schools to develop effective policy with regard to health promotion and to create a school environment, both physical and social, that facilitates healthy eating behavior in children. Finally, the Centre has developed the "Healthy School Canteen" program: a school-based prevention program designed to create a healthy food environment and promote healthy food choices in secondary schools and schools for vocational training. This intervention entails a multicomponent strategy involving all parties: students, teachers, parents, school boards, canteen employees, municipal health services, and caterers (cf. Mensink et al. 2012). While completing the four steps of this program, schools are guided toward a healthy school canteen, a canteen in which between 60% and 80% of the visible assortment is in accordance with the Wheel of Five (Veldhuis et al. 2017). Between 2016 and 2018, the number of schools with a healthy school canteen according to the guidelines of the Netherlands Nutrition Centre increased from 78 to more than 500 schools. There is a rapid growth in the number of schools that have improved their assortment. To date, one out of four secondary schools in the Netherlands has an assortment that is in accordance with the guidelines, and the large majority of other schools are working on the implementation of these guidelines. Ultimately, the Dutch government would like to see all school canteens in the Netherlands become healthy school canteens. To help reach this goal, the Centre continuously informs schools about the healthy school canteen program and stimulates and motivates schools to improve their assortment.

In addition to these universal school-based prevention programs, the Centre acknowledges that nutrition education is a viable strategy to teach young people about nutrition and to provide them with skills to make healthy food choices (Contento et al. 1992). An example of such a program is "Weet wat je eet" (translated as "Know what you eat"): a free online learning package focused on healthy and sustainable eating aimed at students 12–15 years. The package consists of nine online lessons and one practical lesson about food temptations. Important elements are knowledge about eating in accordance with the Wheel of Five and one's energy balance. Information is transferred through interactive games and quizzes. During the lessons, specific health aspects of food are discussed, and students are encouraged to self-monitor their own eating habits. In addition, students learn to read and interpret food labels and make food preparations. Effect evaluations have shown that this program increases the nutritional knowledge of students, in particular of those with a lower educational level. To date, no information is available on whether this increased nutrition knowledge has translated into more positive eating habits. Here, the same issues apply as with the evaluation of mass media campaigns: it is rendered difficult for the Centre to independently assess the behavioral effects of a nutrition education program without tracking or monitor students' actual food consumption throughout the day. Within this context, the Centre is therefore focused on strengthening the collaboration with research scholars in the domain of health promotion to develop and evaluate nutrition education programs. Specific examples of programs that are already developed in such collaborative effort are "Smaaklessen" (translated as "Taste Lessons") aimed at children 6–12 years in elementary school and "Krachtvoer" (translated as "Power Food") aimed at adolescents 12–14 years attending preparatory secondary vocational education. These programs have been shown to increase children's knowledge and several other psychosocial determinants of healthy eating behavior (Battjes-Fries 2016) and had short- and longer-term favorable effects on adolescents' fruit consumption and snack choices (Bessems et al. 2012).

Challenges in Public Health Nutrition Communication

Reaching and Engaging Individuals Who Benefit Most from Nutrition Advice

By connecting both directly (via the website, social media, and apps) and indirectly (e.g., via healthcare professionals) with consumers, the Centre reaches many people throughout the population. An important challenge, however, is to have impact on those who might benefit most from nutrition advice, as there is evidence that preventive activities can have varying impact on different socioeconomic groups within a population. In particular, it has been shown initiatives that are primarily based on information provision are largely ineffective among those with a low socioeconomic position (Beauchamp et al. 2014). These differences are often explained by structural barriers such as neighborhood-related factors or limited financial resources but also because of the differences that exist among social classes in accessing, processing, and taking advantage of information and their capacity to act on it (Viswanath 2006). Communication inequalities in public health nutrition communication could therefore widen existing differences among social classes. Indeed, there is ample research that have linked low health literacy with lifestyle behaviors and health outcomes (DeWalt et al. 2004; Carbone and Zoellner 2012). Consequently, socioeconomic disparity in nutrition is well documented (Darmon and Drewnowski 2008), with nutrition literacy being an important factor accounting for differences in dietary habits.

The Netherlands Nutrition Centre has taken several steps to gain more and better insight into the specific strategies that can be applied to reach individuals with low health literacy skills and/or low socioeconomic position. First, readability assessments and screening tools are used to evaluate how current and future education materials match the literacy skills of the individuals targeted (cf. Carbone and Zoellner 2012). This is done in order to ensure that the Centre's information is available and understandable to all of those who need it, regardless of their social class, cultural, and individual backgrounds. Second, the Centre is involved in different national and local initiatives that pay attention to health-related socioeconomic inequalities. Here, evidence for and practice-based knowledge of tackling health differences are shared and disseminated within the own organization via an internal working group. Third, the Centre invests in research that aims to gain insight into the specific needs of those with a lower socioeconomic position with regard to nutrition information. On the basis of this information, the Centre tailors its education material to the specific needs of intervention recipients.

Despite these efforts, however, it should be acknowledged that improving health literacy and dietary behavior involves more than effective transmission of health and nutrition information. Thus, although nutrition knowledge is an important condition for adopting healthier eating patterns, it is usually an insufficient trigger for behavior change (Worsley 2002). If the ultimate goal is to eliminate health and nutrition disparities, we also need to focus on overcoming structural barriers to health. In this context, evidence-informed government nutrition policies are therefore recommended as an important step toward the reduction of dietary and health inequities (Mozaffarian et al. 2018).

Achieving Sufficient Exposure for Public Health Nutrition Communication in Today's Food Environment

An important factor in determining the success of public health nutrition communication is exposure. If the intended audience does not frequently hear or see the communication message, then there is limited probability that the message will lead to any changes in the behavior of interest. Within this context, it must be acknowledged that there is huge difference in resources between public and private sectors that they can provide to develop and deliver strategies to have an impact on nutrition behavior. The food industry spends billions of euros on creative and pervasive advertisements to encourage the purchase and consumption of their foods. The marketing of energy-dense foods and beverages, in particular, is widely recognized as contributing to an obesogenic environment for children and adults. Within this context, the public sector has to compete with highly constrained budgets with specific health-related messages, such as the potential health benefits of healthy eating. Promoting such positive outcomes is rendered difficult as it has fierce competition to gain consumers' attention, processing capacity, and willpower. Moreover, these positive outcomes are weighed heavily against other motives such as taste, price, and convenience (Verbeke 2008).

Trustworthiness of Public Health Nutrition Communication

Similarly, the number of dietary behavior-related messages that reach consumers in today's media and communication environment is overwhelming. One of the most influential factors that can impact message reception is the extent to which the target audience perceives the source and message as trustworthy. There are several examples of how the trustworthiness of public health nutrition communication could be affected. Firstly, there are several examples within the literature about how financial interests may have influenced scientific findings. For example, there are concerns about biases introduced by industry funding with regard to calorie control, physical activity, and sugar-sweetened beverage consumption (Nestle 2016). As a result, an increase in the public's confusion about nutrition and appropriate dietary choices may arise (Hornik and Kelly 2007). Secondly, growing numbers of individuals, both health professionals and lay people, have created food and nutrition blogs, websites, and videos and are using (social) media to promote books or others products, attract new clients, and build networks. These individuals may all have different interests in providing nutrition information and may introduce confusion about the concept of "healthy eating." If these food-related debates receive widespread media attention, then it is highly likely that it leaves the general public with the impression that public health nutrition communication is full of inconsistencies and that nutrition messages are contradictory, are confusing, or lack clear personal benefit. This misinterpretation fuels confusion, which may prevent consumers from adopting better eating habits (Miller et al. 2006). The challenge of nutrition centers, therefore, is to strategically position itself in this playing field and keep up with the latest food trends and hypes and appeal to the needs, expectations, and interests of the general population, without losing its trustworthiness and scientific credibility. Before designing a health message or media campaign, the Netherlands Nutrition Centre therefore always invests in becoming knowledgeable about the target audience. For this aim, the Centre conducts literature searches, surveys or interviews, focus groups, or pretests to gain insight in the target group's determinants of nutrition behavior. This helps to tailor the communication style toward the consumers' needs and expectations.

Integration of Health and Sustainability in Public Health Nutrition Communication

Sustainable dietary guidelines are more and more seen an essential part of a coherent twenty-first-century food policy. They provide an essential first policy step, a clear steer on how people should and could be eating at population level (Mason and Lang 2017). Although there is still debate about the sustainability issues to be included (beside greenhouse gas emissions and land use, Van Dooren 2018) and the implementation of new calculation methods to combine nutrition, environmental impact, affordability, and preferences (Van Dooren 2018), the main issues to be addressed are clear. Willet et al. (2019) demonstrated that a change in diet – more plant-based, with lower environmental impacts, and with halve the food waste – is necessary to feed in 2050 ten billion people with a healthy diet within the planetary boundaries. As a result, various European countries (e.g., Finland, Sweden; the Netherlands; Belgium, the UK, Estonia) and also Canada have started to integrate sustainability principles into their dietary guidelines. This approach was backed up by scientific background reports of different regional or national health authorities (e.g., Norden 2014; Health Council of the Netherlands 2011). In other countries, sustainability principles were considered but ultimately not included (Australia, the USA) (Gonzalez Fischer and Garnett 2016). The key dietary sustainability messages that emerge from evidence and dietary guidelines are, for instance, consuming a primarily plant-based diet, reducing meat consumption, and consuming seasonal field-grown fruit and vegetables (cf. Seed and Rocha 2018). At the level of the consumer, the required change in dietary intake pattern asks them to adapt their current eating behavior, both at a conscious and at a habitual and automatic level. Hence, nutrition-related messages will have to be developed in ways that guide consumers toward a healthier and more sustainable eating pattern, preferably in the context of a step-by-step approach to change decisions at the level of meals and snacks. Although it may not yet be clear what health and sustainability information has to be provided to effectively stimulate the required changes, it is crucial not to overload consumers with written information related to the food-environment issue. Instead, these strategies should combine multiple-food-related values that consumers can easily identify with and pay attention to the whole diverse range of consumers and their dietary choices (cf. de Boer et al. 2014). Altogether, there is thus a direct challenge for public health nutrition communication to increase consumer knowledge of the interplay between health and sustainability and stimulate the needed changes in intake patterns.

Future Directions

Extending National Food Consumption Surveys with the Assessment of Behavioral Determinants

In many countries, national food consumption surveys are conducted. Food consumption data give insight into the consumption of foods, the intake of macro- and micronutrients, and the development of food and nutrition trends (Ocké et al. 2005). This insight is important for formulating and evaluating food policy. In addition, these data can be used for public information purposes and scientific research. We propose to extend these consumption surveys with questions that give more insight into consumers attitudes related to nutrition, health and sustainability, as well as other behavioral determinants of food choice and intake behavior. This makes it possible to annually assess concepts such as nutrition knowledge and literacy, awareness and risk perception, attitudes, beliefs, risk perception, self-efficacy, perceived barriers, and social norms related to food consumption. The assessment and monitoring of these behavioral determinants could provide nutrition centers with further insight into the short- and long-term effectiveness of its communication efforts and help to elucidate which concepts related to nutrition, health, and sustainability should be targeted in future initiatives. Altogether, this will help to develop messages that are supported by behavioral and health communication theory and that will further encourage consumers to initiate and maintain healthy and more sustainable dietary choices.

Joining Forces Across Countries

In many countries, there are independent organizations that are responsible on the country level for nutrition and health education. In some of these countries, the development of guidelines and nutrition education happens ad hoc, for instance, by a committee of experts. To enhance learnings on nutrition education between countries, the *European Public Health Nutrition Alliance* (EPHNA) was set up in 2014. The EPHNA is a network of European Nutrition Centres, independent organizations that are responsible for nutrition and health communication on a national or regional level. To date, the network has 15 members, and it is continuously growing. The network has the support of the World Health Organization. Member countries have very similar tasks and responsibilities and share their insights and materials on themes such as nutritional guidelines and criteria for school meals. All of the organizations have many projects that inspire others and give them opportunity to learn and work together on many different levels. The EHPNA wants to expand its network and become the leading partnership on nutrition communication between European countries. Funding of cross-country structures is likely to increase efficiency in public health nutrition communication, as it will lead to all Europeans being provided with the most adequate information on nutrition. Structures like EPHNA are recommended especially for continents where not all countries have guidelines yet and where the nutrition transition is happening quickly, such as Africa and Asia.

Political Commitment for a Systems Approach to Prevent Malnutrition in All Its Forms

Malnutrition is the leading contributor to the global burden of disease (WHO 2017). Recognition of the need to address the common drivers of undernutrition, obesity, and climate change has therefore become a key focus of the Lancet Commission on Obesity. As a result, ending "malnutrition in all its forms" has become a high-profile global ambition (Swinburn et al. 2019). If we aim to prevent and reduce the current increase in malnutrition (FAO et al. 2019), then the focus must be on the food supply and improving the quality of diets while reducing total energy intake (cf. Popkin et al. 2012). This asks for evidence-based evaluated programs and policies that go beyond the individual level but also take social contexts such as public policy, industry practices, and the immediate food environment into account. Although some countries are making steady progress in tackling the issues related to malnutrition, the large majority of countries fall short in governance, policy, and program responses (WHO 2013). One potential reason for the difference in countries in terms of success is the extent to which important stakeholders within those countries are willing to act and to keep on acting to attenuate the drivers and manifestations of malnutrition. Without such a commitment, policies, programs, and resources needed to improve nutrition and generate environmental benefits are unlikely to be adopted, effectively implemented, or sustained. A systems approach, as a promising example, is a method for informing action including policy development, program design, implementation, and governance (Swinburn et al. 2019). Within this context, behavior change communication has been proposed as a necessary complement to direct changes to the food systems and environment, as it enables individuals to respond to these changes (Hawkes et al. 2013). Governments (top-down) and municipalities (bottom-up) both can play an important role in public health nutrition communication, by further implementing national food-based dietary guidelines, and implement effective preventive and interventive efforts to reduce overweight and obesity. In line with the NOURISHING framework, then, it is important to provide individuals with evidence-based nutrition information and stimulate nutrition literacy through nutrition education (Hawkes et al. 2013). Specifically, public health nutrition communication plays a crucial role in increasing public awareness about the beneficial health effects of good nutrition.

Conclusion

Since the launch of the Netherlands Nutrition Centre, eight decades ago, public health nutrition communication has seen huge progress. In the last century, nutrition science focused first at foods, then nutrients, and now back to foods and food patterns. Also, focus on health is extended with sustainability. Public health nutrition communication had to keep up with these rapid changes in nutrition science and take people through these changes. From an approach largely focused on the passive transfer of information at the individual level, the Centre moved to stimulating and motivating behavioral change communication as a complement to changes to food environments and food systems. Step-by-step food-related behavior change processes are unraveled, and trigger points for action are identified.

A key challenge in nutrition communication is to reach and engage the individuals who benefit most from better nutrition. There are huge health and lifestyle differences between socioeconomic groups, and public health communication inequalities could widen these existing differences among social classes in the adoption and maintenance of a healthful diet. Public health nutrition communication must pay close attention to such inequalities and reflect the particular needs of specific groups of individuals, resulting in communication campaigns in nutrition that are beneficial to all groups in society. This asks for a continuous evaluation of the tone of voice of communication. A further challenge is to integrate health and sustainability in public health nutrition communication. The big opportunity for nutrition communication in the next decades is to capitalize on the growing consumer interest in food and health and turn this into behavioral change. To increase the impact of nutrition communication on people's diet, a good exposure to credible and practical dietary advice is required. In today's food and media environment, with high availability and heavily advertising of unhealthy foods and opposing diet-related messages, this requirement is not always fulfilled. Finally, joining forces across countries in public health nutrition communication is relevant to speed up progress and increase impact.

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32 Sensory Responses in Nutrition and Energy Balance: Role of Texture, Taste, and Smell in Eating Behavior

Kees de Graaf

Contents

Abstract

Billions of people, almost 40% of the world's population, are either overweight or underweight, which is a direct consequence of the food environment. In more and more countries in the world, people are overweight in a large part due to the obesogenic food environment. The obesogenic food environment leads to an overconsumption of energy; it is obvious that sensory characteristics of food have a tremendous impact on food choice and intake. The chapter deals with the effects of texture, taste, and smell on intake. The effect of texture on energy intake is dramatic. Liquid and soft foods are consumed at much higher rates compared to more harder foods. The energy intake rate of energy dense liquids (like sugar

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sweetened beverages) and soft solids (like cake, sausage roll, minced meatball) is in the range of 150–450 kcal/min, quickly leading to overconsumption of energy. Liquid and soft solid calories are not well sensed by the sense of taste, due to their short oro-sensory exposure time per kcal ingested. Various recent studies show that across the food supplies in Australia, Malaysia, the Netherlands, and the USA, sweetness, umami, saltiness, and fat sensation intensities relate to concentrations of carbohydrates, protein salt, and fat in food. So, taste serves as nutrient sensing system, and this sensing system contributes to satiation. The role of smell is different. Retronasal smell sensations coming through flavors within foods do not have an impact on satiation; odors in the environment may lead to sensory specific appetites. In summary, sensory signals from foods have a large impact on energy intake, and designing foods in an optimal way leads to a higher satiating efficiency per kcal, while maintaining palatability. In this way we can make the healthy choice the happy choice.

Introduction

One of the biggest nutritional problems in the world is obesity. For a number of years, the prevalence of obesity has surpassed the issue of undernutrition. Globally, more than 820 million people remain undernourished, whereas more than 2 billion people are overweight or obese (Willett et al. 2019). The global prevalence of diabetes, which is strongly associated with obesity, doubled in the past 30 years. Prevalence of overweight and obesity varies greatly between countries with highest prevalence in the South Pacific and the USA and lowest prevalence in South Asia and sub-Saharan Africa (Abarca-Gómez et al. 2017).

Before the 1960s it was thought that obesity was a metabolic or neurobiological disorder and that the cure or prevention of obesity was a matter of medical treatment of adjusting circulating levels of appetite and satiety hormones or repairing the hypothalamus. Since the paper of Schachter in 1968 (Schachter 1968), it has becoming increasingly obvious that the food supply in the world around us plays an important role in overeating. First it was thought that only obese people were sensitive to external signals from the food environment (Schachter 1968); later it became apparent that most humans, both normal weight and overweight people, eat differently in different eating environments (e.g., Rodin 1981; Swinburn et al. 1999).

The increasing prevalence of obesity and overweight is caused by changes in the food environment resulting in modifications of eating behavior. In general for optimal health, people eat too little fruits, vegetables, legumes, nuts, whole grains, and fish, whereas they consume too much animal source products, added sugar, saturated fats, refined grains, and so-called highly processed foods (Willett et al. 2019). In the last few years, there is also an increasing attention to the consumption of so-called “ultraprocessed” foods and its association with the prevalence of obesity (Schnabel et al. 2019). The definition and usefulness of this concept are strongly debated (Gibney et al. 2017). However, in the context of this narrative, there is a strong societal pressure to decrease salt, sugar, and fat levels in foods. This makes the issue of obesity and the regulation of appetite also a sensory science issue.

Fig. 1 Two meals of 1675 kcal: the left-hand side meal is with high-energy-dense foods and the right-hand side is with low-energy dense foods. (Courtesy of The Laboratory for the Study of Human Ingestive Behavior at The Pennsylvania State University, Director: Barbara J. Rolls, PhD)

The satiety literature shows that there are dramatic differences in the satiating capacity of foods. For some foods, it is very easy to overeat, whereas from others it is much more difficult. While for some diets people may have real difficulties to ingest enough calories for energy balance, for most diets in the current food environment, it is very easy to overeat. One of the most important properties of food that is related to overeating is the energy density of foods. Figure 1 gives one picture with two meals by Barbara Rolls, Penn State University, USA. Each meal contains 1675 kcal, on the left with high-energy-dense foods and on the right with low-energy-dense foods. Almost everyone will intuitively understand that the satiating capacity of the left meal is considerably smaller than the satiating capacity of the meal on the right-hand side.

In an unprecedented series of carefully designed studies, Barbara Rolls and colleagues showed how crucial energy density is in moderating daily energy intake (e.g., Rolls 2009, for a review, and the chapter by Rolls, this Handbook on portion size). Energy density is probably the most important food characteristic that affects energy intake and energy balance, and for an overview of this work, the reader is referred to papers of the Rolls ingestive behavior lab (Rolls 2016). This chapter does not deal with energy density, but with texture, taste, and smell. However, it may be good to realize that when energy density is cut by a factor of 2, the weight and sensory exposure per kcal ingested is doubled (e.g., Bell et al. 2003).

Figure 2 shows a version of the satiety cascade of Blundell et al. (2010). In this cascade, one makes a distinction between satiation, i.e., the processes that bring a meal to an end, and satiety, the absence of hunger in between meals. From this figure it is clear that sensory and cognitive factors mainly play a role around the time of eating. Sensory factors like taste and smell are operational during eating and less so in between eating occasions. From that perspective it may be expected that sensory factors have larger role on satiation than on satiety.

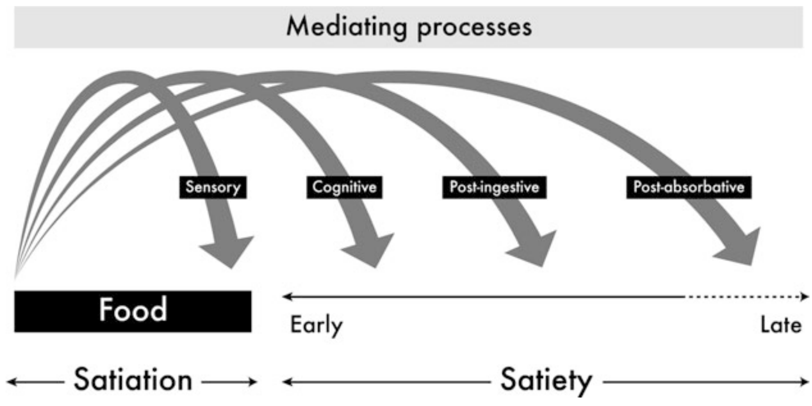

Fig. 2 Satiety cascade John Blundell, referring to different phases, influences on satiation and satiety. Satiation refers to processes that bring a meal to an end; satiety refers to the absence of hunger in between meals. Sensory, cognitive, postingestive, and postabsorptive factors refer to different physiological and psychological processes involved in eating. From this cascade, it is clear that sensory processes are mainly operational around the time of eating

This chapter deals with the role of texture, taste, and smell in food intake. First, the role of texture is discussed. There is a large body of literature that shows that texture has a dramatic impact on satiation (=meal termination), but also on satiety and subsequent energy intake compensation. The section on taste deals with the role of taste in dietary patterns across the globe, but also with its role in satiation and the regulation of food intake. Finally, the role of smell is discussed, both as a property of food and also as a characteristic of the ambient environment. The discussion is focused on what we know and do not know in this area and possible future direction of research both from a more societal perspective and from a fundamental science point of view.

Role of Texture in Food and Energy Intake

Texture and (Expected) Satiation

Texture has a strong effect on satiation, ad libitum food intake, i.e., people get a meal with plenty of food, and they can eat as much or as little as they want. By measuring ad libitum food intake, one measures satiation or meal termination (see Blundell et al. 2010). The softer a texture becomes, the more people eat. People consume more from liquids than from semisolids or solids. This was became clear for the first time from a study of Zijlstra et al. (2008), where people consumed on average about 800 g (30% more) of a liquid chocolate milk, compared to about 550 g from a semisolid chocolate custard with the same energy density, macronutrient composition, and palatability. Four years later, Hogenkamp et al. (2012) obtained a similar result with liquid and semisolid yogurts, where the intake of the liquid was about

30% higher compared to the semisolid (Hogenkamp et al. 2012). In a later study of Lasschuijt et al. (2017), it was observed that the ad libitum intake of a soft model food was about 30% higher than the intake of harder foods matched for energy density and palatability. McCrickerd et al. (2017) also showed that people consumed about 10% less from a thick porridge compared to a thin porridge with equal palatability ratings at each of two levels of energy density.

It should be acknowledged though that one needs certain differences in texture to produce differences in satiation. In the study of Zijlstra et al. (2010) with soft and harder version of three solid savory foods (luncheon meat, meat replacer, and candy), there were no differences in ad libitum intake. Apparently the differences were too small to result in changes in intake.

Hogenkamp et al. (2011) varied the texture and flavor of various dairy products, and they observed that variation in texture produced much stronger effects in expected satiation than variations in flavors. Changes in texture from liquid to more solid versions of the same product produced large differences, whereas changing the flavor from a typical fruity flavor (lemon; low-energy density) to a more creamy flavor (merengue; high-energy density) did not have an effect (Hogenkamp et al. 2011). McCrickerd et al. (2012, 2014) also showed that slightly viscous thicker drinks enhanced the expected satiety compared to slightly thinner drinks.

Texture and Satiety, Subsequent Energy Intake Compensation

Mattes was one of the first scholars to show that liquid foods have a weaker satiating capacity than solid food (Mattes 1996, and see also ▶ Chap. 33, “The Role of Eating Frequency and Snacking on Energy Intake and BMI” by Mattes, this Handbook). Later, this was confirmed again and again. A comprehensive systematic review of preload-test meal studies by Almiron-Roig et al. (2013) showed that liquid preloads lead to less energy intake compensation than semisolid or solid preloads, showing that liquids have a weak satiety effect. One of the most impressive studies in this respect is the study from Cassady et al. (2012), where subjects consumed solid and liquid preloads after which they were served an ad libitum test meal. Additionally, they were told that the preload would either be liquid or solid in the stomach. Both the real solid versus real liquid and the belief, expectation that the food would be solid in the stomach led to higher satiety rating and lower intake in a subsequent test meal (Cassady et al. 2012).

The notion that liquids and solids have different satiating effects, not only after one time but also after repeated exposure, was also elegantly shown by DiMeglio and Mattes (2000). Four weeks of consuming a liquid form of carbohydrates (soda) did not lead to energy intake compensation and led to a higher body weight, whereas 4 weeks of consumption of the same carbohydrate, but then in solid form (gel), did lead to energy intake compensation and a stable body weight (DiMeglio and Mattes 2000).

The relevance of the weak effects of liquids on satiation and satiety for nutrition and obesity is paramount. There is a large body of literature that shows that the consumption of sugar sweetened beverages leads to obesity, both from long-term experimental clinical trials (e.g., Rogers et al. 2016) and from observational prospective cohort studies (e.g., Malik et al. 2010). The Dutch Health Council is one of the first public health institutes to recommend minimizing the intake of sugar sweetened beverages, not only soft drinks but including fruit juices (Kromhout et al. 2016).

The Role of Eating Rate and Oral Processing Characteristics in Satiation and Satiety

The effects of texture on satiation and satiety are abundantly clear. One of the principle questions is the biological mechanism behind the weak satiety effects of liquid calories. The evidence suggests that eating rate has a big role in this effect. In the study of Zijlstra et al. (2008), liquid chocolate milk led to a 30% higher ad libitum consumption compared to a semisolid chocolate custard. The chocolate milk was consumed much faster than the chocolate custard. When the eating rates were made equal, this difference between the ad libitum intake of the liquid and the semisolid disappeared. In a subsequent study Hogenkamp et al. (2010) manipulated the mode of consumption, consuming liquid yogurt either with a straw (faster) or with spoon (slower). It was observed that eating liquid yogurt with a spoon led to lower eating rates and ad libitum intake than consuming the liquid yogurt with a straw, not only once but ten times in a row at breakfast (Hogenkamp et al. 2010).

The results of other studies reinforce the idea that eating rate is an essential variable in the satiating capacity of a food. Viskaal-van Dongen (2011) showed across a sample of more than 40 foods that eating rate predicted ad libitum food intake (Viskaal-van Dongen et al. 2011). A systematic review by Robinson et al. (2014) confirmed the idea that eating rate, manipulated in various ways, is positively related to energy intake.

Recently, van den Boer et al. (2017) published a paper with the eating rates of more than 250 regularly consumed Dutch foods. She observed that the energy intake rate could vary between 0 kcal for water, diet drinks, and more than 400 kcal/min for sugar sweetened beverages like apple juice and full-fat chocolate milk. Examples of solid foods with a high-energy intake rate were products like meatballs, sausage rolls, cake, and soft cookies which were consumed at rates of more than 200 kcal/min. This would imply that eating 10–15 min from such product is enough to cover the regular energy needs for a day. Table 1 gives the top ten foods and drinks in kcal/min in the Netherlands. The energy intake rate may be considered as a measure for the obesogenic capacity of a food.

Another piece of evidence in the direction that eating rate is important in the satiating capacity of foods and drinks is the notion that soup is a satiating liquid. Soup, a liquid which is normally eaten with a spoon, has a much lower eating rate than liquids that are usually drunk (Viskaal-van Dongen et al. 2011; van den Boer et al. 2017). In a study of Mattes (2005), apple soup was equally satiating to apples and much more than apple juice. The finding suggests that cognitive factor and oral processing characteristic play a role in this effect. Extensive studies by Forde et al. (2013, 2017, see also ► Chap. 35, “The Impact of Eating Rate on Energy Intake,

Table 1 The top ten beverages and solid foods in the Netherlands in terms of energy intake rate (=kcal/min). (Source: van den Boer 2017)

	kcal/min
Liquids	
1. Full-fat chocolate milk	471
2. Breakfast fruit drink	330
3. Apple juice	297
4. Semi-skimmed chocolate milk	249
5. Freshly squeezed orange juice	240
6. Pasteurized orange juice	232
7. Whole fat milk	230
8. Yogurt drink	190
9. Skimmed milk	188
10. Breakfast drink with grains	161
Solids	
1. Sausage roll	182
2. Syrup waffle	164
3. Minced meatball	156
4. Cake without butter	152
5. Cake wrapped in marzipan and chocolate	145
6. Almond paste-filled tarts	142
7. Iced cupcakes	136
8. Apple turnover with puff pastry	132
9. Dairy soft cheese spread on whole wheat bread	131
10. Fromage frais half fat with fruit	131

Body Composition, and Health" by Forde's, this Handbook) for European and Asian foods suggested that oral processing characteristics like time of food in the mouth and number of chews per gram/kcal were positively correlated with measures of expected satiety/satiation. A recently comprehensive published systematic meta-analysis of Krop et al. (2018), on oral processing and appetite and food intake, confirmed that the number of chews and longer time of food in the mouth leads to earlier satiation. The oro-sensory exposure time of food in the mouth is directly and linearly related to the duration of the exposure to taste. The role of taste exposure in satiation is discussed in the next section of taste.

Role of Taste in Food, Energy Intake, and Weight Status

Taste Space of the Food Supply

In the last 5 years, three groups worked independently on the taste profile of whole diets, one in Australia (Lease et al. 2016), one in France (Martin et al. 2014), and one in the Netherlands/Malaysia (Teo et al. 2018). They did this by profiling hundreds of commonly consumed foods that were more or less representative for the consumption patterns in these countries. Figure 3 shows the results on the taste space in three dimensions from the study of Martin et al. (2014) in France. The studies in the Netherlands and Australia yielded similar taste configurations.

From Fig. 3, it is clear that the main taste distinction across the food supply is the sweet-savory/salty dimension. The fat sensation (not fat taste, see below) dimension is orthogonal on the sweet-savory/salty dimension, indicating that both sweet and savory/salty can be easily combined with fat sensation. Bitter-sour tastes are more articulated in the third dimension.

As the legend of Fig. 3 shows, the grouping of foods into taste clusters in the French database yielded (1) savory/salty/fatty, (2) sweet, (3) sweet/sour/bitter, (4) bitter, (5) salty/umami/sour/bitter (condiments, sauces), and (6) salty foods/drinks. In comparison, Teo et al. (2018) in the Netherlands also got six taste clusters, (1) neutral, (2) sweet/sour, (3) sweet/fat, (4) savory/salty/fatty, (5) bitter, and (6) fatty. The difference between the two clusters may come through the way of data collection. Martin et al. (2014) used foods as consumed in the home of consumers (bread with spread, rice with sauce); Teo et al. (2018a) mainly profiled single frequently consumed foods (e.g., bread without spread; rice without sauce) that encompassed >80% of the regular energy intake in the Netherlands. The Dutch taste database included a category of frequently used butters/margarines, which make up the fatty cluster.

Taste as a Nutrient-Sensing System

In textbooks, the taste systems referred to as a nutrient-sensing system. Sweet signals the presence of energy/carbohydrates in foods, salt intensity represents sodium concentrations, umami may be related to the protein content of food, and sour and bitter relate to the PH and the concentration of potentially toxic substances. Since a number of years, it is also clear that free fatty acids have a taste signalling function (Keast and Costanzo 2015; Running et al. 2015), not to be confused with the fatty, smoothing mouthfeel properties of triglycerides.

The three groups that constructed the taste databases also investigated the relationships between the taste intensity and nutrient concentrations within more or less representative food supplies in various countries, i.e., Australia (Lease et al. 2016), the Netherlands and Malaysia (Teo et al. 2018a), France (Martin and Issanchou 2019), and the USA (van Langeveld et al. 2017). Table 2 summarizes some of the correlation coefficients as found in these studies. This Table shows that sweetness intensity does *not* signal the energy content of foods, but it does correlate with the carbohydrate content across the food supply. As hypothesized, umami intensity relates to the protein content, salt intensity relates to the sodium concentration, and fattiness/fatty mouthfeel (not fat taste) is associated with the fat content of food. As one might expect, this is not a one-to-one relationship but a fuzzy association that depends on the structure of foods, the presence of taste, and other confounding factors. However, these data do confirm that taste intensity is related to the nutrient content in representative food supplies across the world.

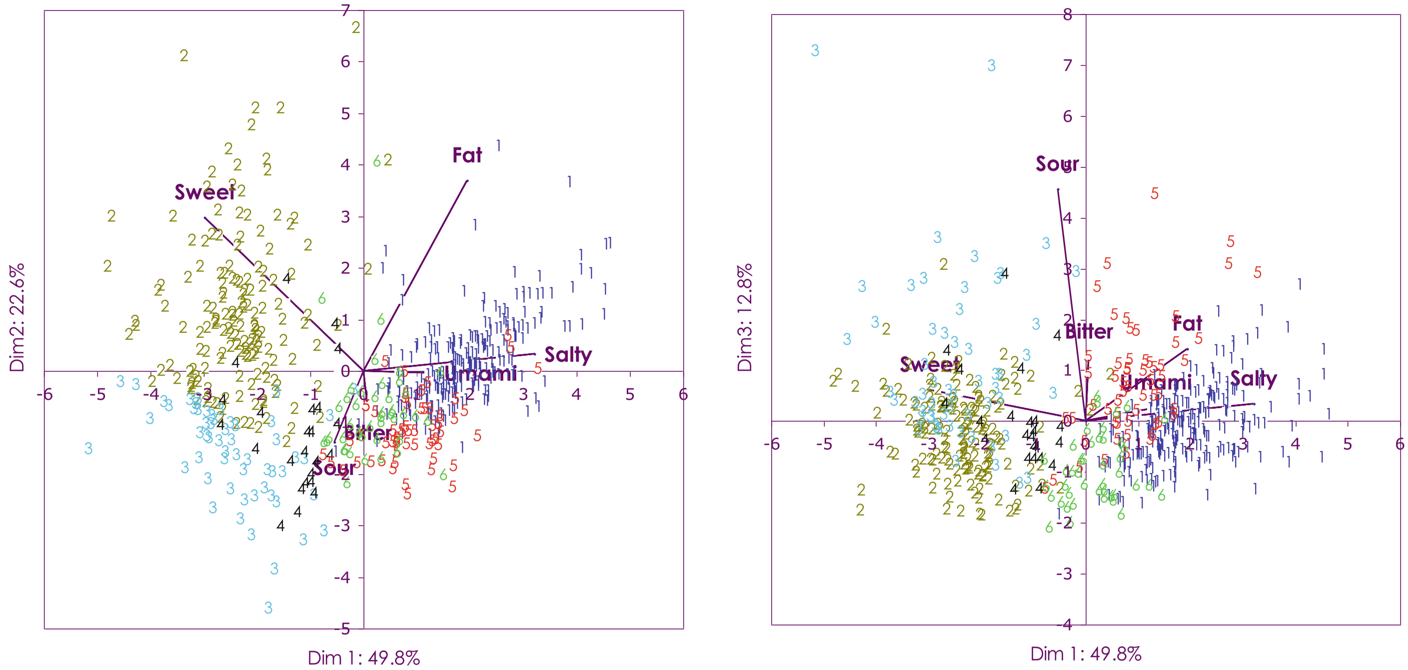

Fig. 3 Biplot representations from covariance PCA of 590 food means (planes 1–2 and 1–3). Twelve trained panelists rated at least 75 food items per month for a period of 8 months. The numbers in the figures refer to six different taste clusters: 1, more salty/umami/fatty and less sour/bitter/sweet foods, compared to the average; 2, sweeter than the average and less intense for other tastes; 3, sweeter than average foods, which, unlike the food in Class 2, were also more bitter and sour than average; 4, mainly bitter; 5, more intense saltiness, umami, sourness, and bitterness than average; and 6, salty foods. (Source: Martin et al. 2014)

Table 2 Correlation of taste intensity with nutrient concentrations in various representative food – databases across the world. (Source: Lease et al. 2016; Van Langeveld et al. 2017; Teo et al. 2018b; Martin and Issanchou 2019)

	N foods	Sweet – energy	Sweet – CHO	Umami – PRO	Salt – sodium	Fat sensation – fat
Australia	377	−08	41	27	64	65
USA	237	11	42	n.a.	72	n.a.
Netherlands	489	11	54	54	69	75
Malay	423	04	33	51	52	42
France	≈350	−11	57	62	77	72

Taste Patterns, Preferences and Energy Intake, and Weight Status

Following up on the previous paragraphs, one might expect that a substantial part of our energy intake comes from foods with a dominant sweet, salty, savory taste, and/or a fatty mouthfeel. This is indeed what van Langeveld et al. (2018) and Teo et al. (2018) showed in an analysis of taste consumption patterns in the Netherlands and Malaysia. They observed that more than 50% of the energy intake comes from sweet, savory, and fatty tasting foods, both in the Netherlands and in Malaysia.

One of the popular narratives in the public health debate is that consuming (too much) sugar/sweetness makes you fat. One should lower the sweetness/sugar levels in foods, as this will lead to a lower sweetness preference, a lower sugar intake, a lower energy intake, and in the end a lower body weight. The idea of the adjustment of taste preferences to exposure levels comes from the early work with salt by Bertino, Beauchamp, and colleagues in 1980s, who showed that the long-term exposure to a low-salt diet leads to lower optimal levels of salt in foods (Bertino et al. 1982, 1986). However, it is questionable whether or not this also applies to sweetness. In a recently published study from Wise et al. (2015), one experimental group was exposed to a low sweetness/sugar diet for a period of 4 months. The results showed that optimal preferred sweetness levels did not change (Wise et al. 2015). A similar conclusion was reached by a systematic review/meta-analysis of Appleton et al. (2018) on the effect of repeated exposure to sweetness on generalized preferences for sweetness. This field needs further attention.

Another narrative is the sweet tooth hypothesis for obesity. Sweetness signals energy; obese people consume more energy, which is caused by a higher consumption of sweet foods, driven by a higher preference for sweet foods compared to normal weight people. The results in Table 2 show that sweetness does *not* signal energy. Saltiness and fattiness have much higher correlations with the energy content than sweetness (Lease et al. 2016; Teo et al. 2018b; Martin and Issanchou 2019).

The idea that obese people have higher preferences for sweet foods or higher sweetness levels in food is also a myth. Already from the early 1980s onward, there have been studies showing that preferences for sweetness are similar for obese and normal weight people (e.g., Frijters and Rasmussen-Conrad 1982; Alexy et al. 2011; Hill et al. 2009; Bobowski and Mennella 2017; Deglaire et al. 2015). A recent study of van Langeveld et al. (2018) demonstrated that overweight and obese people also do not consume more sweet tasting foods than normal weight people.

With respect to taste preferences, taste intake patterns, and obesity, there is more evidence for a heightened liking and intake for savory, salt, fatty foods than for sweet. The narrative review of Cox et al. (2016) suggests that there is some evidence for a heightened fat preference in overweight and obese people compared to normal weight people. This finding is in line with the work of Deglaire et al. (2015) which showed that French obese/overweight people have higher preferences for salty/savory/fatty foods. This is also congruent with the findings from Van Langeveld et al. (2018), who observed that Dutch overweight/obese people have a tendency to consume more salty/savory fatty food compared to normal weight people.

The Role of Oro-sensory Exposure Time to Taste in Satiation

From the studies cited under the section of texture, the eating rate and oral processing characteristics like time of food in the mouth, chews/per gram, or kcal of food have a strong effect on satiation and food intake. Holding food in the mouth for longer time or chewing more leads to lower intakes (e.g., Zijlstra et al. 2009). One pertinent question in this discussion is what type of signalling is responsible for this earlier satiation.

Two studies (Weijzen et al. 2009; Bolhuis et al. 2011) looked at satiation as an effect of oro-sensory stimulation with taste while keeping eating rate constant. Weijzen et al. (2009) did a study with sweet lemonades, and Bolhuis et al. (2011) did a study with salty tasting tomato juice. Figure 4 summarizes the results of these

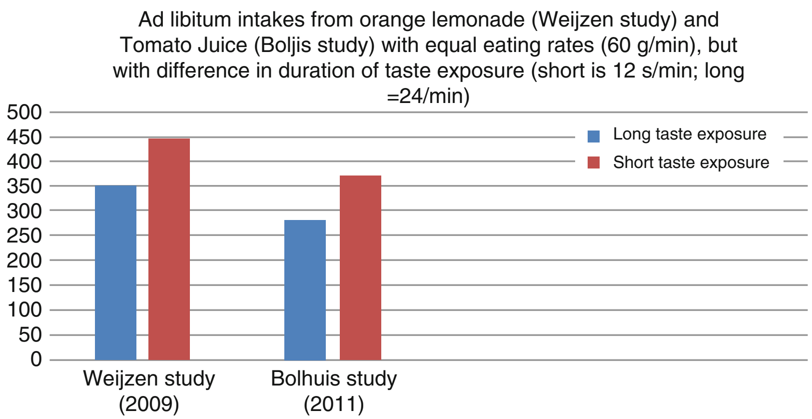

Fig. 4 Average ad libitum food intakes (=satiation) from orange lemonade in the study of Weijzen et al. (2009) and tomato juice in the study of Bolhuis et al. (2011). In both studies the eating rate was constant, and the only factor that was manipulated was the oro-sensory exposure to taste. This was done by varying the sip size through peristaltic pumps. Small size leads to higher exposure times and a lower intake

studies. In both studies ingestion rate was constant, implying that it was only the exposure to taste that was different. In both studies ad libitum intakes (satiation) decreased around 30%, while the exposure duration to taste increased with a factor of 2. The results of these two studies indicate that taste exposure may be strongly involved in meal termination.

Role of Smell in Food and Energy Intake

Smell may effect food pleasantness and consequently choice and intake through two routes, orthonasal stimulation and retronasal stimulation. Orthonasal stimulation reflects smelling foods from the ambient environment, whereas retronasal stimulation reflects aroma perception during eating and swallowing the foods (Buettner et al. 2001). Small et al. (2005) showed that signals from ortho- and retronasal odors are processed by the brain in a different way, i.e., the perceptual processing is different. Retronasally odors are perceived on the tongue and in every language denoted as "tastes," e.g., chocolate taste and strawberry taste (Murphy et al. 1977). In this perspective odors are both perceived from within the body and from outside the body in the environment.

As is discussed above, increasing or prolonging taste stimulation leads to earlier satiation. In a number of studies, a similar idea was tested for retronasal smell stimulation. Is it possible to lower ad libitum food intake through a higher/longer exposure to odor substances? This idea was worked out by Ruijschop in a series of technically advanced studies. However, none of the studies about increasing retronasal aroma stimulation led to a decrease in ad libitum food intake (Ruijschop et al. 2008, 2009; Ramaekers et al. 2014a). In the study of McCrickerd et al. (2014), the addition of a creamy flavor did not also affect satiety. This notion concurs with the notion of Hogenkamp et al. (2012) that flavor as part of the food and perceived retronasally does not affect satiation.

On the other hand, orthonasal odor stimulation coming from the ambient environment may lead to an increase in appetite. Several studies showed that ambient odors lead to an increased appetite which is specific to the food that the odor is cuing (Fedoroff et al. 2003; Ramaekers et al. 2014b; Zoon et al. 2016). For example, smelling banana increases the appetite for banana, but also for other sweet foods. Smelling tomato soup increases the appetite for tomato soup, but also for other savory food. This effect is called sensory-specific appetite, and it is a mirror of the well-known sensory-specific satiety effect (Rolls et al. 1981).

Ramaekers et al. (2014b) showed that the effect of odor on appetite does not only occur immediately after exposure but continues for at least 20 min under the condition that the food is not eaten. This effect is produced by active and passive smelling (Ramaekers et al. 2014c) and occurs rapidly when switching from one odor to the next (Ramaekers et al. 2016).

Although the effect of ambient odor stimulation on specific appetite is clear, the effects on actual food choice are more ambiguous. Zoon et al. (2014) did not find an effect of clearly detectable odors on food choice. Three French studies from the laboratory in Dijon demonstrated that ambient exposure to ambient fruity odors below threshold level increased the choice for fruit in a subsequent lunch (Gaillet et al. 2013; Gaillet-Torrent et al. 2014; Chambaron et al. 2015). However, a later study by Mors et al. (2018) failed to find an effect of subthreshold bread and cucumber odor on subsequent choice at lunch.

Although in general there is a positive relationship between appetite rating and actual subsequent food intake (de Graaf 1993), this is not always the case (Mattes 1990). With respect to the effects of ambient odors on the amount that people eat, there are mixed results. Zoon et al. (2014) found no effects on the amount eaten, Fedoroff et al. (1997) found only an effect in restrained eaters, and, surprisingly, Coelho et al. (2009) observed a decrease in food intake, also only in restrained eaters. However, in a recent study by Proserpio et al. (2019) with obese women, it was found that intake of a vegetable soup at lunch was substantially increased (466 g vs. 369 g) after exposure to a bread odor compared to a no-odor condition.

Summarizing the role of smell on food intake, it is clear that smell plays a role. Odors in foods, perceived retronasally, have a dramatic effect on palatability and therefore will also effect intake. Retronasal odors have a small role in satiation. The role of ambient odors is clearly different; they may attract attention to a food, eliciting sensory-specific appetite. However, it is not entirely clear under what circumstances ambient odors affect food choice and intake. Do the odors need to be consciously be perceived or not? does it only work when people are hungry? does it only work for some people (e.g., obese) and not for others (normal weight, restrained eaters)? All these questions need answers, before we can apply this knowledge to improve healthy food choices.

Discussion

Sensory science forms the bridge between food and health, as sensory signals from food determine to a large extent what is eaten and how much is eaten. The texture and taste of food play a major role in satiety and food intake. Harder textures that lead to lower eating rates may contribute to a less obesogenic food environment. The measure kcal/min may be a good measure for the obesogenic capacity of a food. Taste stimulation, for a large part determined by texture and eating rate, has an essential role in signalling satiation. This point of view is in line with the idea that the taste system senses nutrient concentrations in foods. The sense of smell mainly plays a role as a priming agent in the environment; its role in food choice and intake is an important research area in the future.

The role of food texture in nutritional issues is important, as it is clear that sugar sweetened beverages have an important contribution to the high prevalence of overweight and obesity across the world. The basic and most plausible biological explanation for this fact is that calories from liquids are not well sensed by the sense of taste, and therefore we do not compensate for the ingested liquid calories.

This observation gives rise to two other questions. The energy from sugar sweetened beverages is not well sensed with little subsequent energy intake compensation. How is that with the energy coming from solid sugars? Are they sent accurately and compensated for later onward? Does a high intake of solid sugars lead to overconsumption of energy? Results from meta-analyses (Te Morenga et al. 2013) are clearer on sugars in liquid form than in solid form. The role of solid sugars in energy intake and long-term energy balance is one of the most pressing nutritional issues of today. In this respect we need carefully controlled randomized trials.

Another question is whether the lack of sensing from sugar sweetened beverages also applies to other liquid calories. Soup is a satiating liquid, probable due to its lower eating rate and higher oro-sensory exposure time compared to liquids that are drunk. The question is whether liquid from not-sweet beverages are also not sensed. One issue in this respect is that in the normal food supply, most liquid calories taste sweet, and there are relatively few sources from non-sweet calories in a liquid form.

The non-sensing of liquid calories compared to solid calories is also a fundamental question from a neuroendocrinological perspective. The nucleus tractus solitarius is the first relay station of the taste system on its way to the thalamus and other parts of the brain. The NTS is also the part where satiation is determined and which receives input from vagal afferent from the GI tract. It would be interesting to look at the neurobiological consequences of liquid and solid food intake.

The central role of eating rate in the satiating capacity of food and satiation is obvious and reproducible from short-term intake studies. One of the challenges is to investigate whether a slowing down of the overall energy intake rate of the whole diet leads to reductions of energy intake and long-term energy balance. This challenge also requires long-term well-controlled nutrition intervention studies.

With respect to sweetness, there are still a number of pressing questions on the table. Is it possible to change to generalized preference for sweetness, or is the inborn liking for sweetness stable and not subject to change? Various studies have shown that sweetness preferences decline from early childhood to adulthood (Bobowski and Mennella 2016; de Graaf and Zandstra 1999; Zandstra and de Graaf 1998). However, sweetness preferences in adults seem less likely to change (Wise et al. 2015; Liem and de Graaf 2004). The review of Appleton et al. (2018) discusses the need for long-term intervention studies in this context.

Overall, it is clear that sensory responses play a big role in nutrition behavior. There are still numerous questions to be answered, and answering these questions may help to create a healthy food environment that tastes good.

Conclusion

Obesity is one of the most pressing nutritional problems in the world today, due the obesogenic food environment which induces the overconsumption of energy. Sensory characteristics of food play a paramount role in energy intake. Soft and fluid textures with a high energy density easily lead to overconsumption. Food design may be used to develop products with a high satiating capacity per kcal. This may help to limit intake while maintaining palatability.

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The Role of Eating Frequency and Snacking on Energy Intake and BMI

33

Stephanie R. Hunter and Richard D. Mattes

Contents

Abstract

Eating frequency and the prevalence of snacking in particular have increased in Western nations over the past 35 years. There is strong epidemiological evidence that there is a positive association between eating frequency and energy intake. However, whether this translates to an increase in BMI is less clear. With adjustment for underreporting, a major confounder in eating frequency outcomes, the sometimes reported negative association between eating frequency and BMI, is often reversed. Snacks are most problematic when they are unplanned and evoke weak compensation, contributing to increased energy intake. Mechanisms that contribute to this include a weak satiation/satiety effect, distracted eating, low

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thermogenic (heat production) response, and disrupted biological cycles. Although snacks are commonly energy dense, this attribute alone does not make them more problematic, as fruits and vegetables as snacks can also increase total energy intake. Thus, problems with snacks do not necessarily stem from the food themselves but rather how they are incorporated into a diet. Snacking as part of an energy balanced diet can help manage short time intervals allotted to eating, contribute positively to the nutrient quality of the diet, and may moderate blood sugar and metabolic disease risk factors.

Introduction

Total energy intake is a product of portion size and eating frequency. Theoretically, there is an inverse relationship between these variables that permit stability of energy intake, and if that balance matches energy need, body weight would remain stable. However, the high prevalence of overweight and obesity indicates the expected reciprocity does not hold for approximately two-thirds of the US adult and one-third of the global adult populations, and the prevalence is rising rapidly for children and adolescents (Malik et al. 2013b; Ng et al. 2014). There is considerable evidence that portion sizes have increased in Western populations, and this has been linked to positive energy balance and weight gain (Mattes 2014). Less attention has been focused on eating frequency, but its contribution to overweight and obesity may be as great, if not greater than the changes of portion size. Nationally representative data from the National Health and Nutrition Examination Surveys (NHANES) in 2009–2010 reveal that while energy from meals increased by 63 and 112 kcal/day in males and females, respectively, energy from snacks increased more: by 132 and 142 kcal/day in males and females, respectively, in the past 40 years (Kant and Graubard 2015). While most research on snacking is in the United States and Europe, snacking is prevalent globally. For example, in the United States, 97% of adults, 83% of adolescents, and 98% of children snack; in the United Kingdom, 84% of women and 75% of men snack (O'Connor et al. 2015); in China, about 73% of adults and 46.3–58.8% of children and adolescents snack (Wang et al. 2012); in Mexico, 73.2–79.4% of children and adolescents snack, while 66.5–74.5% of adults snack (Duffey et al. 2014); and in Brazil, 78.7% of adolescents and 72.2–74.8% of adults snack (Duffey et al. 2013). Thus, snacking is an important area to target for reduction of energy intake to control overweight and obesity.

Eating frequency and snacking are not synonymous as people skip meals, but snacking generally leads to increased eating frequency (Mattes 2018). American adults report about 4.96 eating episodes per day (Kant 2018). European countries report eating frequencies between 4.9 and 7 occasions per day (Huseinovic et al. 2016). Adults in China report less than 1 snack per day (Wang et al. 2012). Adults in Mexico report 1.9–2.1 snacks per day (Duffey et al. 2014). Adults in Brazil report 1.4 snacks per day (Duffey et al. 2013). Adults in Finland consume an average of 3.6 snacks per day, but range from 1 to 12 (Ovaskainen et al. 2010). Over the past 35 years, energy intake from snacks increased from 300 to 526 kcal per day in US adolescents. Adult men and women in the United States consume about 421 and

586 kcal per day from snacks (Mattes 2014), while adults in Mexico consume 207–336 kcal per day from snacks (Duffey et al. 2014), and adults who are light (one to two snacks/day) and heavy (three or more snacks/day) snackers in Brazil consume 342–894 kcal per day from snacks (Duffey et al. 2013). About 9% of the US population consumes more than 50% of their daily energy from snacks (Kant and Graubard 2015), while in Finland, 25% of adults consume a greater proportion of their total daily energy intake from snacks than meals (Ovaskainen et al. 2010), and in the Mediterranean countries and Canada, snacks contribute more energy than breakfast (Huseinovic et al. 2016; Larson and Story 2013). Overall, in Western nations, snacking contributes about 15–30% of daily energy intake (Mattes 2018); daily energy intake from snacks is also high in Mexico (16.7%) (Duffey et al. 2014), Nordic countries (29%) (Huseinovic et al. 2016), Central European countries (31%) (Huseinovic et al. 2016), the Middle East (20%) (Ng et al. 2011), and Brazil (19.6%) (Duffey et al. 2013), but in China, snacking contributes only 4% of energy intake in adults (Wang et al. 2012). However, there has been a dramatic increase in snacking since 2004 in China that, along with other developing countries, is expected to undergo future growth (Nielsen 2014).

Two major problems in the literature that limit confidence in measuring eating frequency outcomes are underreporting and defining snacking behaviors. Often consumers, especially those with overweight or obesity, underreport energy intake on questionnaires (Mattes 2018). This may be especially true for snacks compared to meals. For example, in one tightly controlled trial in women with overweight or obesity who were provided ad libitum access to meals and snacks in a metabolic facility for 24 h, energy derived from snacks was disproportionately underreported compared to energy from meals and was correlated with underreporting of total energy intake (Poppitt et al. 1998b). Participants omitted about 400 kcal of energy intake from snacks.

Different definitions of meals and snacks can also lead to mis- or underreporting (Leech et al. 2018). Common definitions of snacks include consideration of: time of day, amount of energy consumed, eating alone, short eating periods, standing while eating, nutrition quality, and type of food (Hess et al. 2016). The most common terminology is that "snacks" are "ingestive events (food or beverage) that occur between meals" (Hess et al. 2016). However, the lack of a definition of meals hampers application of this definition. Because different definitions can lead to varying results, the role of eating frequency in both energy intake and BMI and mechanisms for the associations will be reviewed. Because the overwhelming majority of the population chooses to snack, it is assumed this behavior is not easily eliminated so must be addressed by other means. Thus, this review will focus on snack choices, determinants of increased snacking, and the negative and positive facets of snacking.

Eating Frequency and Energy Intake: Review of Literature

Epidemiological data reveal that increased eating frequency results in increased energy intake (Zhu and Hollis 2016; Wang et al. 2016; Kerver et al. 2006; Kim and Kim 2010; Bachman et al. 2011; Edelstein et al. 1992). NHANES data reveal that both adolescents and adults who snack four or more times per day consumed 1.5 times more energy than those who did not snack (Sebastian et al. 2011; Sebastian et al. 2010). Forty-year trends in NHANES data reveal energy from snacking increased by 3% and 5% in males and females, respectively (Kant and Graubard 2015). This increase was not fully offset by a reduction in meal energy intake. Additionally, men and women who consumed two or more snacks in addition to three meals consumed significantly more energy than those who consumed one or no snacks (Hampl et al. 2003). Light (one to two snacks/day) and heavy (three or more snacks/day) snackers in Brazil consume significantly more energy per day (381 and 786 kcal/day) than those who do not snack (Duffey et al. 2013). Overall, epidemiological and observational data from the United States and Brazil provide strong evidence of a direct relationship between eating frequency and energy intake.

Some clinical trials report increased energy intake from increased eating frequency. This holds across the life cycle and in individuals who are lean or have obesity (Toschke et al. 2012; Berteus Forslund et al. 2005). Still, this evidence base is not uniform. Other studies observed no increase in energy intake with increased eating frequency (Taylor and Garrow 2001; Johnstone et al. 2000). However, many trials are of less than 1 day in duration, and the validity of extrapolating findings to the longer-term, nutritionally meaningful (months to years) intake is uncertain. Additionally, clinical trials often entail controls that reduce their ecological validity and recruit limited sample sizes which undermine conclusions relating eating frequency to energy intake (Johnstone et al. 2000; Allirot et al. 2013).

Additional evidence supporting a role for eating frequency in increasing energy intake is its purposeful use in clinical cases to increase body weight. Clinical nutrition guidelines recommend small frequent meals (6–10 meals) for patients with early satiety, anorexia, and gastrointestinal symptoms (Dashti and Mogensen 2017). Malnourished patients who consumed three meals and two snacks increased their energy intake by 600 kcal/day (Kruizenga et al. 2005), and snacking in nutritionally at-risk older adults increases energy intake (Zizza et al. 2007). In these populations, weight gain is warranted and improves health.

Eating Frequency and BMI

The contribution of eating frequency to BMI is unclear. In a study of Seventh Day Adventists (a relatively healthy population that refrains from smoking, infrequently consumes alcohol, and largely follows a vegetarian diet in the United States and Canada), those who ate more than three times per day had a significantly higher BMI compared to those who ate three times per day (Kahleova et al. 2017). Those who ate only one or two times per day had a lower BMI compared to those who ate three times per day. Further, men in the Health Professionals Follow-Up Study, a sample of 20,064 health professional males aged 40–75 in the United States from 1992 through 2002, had a higher risk of weight gain with increased eating frequency (van der Heijden et al. 2007). In a similar study, Swedish men and women with obesity had higher eating frequency and energy intake than normal weight men and women

(Berteus Forslund et al. 2005). Surprisingly, many studies report increased eating frequency and energy intake, but no change (Sebastian et al. 2011) or decreased BMI in adults (Zhu and Hollis 2016) and adolescents (House et al. 2015). Interestingly, breakfast skipping, which may lower eating frequency, is associated with obesity and higher BMI. The question is how this apparent inconsistency (i.e., higher energy intake without higher body weight) can be reconciled.

Epidemiological evidence is notoriously biased by underreporting. When underreporting is considered, negative associations between eating frequency and BMI are often reversed. This has been observed for males and females in NHANES data as well as The Continuing Survey of Food Intakes by Individuals in America (CSFII) data (another nationally representative sample of the United States population (McCrory and Campbell 2011)). In the National Diet and Nutrition Survey in British adults, where eating frequency was negatively associated with BMI, men and women who were overweight underreported energy intake by 27% and 31%, respectively. When participants with implausible energy intakes were excluded from the analysis, there was a positive association between eating frequency and BMI (Murakami and Livingstone 2014). Another explanation is that individuals with overweight or obesity may actually reduce eating frequency to decrease their energy intake to control their weight (Wing and Hill 2001). This results in an erroneous conclusion that reduced eating frequency is associated with high BMI, while the association is actually due to reverse causality.

Clinical trials assessing the role of eating frequency on body weight also have limitations (Hutchison and Heilbronn 2016). Most notably, they are often short term (8 weeks or less) so lack the power required to ascertain a sustainable effect of eating frequency on BMI (Hutchison and Heilbronn 2016). Longer-term trials (greater than 12 weeks) have reported no change in BMI or energy intake (Huseinovic et al. 2013).

Taken together, there is evidence that high eating frequency and snacking is prevalent around the world and that increased eating frequency results in greater energy intake in Western nations, but the evidence this leads to increased BMI is less clear. The expected association is often only noted after correction for underreporting.

Mechanisms for Positive Associations Between Eating Frequency and Energy Intake

Planned Eating

While children (Birch et al. 1991) and adults (McKiernan et al. 2008) are capable of compensating for energy from snacks, it is often not practiced. Compensation largely depends upon whether the snack is planned. Weight loss studies have shown that when the number of eating occasions is planned and there is a fixed energy intake, increased eating frequency will not lead to weight gain (Bachman and Raynor 2012; Cameron et al. 2010). In France, the mid-afternoon eating occasion called the goûter is eaten by most children and adolescents as well as some adults (Chapelot et al. 2004). When compared directly, goûter consumers requested dinner later and consumed less energy than non-goûter consumers, whether the non-goûter group consumed a mid-afternoon snack or not (Chapelot et al. 2004). Another study in lean and obese adults found that those who regularly consumed snacks prior to the research study compensated better for the supplemented snacks of low or high energy or no snack than did participants who were not habitual snack consumers (Whybrow et al. 2007). Thus, when an extra eating occasion is planned or is part of a routine, strong energy compensation may occur. In contrast, compensation commonly does not occur in pre-load (Rolls et al. 1991) or short-term (Chapelot 2011) studies. A theoretical model proposed by McCrory and Campbell suggests that when energy intake is not monitored, there is an increased risk of appetite dysregulation and weight gain especially when eating frequency exceeds six times per day (McCrory and Campbell 2011).

Weak Satiation/Satiety

Snacking may be uncompensated due to lowered feelings of satiety after such an eating occasion. A larger eating occasion results in a lower reported nadir in hunger and desire to eat, and a higher peak in fullness, which determines the time until an appetite sensation of sufficient magnitude is experienced to motivate a new eating occasion. Snacks lead to smaller changes in appetite than meals if they are defined as having lower energy content (Bellisle et al. 2003). Students in France who self-defined meals and snacks reported higher energy intake at meals and rated feelings of hunger and thirst as more intense before meals but less intense after meals compared to snacks (Bellisle et al. 2003). However, when energy intake is the same, subjects consumed less energy at a load 20 min later when they perceived the eating occasion as meal foods compared to snack foods (Capaldi et al. 2006). However, energy intake was not different 3 h later. When daily energy intake is controlled, increased eating frequency does not have as large an effect on appetite. Normal weight participants who consumed one meal reported lower hunger, desire to eat, and overall composite appetite ratings, calculated as the mean of hunger, desire to eat, and inverse of fullness ratings, over a 4-h period compared to when the participants consumed the same meal as two eating occasions in a 4-h period, although there was no difference during the final hour of testing (Perrigue et al. 2016). Another study in men who were overweight or had obesity reported lower levels of fullness over the day with six versus three isocaloric eating occasions (Leidy et al. 2010). However, the literature is not conclusive, and other studies have reported higher eating frequency to suppress hunger and energy intake (Speechly et al. 1999). Resolution of this issue may require factoring in the definition of snacks.

Gut Peptides, Glucose, and Insulin

Gut peptide release and gastric emptying are sometimes used as "objective" biological indices of appetitive sensations, although the degree to which they determine or are even associated with appetite, energy intake, or BMI is debated. Obese adults consuming three or six meals a day in a hypocaloric feeding study for 8 weeks did not report differences in hunger, fullness, or have different ghrelin or PYY concentrations between groups (Cameron et al. 2010; Leidy and Campbell 2011). However, equi-energetic feeding regimens composed of 2 or 12 eating occasions per day revealed greater fluctuations in glucose, insulin, and ghrelin during the 2 compared to the 12 eating occasion patterns in a day (Solomon et al. 2008). The 12 eating occasions per day, identified as a nibbling eating pattern, resulted in stable plasma insulin and ghrelin concentrations. However, this could be problematic. If a drop in insulin or a rise in ghrelin is a signal that drives ingestive behavior, then eating frequently essentially eliminates the signal, possibly desensitizing those with high eating frequencies to endocrine signaling systems that drive ingestive behavior. Subjects who consumed isoenergetic meals hourly for 6 h compared to subjects who consumed two isoenergetic meals 3 h apart had a delayed onset of gastric emptying, but there were no differences in overall gastric emptying rate nor differences in subjective measures of appetite (Jackson et al. 2007). However, the results of these studies must be interpreted with caution as meal patterns were fixed, and it is not clear how findings from such controlled studies hold under more naturalistic eating conditions.

Distracted Eating

Distracted eating occurs when the consumer is eating, often where portion size is not fixed, while engaged in some other activity (e.g., eating from a large bag of food while watching television). As a result, they may lose track of what and/or how much they have ingested so cannot use this knowledge to adjust subsequent intake. Distracted eating can lead to increased energy intake later in the day (Hess et al. 2016). Undergraduate women who consumed a fixed lunch while watching television ate significantly more cookies as an afternoon snack compared to undergrad women who consumed the same lunch without distraction (Higgs and Woodward 2009). Subjects who consumed a standardized lunch while playing a computer game reported feeling less full immediately after lunch, had a less accurate recall of lunch foods, and consumed more biscuits at a taste test 30 min after lunch compared to subjects who were not distracted while eating the same lunch at the same rate (Oldham-Cooper et al. 2011). However, most of these results are from adults 20–47 years old with healthy BMIs (Robinson et al. 2013). Thus, assessment of more heterogeneous populations is needed to validate these findings. More representative data are available through the American Time Use Survey. Americans spent an average of 64 min a day eating and drinking as a primary activity, lower than 30 years ago, and 16 min a day eating as a secondary activity (Zick et al. 2011). Another 57 min a day for males and 69 min a day for females were spent drinking anything other than water as a secondary activity, and this is positively associated with BMI.

Thermogenesis

A number of trials reveal increased eating frequency decreases diet-induced thermogenesis, defined as the increase in energy expenditure above basal fasting levels divided by the energy content of the food ingested (Westerterp 2004). The idea is that a decrease in diet-induced thermogenesis would result in more efficient use of energy in the body resulting in positive energy balance and weight gain. Normal weight men who consumed breakfast as four isocaloric eating occasions 60 min apart had lower diet-induced thermogenesis compared to when breakfast was consumed as one isocaloric eating occasion (Allirot et al. 2013). This has also been reported elsewhere (Nacht et al. 1986; Tai et al. 1991). However, this is not observed in all studies (Smeets and Westerterp-Plantenga 2008; Belko et al. 1987; Molnar 1992; LeBlanc et al. 1993). Overweight women tested in a metabolic chamber who consumed two, four, or six meals per day at designated times had no difference in total energy expenditure nor energy balance (Taylor and Garrow 2001). Notably, unplanned eating events may exert a weak thermogenic response. In one trial, lean healthy women consumed similar diets but as six eating occasions per day (regular meal pattern), or varying between three and nine meals per day so that the total number of meals per week were the same over 14 days (irregular meal pattern) (Farshchi et al. 2004). The participants then followed their normal diet for a 14-day washout period. For the last 14 days, the participants consumed the opposite treatment of the first 14 days. Participants consumed more energy when consuming the nine meals per day versus six or three. The thermic effect of food was lower after consuming the irregular meal pattern versus the regular eating pattern. Thus, in addition to excess energy consumed, unplanned eating occasions may also be problematic because of decreased thermogenesis. Whether diet-induced thermogenesis actually has biological relevance is debated (see Bellisle et al. 1997), but to the extent that it is meaningful in the context of eating frequency, it appears to contribute to positive energy balance.

Is the Nature of Snack Foods or Snacking Behavior More Problematic?

Snacking may be defined by the nature of the foods ingested. Often snack foods are considered disproportionately energy dense (Hess et al. 2016). Some argue such foods pose a risk because they deliver a high energy load yet have low satiety properties. However, an assessment of the relative contributions of portion size, eating frequency, and energy density to energy intake revealed the later accounted for the least amount of variance in this outcome (Duffey and Popkin 2011). Additionally, the concept of energy density fails to coincide with a wide array of expected associations (Running and Mattes 2012). For example, trends in the energy density of the food supply have not tracked changes in population weight or BMI. Additionally, evidence based on foods at the extremes of the energy density continuum do not support the concept.

Fruits and vegetables have high water content and, as a consequence, are low in energy density. Thus, increased intake is promoted as an approach to manage energy intake and body weight. However, increased consumption of fruits and vegetables may not be the solution for better energy management. They do not promote nor sustain satiety as is often assumed (Carmody et al. 2011; Drewnowski 1998; Poppitt et al. 1998a). In epidemiological studies, BMI is not different across various levels of fruit and vegetable intake. The European Prospective Investigation into Cancer and Nutrition (EPIC) study, which collects dietary data across ten European Countries to study the relationship between nutrition and cancer, found BMI and energy intake were not significantly different in adults across quartiles of fruit, vegetable, and legume intake (Nöthlings et al. 2008). Adult women in the Nurses' Health Study did not differ in BMI across quintiles of fruit, vegetable, and fruit and vegetable intake (He et al. 2004). Randomized controlled trials show similar results. In the Women's Healthy Eating and Living Trial (WHEL), subjects following the "5-a-day" recommendations consumed more fruits and vegetables every day, but did not have different energy intakes per day nor body weight compared to the control group (Pierce et al. 2007). In another study, adults with overweight or obesity consumed 20% of their estimated energy requirements as fruit and vegetables for 8 weeks with no other dietary guidance (Houchins et al. 2012). Subjects with obesity gained more weight than patients with overweight, but both gained weight during the intervention, and this was due to incomplete compensation. Lean participants in the study fully compensated for fruit and vegetable intake and did not gain weight during the intervention. Thus, if energy from fruit and vegetable consumption is not compensated, excess energy from intake of these snacks can still lead to increases in body weight. Therefore, recommendations to increase fruit and vegetable consumption, especially as snacks, should emphasize the importance of energy balance (Mattes and Tan 2013).

Caloric beverages represent an even more extreme example of how low energy dense foods can be problematic for weight gain (whether consumed with a meal or as a snack). Their consumption as snacks has increased in China and the United States in the past 18–30 years (Piernas and Popkin 2010; Wang et al. 2012; Duffey et al. 2013) and is prevalent in Brazil (Duffey et al. 2013), Mexico (Duffey et al. 2014), and children in Scotland (Macdiarmid et al. 2009) and the Philippines (Adair and Popkin 2005). In China, beverages consumed as snacks contributed about 25% of energy intake (Wang et al. 2012), while in the United States, 50% and 40% of the energy consumed from snacks comes from beverages in males and females (Mattes and Tan 2013). Sugar-sweetened beverages are positively associated with weight gain and obesity in children and adults (Bray et al. 2004; Malik et al. 2006; Malik et al. 2013a), possibly because they are not as satiating as solid foods (Mattes and Tan 2013). This is due to a plethora of factors, including quicker orosensory processing time, increased gastric emptying rate, and intestinal transit time (see Mattes and Tan 2013). Thus, ingesting low energy dense beverages as snacks may lead to increased energy intake due to their weak effect on appetite regulation and energy compensation. However, the risk they pose is not limited to their use as snacks. Both lean adults and those with obesity who consumed matched beverage and solid foods with a standardized lunch had weaker dietary compensation and higher energy intake the remainder of the day after the beverage compared to the matched solid food (Mourao et al. 2007). Adults who are lean or have overweight or obesity who consumed 20% of their estimated energy requirement as juices for 8 weeks had incomplete dietary compensation and weight gain (Houchins et al. 2012).

In contrast to beverages, nuts are rich in fat and low in water so have very high energy density. The prediction then would be that they should be associated with positive energy balance and weight gain. However, epidemiological, clinical, and mechanistic studies with nuts indicate they are not problematic for weight gain (see Tan et al. 2014). This has been attributed to their high satiety value, inefficient absorption, and possible enhancement of resting energy expenditure.

Aside from energy density, it has been proposed that snacks varying in macronutrient content will have varying effects on satiety, compensation, and energy balance. However, this was directly tested in a four-arm crossover study where lean men consumed a standard lunch, and then a high fat, high protein, or high carbohydrate snack 240 min later (Marmonier et al. 2000). During the study, participants were deprived of time of day cues, and freely requested dinner, which was an ab libitum buffet. Dinner requests were significantly later after the high protein snack compared to the high fat or high carbohydrate snack, but energy intake was not different at dinner between treatments, and there was no energy compensation for any snack. It may be that foods varying in sensory appeal or cultural meaning will exert differential effects on appetite and such foods may vary in macronutrient profiles, but the latter does not appear to be the driving force in the response to their ingestion.

Taken together, this evidence indicates risks posed by snacking are not necessarily related to the nature of the foods themselves, but rather to how they are incorporated into the diet. If planned and energy compensated, any food can be included in an energy-balanced diet. However, at the same time, snacking that is not planned and does not lead to precise energy compensation can pose a risk for weight gain regardless of the nature of the food.

Why Are We Snacking More?

Palatability is the strongest predictor of food intake (Mattes 2008) and is often rated highly as a motivation to snack (Hess et al. 2016). Nutritional quality is also a consideration and its importance has been growing, but frequently, snacks are not held to the same nutrition standards as meals (Kant 2018). Additional enablers for snacking include hunger (Cleobury and Tapper 2014; Caruso et al. 2014), temptation (Cleobury and Tapper 2014), convenience (Caruso et al. 2014), emotional eating (i.e., boredom or stress) (Cleobury and Tapper 2014), enjoyment/reward (Verhoeven et al. 2015; Kant 2018), affordability (Nestle and Jacobson 2000; Drewnowski and Darmon 2005), and availability (Nestle and Jacobson 2000). The latter is likely a critical issue. Snacks are widely available, including in grocery stores, restaurants, vending machines, pharmacies, gas stations, hardware stores, auto repair centers, etc.

(Farley et al. 2010). Changes in the culture of eating have also been important. The acceptability of eating almost anywhere at any time has allowed for increased eating frequency (Bellisle 2014). Indeed, the incidence of snacking is greater outside the home than inside and is particularly high when individuals are at the worksite. It also occurs in transit (Liu et al. 2015). Therefore, the numerous motivations and availability of snacks may lead susceptible individuals to consume energy when it is not planned for and consume excess energy (Baskin et al. 2016).

Concerns with Snacking

Snacking commonly leads to increased energy intake resulting in positive energy balance and increased BMI. Consequently, snacking is primarily viewed as a negative health behavior by clinicians and policy makers who provide recommendations to manage body weight. Depending on the type of snacks consumed, they may increase the contribution of food constituents associated with undesired health outcomes or displace desired nutrients (Larson et al. 2016). However, snacks are especially problematic when they are unplanned, uncompensated, and contribute to an irregular eating pattern.

Nonhomeostatic factors that motivate snacking can lead to energy intake at times that are different than homeostatic signals and can therefore disrupt 24-h biological cycles (circadian rhythms). This can lead to negative cardio-metabolic outcomes. In the 1946 British Birth Cohort, irregular meal and snack patterns were associated with an increased waist circumference, BMI, and prevalence of metabolic syndrome (Pot et al. 2016). Hunger reportedly has an endogenous circadian rhythm, independent of wake time or time since energy was last consumed (Scheer et al. 2013). When energy is consumed during a time when the circadian clock promotes sleep, such as in shift work, energy expenditure, hunger, and leptin and PYY concentrations are reduced (McHill et al. 2014). One particular concern is eating later in the evening before sleeping. Observational studies have reported a positive association between evening food intake and BMI, while consuming a larger proportion of total energy intake during midday was associated with a lower risk of being overweight or obese (Wang et al. 2013). However, multiple cultures (e.g., Spain) typically consume a large meal later in the evening, yet have lower rates of overweight and obesity than cultures that complete the largest eating events earlier in the day (e.g., United States) (Ng et al. 2014). In some studies, late eating has been associated with increased energy intake, but this association may be mediated by increased eating frequency, which leads to eating closer to sleep onset and increased daily energy intake (Reid et al. 2014).

Benefits of Snacking

Though snacking has been vilified in the media and by health professionals, increased eating frequency can be a part of a healthy lifestyle (Hartmann et al. 2013). In fact, because a high proportion of the US and global populations snack

(Kant and Graubard 2015; Dunford and Popkin 2017), it should be a priority to determine how to make this habit more healthful. Dietary recommendations regarding snacking are limited. Prior to 2010, there were no recommendations regarding snacking behavior in the dietary guidelines (Kant and Graubard 2015). The Dietary Guidelines for Americans recommend decreasing snack foods, but also recommend a dietary pattern of three meals and two snacks per day, and the distinction between the two is not clear.

Snacks can help manage short time intervals allotted to eating. One of the most commonly reported barriers to healthy eating among adults is lack of time (Pelletier and Laska 2012; de Mestral et al. 2016). Americans are spending less time cooking, and only slightly more than half of Americans spend any time on food preparation (Smith et al. 2013). Commutes to work take away time from food preparation (Christian 2012). The lunch hour for over half of Americans lasts less than 30 min, and 29% of employees report working during their lunch breaks (Half 2018). Lack of time is also a barrier to regular family meals. Due to busy schedules, families may not feel they have time to prepare or sit down around the table for a meal and resort to snacks as a quick meal alternative (Jones 2018). Therefore, the convenience of some snacks can help manage these short times allocated to eating.

Snacks can, and often do, contribute positively to the nutrient quality of the diet. Eating frequency and diet quality are positively associated based on NHANES 2009–2012 data (Zhu and Hollis 2016). Eating frequency was positively associated with total fruit, whole fruit, whole grains, dairy products, and seafood and plant protein in men and women. NHANES 1999–2004 data in adults revealed that snacking was associated with higher HEI-2005 scores, although modestly (Zizza and Xu 2012). However, this must be placed in context. In the Healthy Aging in Neighborhoods of Diversity across the Life span (HANDLS) study in White and African American adults in various neighborhoods throughout Baltimore City, 84% of the population reported consuming snacks, which contributed about 20% of their daily energy intake, had total HEI-2010 scores that were 2% and 4% higher for both African American and White males, respectively, and 1% and 7% higher for African American and White females, respectively, indicative of increased diet quality. However, African American and White men classified as snackers reportedly consumed 483 and 583 kcal/day more than their non-snacking counterparts, and African American and White women classified as snackers reportedly consumed 365 and 468 kcal/day more than their non-snacking counterparts. Thus, the benefit in nutrient quality came with a disproportionately higher energy content, so the overall value must be interpreted with caution. This point is further highlighted by data on Australian adults indicating that meal frequency and eating occasions, but not snack frequency, were positively associated with diet quality, whereas higher snack frequency was associated with lower compliance to dietary guidelines (Leech et al. 2016).

Higher eating frequency is clearly beneficial in select populations. Increased eating frequency helps patients at risk for malnutrition increase their energy and nutrient intake. This is also true for children and the elderly, who cannot consume enough energy through three eating events per day due to early satiation. Frequent eating may also help meet energy needs of those who are more physically active (Drapeau et al. 2017). However, interestingly, this may stem from a higher proportion of eating events deemed to be meals rather than snacks (Chapelot 2011).

Though much of the concern with increased eating frequency stems from its contribution to energy intake, some have proposed there are benefits of increased eating frequency on other health outcomes. Perhaps the most studied outcome is blood sugar. Consumption of an isocaloric diet as six versus three eating events per day tended to moderate blood sugar (Leidy and Campbell 2011). Men in the Health Professionals Follow-Up study who ate three times per day had a lower risk of type 2 diabetes than those who ate one to two times per day. However, there was no association between those who consumed snacks in addition to three meals compared to those who didn't snack on type 2 diabetes risk after adjustment for BMI (Mekary et al. 2012). Further, there was no association between eating frequency and risk of type 2 diabetes in the Nurses Health Study (St-Onge et al. 2017). Healthy men and women who consumed their usual diet as three or nine meals per day with the same energy intake had reduced fasting plasma total cholesterol and LDL and HDL cholesterol when nine meals were consumed compared to three (Arnold et al. 1993). However body weight, fasting triglycerides, LDL:HDL, and insulin and glucose AUC were not different between groups (Arnold et al. 1993). Increased eating frequency was associated with decreased cardiovascular mortality in NHANES data, even after controlling for HEI score and energy intake (Chen et al. 2016). Cross-sectional data reveal increased eating frequency is associated with lower total and LDL cholesterol (St-Onge et al. 2017). Men who consumed a diet of 17 snacks per day for 2 weeks had reduced fasting total cholesterol, LDL-Cholesterol, insulin levels, C-peptide excretion, and cortisol levels compared to when they consumed a metabolically identical diet as three meals a day for 2 weeks (Jenkins et al. 1989). However, in many studies, there is an inverse association or no association between eating frequency and health outcomes (see St-Onge et al. 2017). Overall, it is not clear if eating frequency improves risk factors for metabolic disease. The American Heart Association concludes that "altering meal frequency under isocaloric conditions may not be useful for improving traditional cardio metabolic risk factors" (St-Onge et al. 2017).

Conclusions

There is strong evidence that eating frequency is positively associated with energy intake in Western nations. An association between eating frequency and BMI is less clear, but with correction for underreporting, a positive association is apparent. Multiple mechanisms have been proposed to account for these associations. Lower satiety, thermogenic, and endocrine effects, circadian misalignment, as well as eating while distracted may contribute. Snacks are likely especially problematic for energy balance when unplanned as they often elicit incomplete energy compensation. However, snacking can contribute to a healthful diet and, because the majority of the population snacks, should be used to advantage. Snacking can fit in a fast pace of life allotting only short time intervals to eating. It can also improve diet quality and promote beneficial effects on cardio-metabolic health. Overall, it may be argued that the benefits or complications associated with high eating frequency will be determined more by how the portion sizes and the balance of the nutrient profile of the diet are adjusted rather than the nature of the foods comprising each eating event.

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The Influence of Portion Size on Eating and Drinking

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Abstract

There is growing interest in the role of large portions in overeating. Experimental studies consistently demonstrate that serving large amounts of food leads individuals to consume more food and energy than they require. This portion size effect has been observed across different types of foods and beverages and can be sustained over several months. Furthermore, there is evidence that prolonged provision of large portions can lead to weight gain. The robust nature of this effect has led to efforts to identify strategies to manage food and beverage portions. Certain characteristics of the consumer (e.g., satiety responsiveness, slowness of eating) and the available food (e.g., relative palatability, value) have been found to influence the effect of portion size, and these are potential targets for interventions to attenuate the response. To date, the most reliable and effective method to moderate energy intake from large portions is reducing the energy density of the diet. Future studies need to build on current knowledge to understand individual and contextual variability in the response to portion size. A more comprehensive understanding of the portion size effect can lead to the development of a systems approach in which the food, individual, and environment are targeted simultaneously to counter the effects of large portions.

Introduction

It is well-established that large portions increase food and beverage intake and that the effect is sustained over multiple days in both adults and children (Rolls 2003, 2014; Kral and Rolls 2004, 2011; Ledikwe et al. 2005; Steenhuis and Vermeer 2009; Zlatevska et al. 2014; Livingstone and Pourshahidi 2014; Benton 2015; Hollands et al. 2015; Hetherington et al. 2018). These findings, along with the observation that portion sizes and obesity rates have increased concurrently (Young and Nestle 2012), led to the suggestion that large portions could play a causal role in the development of obesity (Rolls 2003, 2014; Hill et al. 2003; Young and Nestle 2012). Given the ubiquity of large portions of energy-dense foods in the eating environment, the "portion size effect (PSE)" has become an important topic of obesity- and public health-related research. The abundance of recent data related to the PSE has led to the publication of several systematic reviews and policy documents (NHLBI 2013; Dobbs et al. 2014; Raynor 2014; Fisher et al. 2015; Pomeranz and Miller 2015; Hollands et al. 2015; Marteau et al. 2015; CDC 2016; NIDDK 2016; Steenhuis and Poelman 2017; USDA 2018a; Hetherington et al. 2018). In this chapter, the reader will be directed to these publications, and the present narrative review will contextualize and provide perspectives on the PSE in relation to obesity. Since the issues related to the PSE differ between adults and children, this review will focus primarily on adults, though influential studies in children will be cited. The aims are to provide an overview of the PSE on eating and drinking behavior, to explore the proposed explanatory variables, and to suggest strategies to moderate the effect.

Establishing the Effect of Portion Size on Intake

In 1957, while observing people eating different amounts of cookies, Siegel found they had a "completion compulsion" or tendency to eat entire portions of food offered (Siegel 1957). Perhaps this is the first published observation of the PSE? Over the next 30 years, only a few studies tested the link between portion size and consumption. In one study, Nisbett (1968) found that subjects with obesity ate more when offered three sandwiches rather than just one; however, subjects with normal weight tended to eat a similar amount in both conditions (Nisbett 1968). This ambiguous finding in relation to the PSE was followed by another. In 1986, Edelman and colleagues tested the effect of varying the portion of a pasta dish available in a military cafeteria. Unless portions were very different, no effect of portion size was found in men with either normal weight or obesity (Edelman et al. 1986). It is not clear why the PSE was elusive in this study; one explanation could be that participants were allowed to serve themselves beyond what was initially provided. Despite a lack of evidence clearly linking portion size to intake, other findings suggested that systematic investigation of the PSE was needed. Early observational studies indicated that portion sizes were becoming a problem, not only because people with both normal weight and obesity were inaccurate at estimating portions (Blake et al. 1989) but also because portion sizes were getting larger (Young and Nestle 2002; Nielsen and Popkin 2003).

In a series of well-controlled studies, Rolls and colleagues tested the impact on intake of systematically varying the portion size of different types of food served to both children (Rolls et al. 2000; Fisher et al. 2003, 2007a, b; Fisher 2007; Kral et al. 2010; Spill et al. 2010, 2011a; Mathias et al. 2012; Kling et al. 2016) and adults (Rolls et al. 2002, 2004a, b, 2006a, b, 2007, 2010; Diliberti et al. 2004; Roe et al. 2016). The first food tested was macaroni and cheese. It was chosen because of its popularity and its amorphous shape, which makes portion estimation difficult (Slawson and Eck 1997). These early studies showed clear relationships between the portion served and the amount consumed, and this PSE was confirmed in the subsequent studies.

Definitions and Methodological Considerations

Before undertaking a further review of findings related to portion size, a pause is needed to consider how the PSE is defined and how behavioral responses can best be assessed. Previous narrative reviews have considered these issues and coincide in most part with thinking here (Herman et al. 2015; Almiron-Roig et al. 2018). In the present chapter, "portion size" is defined as the weight of food *served* to an individual, and the "portion size effect" refers to the weight of food *consumed* in response to variations in the weight served. This definition narrows the scope of this review to studies that have measured food or beverage intake. A number of recent studies have asked participants to estimate the size of portions they would serve themselves or select to eat (Brunstrom 2014). While these studies shed light on how pre-meal decisions are made about how much food to serve, they do not indicate how much people would eat in response to being provided a large portion. Such studies have been included in several reviews (Brunstrom 2014; English et al. 2015; Benton 2015; Hollands et al. 2015) and are not the focus here.

When designing studies to measure the PSE, careful consideration is needed to determine the portions to be tested and the foods that will be provided. If any of the portions served are too small, results could be driven simply by limiting intake. To avoid this, a common practice is to serve slightly more food in the smallest condition than is likely to be consumed. This smallest amount can be determined from food labels, dietary data from epidemiological studies, or average intakes from previous controlled studies (e.g., Zuraikat et al. 2018a, b, c). On the other hand, serving overly large portions is problematic. Recent studies (Roe et al. 2016; Zuraikat et al. 2018c) and a meta-analysis (Zlatevska et al. 2014) show that the response to portion size is curvilinear (Fig. 1). If the portions tested are within the range of those usually consumed, as the portion size increases, intake accelerates in a linear fashion. When the portions exceed this range, intake reaches a plateau and can even decline (Zuraikat et al. 2018c). This trajectory of intake is best characterized when the responses to multiple portions are tested; for example, the curve is generally well-characterized by comparing four portions (Roe et al. 2016; Zuraikat et al. 2018a, c). A failure to find a PSE could simply be that the portions tested were all large and fell on the plateau of the curve. Thus, the PSE relies heavily on the baseline amount served, the number of portions tested, and the extent to which portions differ from one another.

Food Characteristics and the PSE

Another critical consideration when studying the PSE is the choice of food(s) to be tested. This choice provides opportunities to determine what factors are contributing to the PSE: is it palatability, familiarity, energy density, perceptions of value, or other

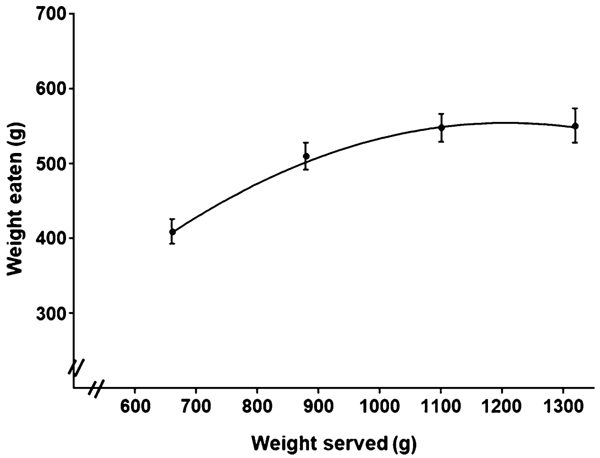

Fig. 1 A curvilinear response best characterizes the portion size effect (PSE). As portions are initially increased from baseline amounts, there is a linear trajectory of intake until reaching a point of maximal intake. As portions are further increased, there is a deceleration, or decline, in the rate of intake. Given the curvilinear nature of the effect, the response is more comprehensively characterized when serving four or more portions.

aspects of the eating context? Previous studies have shown that the PSE is robust across different types of foods. Amorphous dishes, or those without a clearly defined shape, were used in early studies (e.g., Rolls et al. 2002; Diliberti et al. 2004). This reduces the likelihood of the effect being driven by a unit bias, whereby individuals might be motivated to consume full amounts of foods served in discrete units or segments, such as a bag of chips or sandwiches (Geier et al. 2006), or by demand characteristics resulting from noticeable differences in the amount served (Slawson and Eck 1997). Use of amorphous foods was helpful in establishing the PSE, but it is important to determine the generalizability to other types of foods. Table 1 summarizes the diversity of foods and beverages that have been shown to be eaten in greater quantities when portions are larger. For example, intake of a food served in units, such as a sandwich, increased when the units were bigger (Rolls et al. 2004b). Larger packaged snack portions also led to increased energy intake (Rolls et al. 2004a; Raynor and Wing 2007) that was not fully adjusted for at a subsequent meal (Rolls et al. 2004a). Thus, the PSE extends across a range of foods with different properties.

Understanding the PSE in the Context of a Meal with Multiple Components

While early laboratory studies on portion size focused on a single food, it is important to examine the PSE in a variety of contexts. For example, what is the impact of varying portion size in a meal where multiple foods are available? A particular interest has been on the effect of increasing vegetable portions at a meal, since current dietary advice such as MyPlate recommends serving a greater proportion of vegetables (USDA 2018b). In both children and adults, increasing the amount of vegetables served at a meal increased vegetable consumption without affecting total energy intake (Rolls et al. 2010; Spill et al. 2010; Mathias et al. 2012). Of further interest is that substituting vegetables for other ingredients in a dish (Blatt et al. 2011; Spill et al. 2011b) or other meal components (Rolls et al. 2010) can lead individuals to consume more vegetables *and* consume less energy at a meal. Thus, varying meal proportions can be used strategically to leverage the PSE to improve the quality of meals and to moderate energy intake.

The impact that a portion of a food can have on intake depends upon the context, particularly the other foods that are available. In two recent studies, multiple foods of different energy densities were served at a meal, and the portion size of all foods was varied across four test sessions (Roe et al. 2016; Zuraikat et al. 2018a). In both studies, the relative palatability of the foods served (taste ranking) was found to affect the response to large portions. This makes sense. When too much of all foods at a meal is offered, the PSE will be greatest for foods liked the best or those ranked higher in taste (Roe et al. 2016; Zuraikat et al. 2018a). The most palatable foods are often those high in energy density (kcal per gram) (Drewnowski 1998), and the PSE has been observed to be related to the energy density of foods available (Rolls et al. 2006a, 2007; Smethers et al. 2019a). Thus, foods that pack the most calories into a

Table 1 The effects of portion size on intake of different types of foods and beverages in adults

First author and year	Participants and setting	Study design and duration	Portion size manipulation	Food or beverage type	Effects on food and beverage intake (g)	Effects on energy intake (kcal)	Influence of subject characteristics
Nisbett (1968)	$N = 260$ (men)	Intervention	2 portion sizes: 100% and 300% of baseline (1 sandwich)	Sandwich	Increased as portion size increased for individuals with overweight; no effect of portion size for individuals with normal weight or underweight	Not reported	*Weight status*: greater increases for individuals with overweight
	Laboratory	Lunch meal					
Edelman et al. (1986)	*Study 1*: $N = 48$ (men) *Study 2*: $N = 83$ (men)	Intervention	*Study 1* - 2 portion sizes: 100% and 167% of baseline (255 g)	Lasagna with meat sauce	No effect of portion size	No effect of portion size	None significantly influenced the relationship
	Military cafeteria	Lunch meal	*Study 2* - 3 portion sizes: 100%, 167%, and 392% of baseline (255 g)				*Measures tested*: weight status, food preference
Rolls et al. (2002)	$N = 51$ (men and women)	Mixed design: portion size - crossover Serving method - between-subjects	4 portion sizes: 100%, 125%, 150%, and 200% of baseline (500 g)	Pasta main dish	Increased as portion size increased (did not differ between 150% and 200% portions)	Increased as portion size increased (did not differ between 150% and 200% portions)	None significantly influenced the relationship
	Laboratory	Lunch meal		Non-manipulated sides	No influence of serving method	No influence of serving method	*Measures tested*: sex, height, weight, BMI, scores for dietary restraint, disinhibition, hunger, or scores on the EAT-40, Zung, or Eating – Then and Now questionnaires
Diliberti et al. (2004)	$N = 180$ (men and women)	Between-subjects	2 portion sizes: 100% and 150% of baseline 248 g)	Pasta main dish	Increased as portion size increased	Increased as portion size increased	None significantly influenced the relationship
	Restaurant	Lunch meal		Non-manipulated sides			*Measures tested*: age, sex, weight status

Rolls et al. (2004a)	$N = 63$ (men and women)	Crossover	5 portion sizes: 1.5 oz. increases from baseline (1 oz)	Chips	Snack intake: Increased as portion size increased	Snack intake: Increased as portion size increased	None significantly influenced the relationship
	Laboratory	Snack		Non-manipulated dinner		Snack + dinner intake: increased as portion size increased	*Measures tested*: age, sex, weight, height, BMI, dietary restraint, disinhibition, hunger, depression, eating attitudes
Rolls et al. (2004b)	$N = 75$ (men and women)	Crossover	4 portion sizes: 6, 8, 10, and 12 in.	Sandwich	Increased as portion size increased	Increased as portion size increased	*Sex:* greater increases for men as portion size increased
	Laboratory	Lunch meal		Non-manipulated sides			*Measures tested*: age, BMI, dietary restraint, disinhibition, hunger, depression, or tendency to "clean the plate" as a child or as an adult
Levitsky and Youn (2004)	$N = 13$ (men and women)	Crossover	3 portion size: 100%, 125%, and 150% of baseline	Buffet of soup, pasta, bread, ice cream	Increased as portion size increased	Increased as portion size increased	Not reported
	College cafeteria	Lunch meal					
Flood et al. (2006)	$N = 33$ (men and women)	Crossover	2 portion sizes: 100% and 150% of baseline (360 g)	Beverage (water, cola, and diet cola)	Increased as portion size increased	Energy intake from the beverage increased for cola (with larger portions)	*Ratings of pleasantness of taste*: greater increases in intake for diet cola as the taste rating of diet cola increased
	Laboratory	Lunch meal		Non-manipulated lunch		No effect of portion size on total energy intake	*Measures tested*: age, height, weight, body size, dietary restraint, disinhibition, hunger, or scores for depression or eating attitudes

(*continued*)

Table 1 (continued)

First author and year	Participants and setting	Study design and duration	Portion size manipulation	Food or beverage type	Effects on food and beverage intake (g)	Effects on energy intake (kcal)	Influence of subject characteristics
Raynor and Wing (2007)	$N = 28$ (men and women)	Between-subjects	2 portion sizes: 100% and 200% of baseline (4320 kcal)	Snack food (potato chips, cheese crackers, cookies, and candy)	Not reported	Increased as portion size increased	None significantly influenced the relationship
	Home	Snack	2 package sizes (self-reported intake)				*Measures tested*: gender, BMI, restraint, snack food, hedonic ratings
Rolls et al. (2010)	*Study 1 (vegetable addition):* $N = 49$ (men and women) *Study 2 (vegetable substitution):* $N = 48$ (men and women)	Crossover	3 portion sizes of vegetables: 100%, 150%, and 200% of baseline	Vegetable manipulated in both studies	*Vegetable intake*: Increased as portion size increased	*Vegetable intake:* Increased as portion size increased	None significantly influenced the relationship
	Laboratory	Lunch meal		Meat and grain non-manipulated in study 1 Meat and grain manipulated in study 2	*Vegetable + meal intake:* *Study 1*: Increased as vegetable portion size increased *Study 2*: No effect of portion size	*Vegetable + meal intake:* *Study 1*: No effect of portion size *Study 2*: Meal energy intake decreased as	*Measures tested*: sex, race, ethnicity, age, height, weight, and BMI or scores for restraint, disinhibition, hunger, depression, or disordered eating

						vegetable portion size increased	
Freedman and Brochado (2010)	$N = 703$ (men and women)	Quasi-experimental	4 portion sizes: 88 g, 73 g, 58 g, 44 g (allowed to select more than one)	French fries (daily intake at the population level)	Significantly lower when the smallest amount served	Significantly lower when smallest amount served	Not reported
	University cafeteria	Lunch meal					
Roe et al. (2016)	$N = 48$ (women)	Crossover	4 portion sizes: 100%, 125%, 150%, and 175% of baseline amounts of all foods served	6 foods across a range of ED; all foods varied in PS	Increased as portion size increased. The effect of portion size on food intake was curvilinear	Increased as portion size increased	*Taste:* greater increases as portion size increased for foods that were ranked higher in taste
	Laboratory	Lunch meal					*Disinhibition:* participants with higher disinhibition showed a stronger response to large portions
							Measures tested: age, BMI, restraint, prospective consumption, estimated daily energy expenditure, scores on the eating attitudes test

portion are likely to be overeaten when portions are large. Strategies to moderate the combined effects of portion size and energy density will be discussed later.

The impact of the portion size of beverages served with a meal has also been assessed (Flood et al. 2006; Rolls et al. 2006a). When two portions of different beverages (cola, diet cola, or water) were served along with lunch on six occasions, beverage intake increased with larger portions, while food intake remained stable across conditions. The extra calories consumed from the regular cola led to additional energy intake at the meal (Flood et al. 2006). Another study found that the effect on intake of beverage portion size was influenced by the energy density of the beverage (Rolls et al. 2006a). Increasing portions only increased intake of caloric beverages, which contributed to the overall effect on energy intake. Thus, serving large portions of caloric beverages can lead to significant increases in total energy intake at meals.

Laboratory-based studies demonstrate that the PSE extends to many types of foods and to beverages. In such controlled settings, although robust, the PSE can vary depending upon the type, amount, and number of foods offered, as well as other contextual factors. Experiments conducted across a broader range of contexts are helping to further characterize the PSE.

Does Portion Size Affect Intake Outside the Laboratory?

Once the PSE was established in the laboratory, an essential step forward was to evaluate its generalizability. One way to do this was to extend the research to different settings, since it is well documented that contextual cues related to the setting can influence eating behavior (Meiselman and Kramer 1994; Meiselman 1996). While environmental influences on eating are controlled for in the laboratory, aspects of the natural eating environment, such as the presence of others (Hermans et al. 2012) and a larger variety of foods (Rolls et al. 1981), could influence intake from large portions.

Despite the challenges associated with transitioning from the laboratory to more natural eating environments, researchers have studied the PSE in adults eating in restaurants (Diliberti et al. 2004; Reinders et al. 2017), dining halls (Freedman and Brochado 2010), buffets (Levitsky and Youn 2004), and other free-living settings (Jeffery et al. 2007; Raynor and Wing 2007; French et al. 2014). In addition, the effect of portion size on children's food intake has been evaluated in childcare settings (Fisher and Kral 2008; Kral and Rolls 2011; Birch et al. 2015; Hetherington and Blundell-Birtill 2018). Across all of these settings, varying the amount of food served significantly affected intake. For example, when the weight of a popular pasta dish served at a restaurant was increased by 50%, customers consumed approximately 43% more food and energy (Diliberti et al. 2004). A similar effect was observed when the portion size of snacks consumed in the home was doubled (Raynor and Wing 2007). These findings demonstrate that the PSE is not just a laboratory-based phenomenon. The influence of portion size on intake in natural settings has led to the development of several interventions to moderate the PSE in worksites and restaurants; these will be discussed later.

Does the PSE Extend Beyond Western Settings?

It is noteworthy that the PSE is not restricted to Western societies. Much of the initial research showing a PSE was conducted in the USA, where the prevalence of large portions coincided with the rise in obesity rates (Young and Nestle 2002, 2012; Nielsen and Popkin 2003; Rolls 2003; Ledikwe et al. 2005). These trends also occurred in the UK (Wrieden et al. 2008) and the Netherlands (Steenhuis et al. 2010), and the PSE has now been observed in several Westernized countries (summarized in Hollands et al. 2015). In addition, the PSE extends to both children and adults in Singapore (McCrickerd et al. 2017a, b) and to Samburu (Kenya) pastoralists (Myers et al. 2019), a population whose food environment is characterized by scarcity and minimal variety. It is of interest to determine why the amount of food served is a primary determinant of intake across different populations whose cultural norms vary widely. Such investigations could provide insight into factors that contribute to or moderate the PSE.

Do Individuals Differ in How They Respond to Large Portions?

Much of the research on the PSE is driven by the assumption that large portions could be fueling the current epidemic of obesity. Individuals that are particularly susceptible to this external cue may be at greater risk for obesity (English et al. 2015; Herman et al. 2016). Identifying biological or behavioral characteristics associated with the PSE could be used to tailor interventions to individuals who present traits or behaviors associated with higher risk of overeating from large portions.

Studies show that, in both children and adults, the PSE is observed across a range of subject characteristics. In adults, it has been particularly challenging to identify characteristics that influence the PSE. The effect has not been shown to be reliably related to dietary restraint, disinhibition, tendency toward hunger, age, or plate-cleaning tendencies (Table 1) (Zlatevska et al. 2014; Hollands et al. 2015).

The phenotype that has generated the most interest in relation to the PSE is weight status. Although the PSE was related to weight status in a seminal study (Nisbett 1968), many subsequent studies examining body weight and body mass index (BMI) as covariates have found no significant influence (Rolls et al. 2002, 2004a, b, 2006a, b, 2007, 2010; Diliberti et al. 2004; Kral et al. 2004; Zuraikat et al. 2018b, c). A recent study designed specifically to compare the PSE in women with normal weight and with overweight and obesity also found that intake did not differ with weight status (Zuraikat et al. 2018a). Such lack of association has been used to argue that portion size may not play a role in the obesity epidemic (Herman et al. 2016). This speculation is premature. The short-term nature and small numbers of participants in most studies likely have contributed to the failure to find a strong association between weight status and the PSE. This premise is supported by a recent study that varied the portion sizes of all foods and beverages served to three- to five-year-old children over two five-day periods (Smethers et al. 2019a). Results showed that the response to large portions was greatest in children having the highest BMI-for-age percentile, even after standardizing for energy needs. The role of large portions in the development of obesity will be revisited in a later section.

Several behavioral characteristics are emerging as predictors of the PSE. Studies in children indicate that responsiveness to internal satiety cues and external food cues, assessed through the Children's Eating Behavior Questionnaire (CEBQ) (Wardle et al. 2001), is associated with the PSE. For example, ratings of satiety responsiveness (greater sensitivity to internal cues of hunger and fullness) were related to reduced susceptibility to the PSE (Mooreville et al. 2015; Smethers et al. 2019a). As is shown in Fig. 2, this association was recently corroborated in adults: the PSE was attenuated in men and women scoring higher in satiety responsiveness on the Eating Behavior Questionnaire (EBQ) (Zuraikat et al. 2018b). The observation of this relationship across a range of ages indicates that satiety responsiveness has an important and stable role in the PSE (Kral and Hetherington 2015).

Although robust, the PSE can vary across individuals. Development of novel scales, such as the EBQ (Zuraikat et al. 2018b), and improved methodology (e.g., varying multiple foods over four portions and over multiple days), has enhanced the ability to detect the influence of subject characteristics. Continued identification of characteristics associated with the PSE will aid the development of targeted strategies to moderate intake.

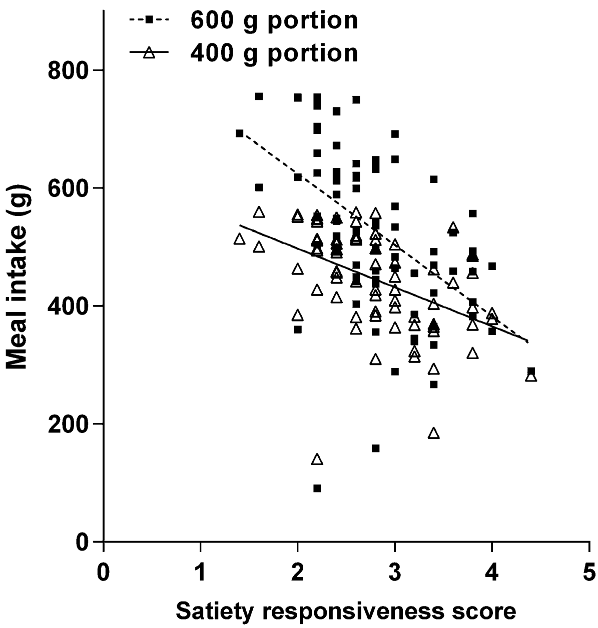

Fig. 2 The effect of portion size on intake is influenced by scores for satiety responsiveness. This has been observed in both children and adults. Higher scores for satiety responsiveness are associated with an attenuated portion size effect (PSE). (Figure reprinted from Zuraikat et al. 2018b, with permission from Elsevier)

Are the Effects of Portion Size Sustained Over Time?

Short-term studies clearly demonstrate that the PSE is strong and pervasive. However, a key question, and one that is related to the role of the PSE in the development of obesity, is whether the response is sustained over time. Many of the studies of the PSE focus on intake at a single meal. Overeating at a meal could lead individuals to reduce intake at subsequent meals. This could be the result of active restriction or of compensation in response to energy perturbations. The latter, however, would likely take three to four days to emerge (Bray et al. 2008). Given the robust effect of large portions on acute energy intake, determining whether prolonged exposure to large portions leads to sustained changes in intake is essential to our understanding of the role of portion size in the development of obesity. The results of studies extending beyond a single day are summarized in Table 2.

In the first study to test the PSE beyond a single meal in adults, Rolls et al. (2006a) served all meals, snacks, and beverages to men and women over three two-day periods. Baseline amounts were served over one two-day period, and portions were increased by 50% and 100% in the other periods. Results showed that energy intake increased when larger portions were served and that the effect was sustained over the two days (Rolls et al. 2006a). Another study conducted over four days also showed that serving large portions resulted in increased energy intake compared to smaller portions (Kelly et al. 2009). To ensure that the test period was long enough for biological systems to sense perturbations in energy balance, the PSE has been evaluated over an even longer period (Rolls et al. 2007). Results showed that increasing portions of all available foods and beverages by 50% resulted in a mean increase in daily energy intake that was sustained over 11 days (Fig. 3).

In two separate longer-term studies conducted in a hospital cafeteria, a boxed lunch was provided to subjects five days a week over periods of one month (Jeffery et al. 2007) or six months (French et al. 2014). Doubling the amount of lunch food provided over a month led to significant increases in self-reported energy intake, with no significant compensation over time (Jeffery et al. 2007). Over six months, individuals provided with smaller lunch portions (400 kcal or 800 kcal) had lower energy intakes than those served the largest portion (1600 kcal); the calorie intake of the largest-portion group resembled that of the controls not provided with a boxed lunch (French et al. 2014). Serving smaller portions countered typical patterns of weight gain in free-living settings, in that participants in the smaller portion groups maintained a stable weight while controls and participants in the largest-portion group gained weight over the six months. Thus, the PSE can persist over prolonged periods, even multiple months. The continuous availability of large portions can override biological compensatory responses associated with excess energy consumption; this is reinforced by a recent review indicating that biological responses to imposed energy surfeits are rarely precise (Levitsky et al. 2019). The sustained increase in energy intake supports the suggestion that large portions are a contributing factor to increased body weight and obesity.

Table 2 Studies testing the effect of portion size on intake and body weight over multiple days

First author and year	Participants and setting	Study design and duration	Portion size manipulation	Test foods and beverages	Effects on energy intake (kcal)	Effects on body weight
Rolls et al. (2006a)	$N = 32$ (men and women)	Crossover	3 portion sizes: 100%, 150%, and 200% of baseline	All meals, snacks, and beverages	Increased as portion size increased	Not reported
	Laboratory	2 days			No adjustment over 2 days	
Rolls et al. (2007)	$N = 23$ (men and women)	Crossover	2 portion sizes: 100% and 150% of baseline	All meals, snacks, and beverages	Increased as portion size increased	Not reported
	Laboratory	11 days			No adjustment over 11 days	
Jeffrey et al. (2007)	$N = 19$ (women)	Crossover	2 portion sizes: 100% and 200% of baseline (estimated intake)	Lunch meal	Increased as portion size increased	Weight change over the month did not differ significantly between conditions ($P = 0.13$), likely underpowered
	Worksite cafeteria	1 month				Large portion: 0.64 ± 1.16 kg
						Small portion: 0.06 ± 1.03 kg
Kelly et al. (2009)	$N = 43$ (men and women)	Crossover	2 portion sizes: based on commercially available units (small and large)	All meals, snacks, and beverages	Increased as portion size increased	Average weight change over the 4 days was significant:
	Residential	4 days			No adjustment over 4 days	Men: 0.9 ± 1.1 kg ($P = 0.002$)
						Women: 0.6 ± .6 kg ($P = 0.001$)
French et al. (2014)	$N = 233$ (men and women)	Randomized controlled trial	3 portion sizes: 400, 800, and 1600 kcal	Lunch meal	Higher energy intake at 1600 kcal	Weight change at 6 months did not significantly differ at the 5% level by experimental group ($P = 0.07$)
	Free-living	5 days per week for 6 months	1 control group (∗dietary recalls used)		Increased body weight in 1600 kcal group	Weight gain over time was significant in the 1600 kcal box lunch group (0.19 kg/month; $P < 0.05$)

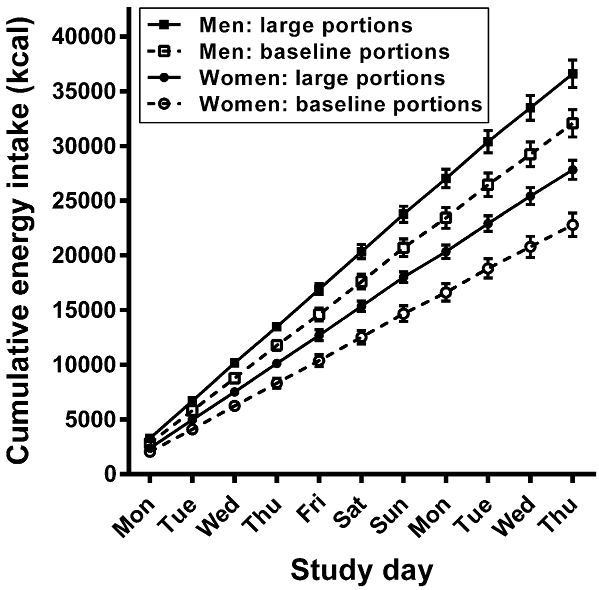

Fig. 3 Men's and women's cumulative energy intake when served baseline portions and larger portions of all foods for 11 days. Increasing the portion sizes by 50% of all foods served over this period led to net increases in energy intakes of 4606 ± 771 and 5027 ± 735 kcal for men and women, respectively. (Figure reprinted from Rolls et al. 2007, with permission from Wiley)

Proposed Explanations for the PSE

The consistent and robust effect of portion size has stimulated efforts to understand why most people eat more when served more food. Several reviews explore the explanatory variables proposed to underlie the PSE (Steenhuis and Vermeer 2009; English et al. 2015; Herman et al. 2015; Benton 2015). In addition, two reviews summarize recent advances in understanding of factors moderating or contributing to the PSE (Steenhuis and Poelman 2017; Zuraikat et al. 2019). Here, a brief summary and interpretation of proposed explanatory variables and related moderators is provided.

Consumption Norms

One of the more commonly referenced propositions is that the PSE stems from a perception that the amount served is appropriate (Rolls et al. 2002; Herman and Polivy 2005; Herman et al. 2015). According to this theory, individuals are unaware of what constitutes an appropriate amount to eat and thus use the amount served as an "appropriateness norm" to determine intake (Herman et al. 2015). Studies testing this theory have produced mixed results. In support of an appropriateness norm, people with both normal weight and obesity are poor at estimating portion sizes (Blake et al. 1989; Hernández et al. 2006; Almiron-Roig et al. 2013), and ratings of perceived normality of portions can be influenced by the amount of food served (Robinson et al. 2016; Robinson and Kersbergen 2018). If a lack of knowledge about appropriateness drives the PSE, contextual information or education should moderate the effect. However, the PSE has been found to persist despite provision of information on the amount served (Reily and Vartanian 2016), a choice of different portion options (Zuraikat et al. 2016), and both short-term (Cavanagh et al. 2014) and prolonged instruction in managing portions (Zuraikat et al. 2018a). Together these findings suggest that it is unlikely that the PSE is driven solely by a lack of knowledge of appropriate portions. In some contexts, the amount served could be used as a situational norm of how much to eat, but actual consumption will also be affected by other factors that are just beginning to be understood.

Value for Money

The value for money provided by large portions is another potential driver of the PSE (Steenhuis and Vermeer 2009). Value pricing makes larger portions cheaper per unit weight than smaller portions, and this could motivate selection and consumption of larger portions. Studies on the effect of replacing value pricing with linear pricing (equivalent price per weight) have not found a significant shift in portion selection (Harnack et al. 2008; Vermeer et al. 2010a, 2011). Another study tested whether the amount paid for a meal affected the response to large portions. According to the behavioral economics “sunk cost” theory, individuals tend to pursue a behavior to the point that it is counterproductive (e.g., continuing to eat when full) in order to justify the investment of time or money (Arkes and Blumer 1985). Thus, higher meal costs could exacerbate the PSE. However, similar to studies varying pricing structure, doubling the (absolute) price paid for a pasta dish from $8 to $16 had no significant influence on the PSE (Zuraikat et al. 2018b). Although meal price has not been shown to impact the response to large portions, this does not preclude a potential role of value in the PSE.

Another way in which large portions could stimulate overeating is through an aversion to wasting food. Indeed, there is inherent value or utility associated with food, which individuals are uniquely averse to wasting (Bolton and Alba 2012). In support of a role for waste aversion, providing subjects the opportunity to take away uneaten food after a meal, and informing them of this option beforehand, attenuated the PSE (Fig. 4) (Zuraikat et al. 2018c). Exploratory analysis also showed that ratings of the value of individual foods served at the meal tended to relate to the PSE, whereby the effect was larger for foods higher in market cost, such as the meat. Taken together, findings indicate that value does play a role in the PSE. However, this may be more closely related to the inherent value of food than the price assigned, since aversion to wasting food was influential and variations in pricing have not yet been found to have an impact.

Visual Cues

Visual cues are another factor proposed to underlie the PSE. In response to a classic study showing that soup intake and subsequent feelings of fullness were more

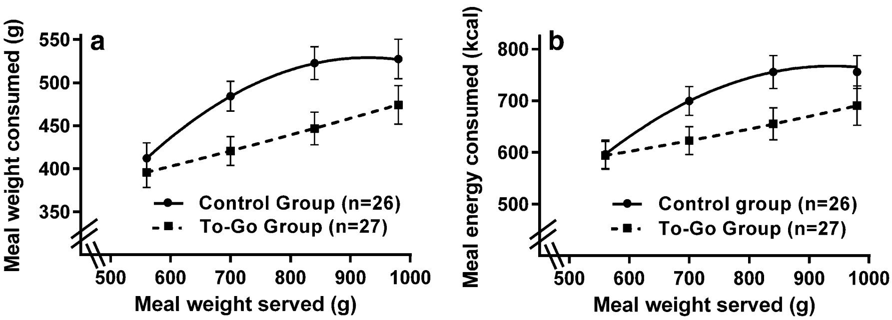

Fig. 4 Comparison of the portion size effect (PSE) between women provided the opportunity to take away uneaten food after a meal (To-Go Group) and those who were not (Control Group). The effects of portion size on both the weight of food consumed (**a**) and energy intake (**b**) were attenuated in the To-Go Group compared to the Control Group. (Figure reprinted from Zuraikat et al. 2018c, with permission from Elsevier)

closely related to the visible amount of food remaining than the amount consumed (Pudel and Oetting 1977), Burger et al. (2011) speculated that individuals rely on the amount of empty space on the plate to determine when to stop eating. This idea was put to the test by blindfolding a group of subjects while they consumed meals varying in portion size. Contrary to the hypothesis, a PSE was observed when visual cues were eliminated (Burger et al. 2011). In a more naturalistic study, the perceived size of a portion was varied by crushing the pieces of a flaky cereal so it was more compact (Rolls et al. 2014a). When the flakes were smaller and it took more cereal to fill the bowl to the same level, subjects served themselves a greater weight of cereal and consumed more energy. Despite this, subjects estimated that they had taken a similar number of calories of the different versions of the cereal. Thus, the perception of the volume of a food affects portion estimation and selection as well as intake, and this supports the suggestion that visual cues can influence the PSE (Rolls et al. 2014a).

Bite Size, Eating Rate, and Sensory-Specific Satiety

The basis for another potential explanatory variable, bite size, came from early studies on variability in children's susceptibility to the PSE. When larger portions were served, both younger and older children took larger bites (Fisher et al. 2003; Fisher 2007). Burger et al. (2011) extended these findings to adults; meal size had a significant effect on both intake and bite size. Further support was provided by a study in which bite size and eating rate in women with overweight were consistently monitored during a series of compulsory lunches (Almiron-Roig et al. 2015). Although this study needs to be replicated in a diverse sample and in an *ad libitum* eating paradigm, results confirmed that larger portions led to larger bite sizes and faster eating rates, when compared to smaller portions. Furthermore, women who reported slower eating on the EBQ (Zuraikat et al. 2018b) had an attenuated response to portion size (Zuraikat et al. 2018c). If oral processing time, which is known to affect intake (Krop et al. 2018), relates to the PSE, methods to slow the speed of eating and increase oral processing time could reduce intake from large portions.

The connection between portion size, bite size, and eating rate has led to speculation that bite size may contribute to the PSE through delaying sensory-specific satiety (Herman et al. 2015). Sensory-specific satiety is a process in which the pleasantness of an eaten food declines more than that of uneaten foods, and this hedonic shift contributes to meal termination (Rolls 1986). An early portion size study found that the greater intake associated with the PSE was not associated with larger changes in pre- to post-meal ratings of pleasantness of the eaten food, as would be expected (Rolls et al. 2002). Systematic study of the interplay between portion size, orosensory processing time, and sensory-specific satiety is needed to better understand this mechanism.

Investigation of explanatory variables has helped to improve understanding of the PSE and allowed for identification of factors that contribute to or moderate the effect. As is discussed in a recent review (Zuraikat et al. 2019), it is likely that numerous factors work in combination to drive the response to portion size. Continued assessment of these explanatory variables will clarify their relative contribution to the PSE.

Strategies for Managing Food Portions: Standard Approaches to Reduce Intake

As discussed in the previous sections, studies of the PSE and its potential contribution to the obesity epidemic confirmed the need for a better understanding of the effect so that approaches to its management could be developed. Indeed, determining why individuals overeat when served large portions and identifying factors that influence the response have aided the development of interventions to counter the PSE. The remainder of this review focuses on research testing strategies to moderate energy intake from large portions. The first section focuses on common approaches to manage food portions, such as labeling, education, and tools. The next section summarizes how food can be used to moderate the effects of large portions. Some of these approaches have been incorporated into weight loss interventions, the results of which are summarized here and more comprehensively described in a previous review (Rolls 2014).

Calorie or Serving Size Labels

Providing calorie information, particularly for restaurant foods, could lead individuals to rely less on the amount served to determine intake and “nudge” them to eat less or select lower-calorie foods. The portion selected and consumed in response to provision of labels displaying nutrition or health information has been the topic of a number of studies, 32 of which are included in a 2018 systematic review (Brown et al. 2018). Experimental studies have found no effect (Harnack et al. 2008), a trend toward smaller choices (Vermeer et al. 2010b), or a significant shift to the selection of smaller portions (Freedman 2011). A recent study conducted in worksite cafeterias found that the efficacy of calorie labeling varied across sites and days, but overall, labeling had no impact on the number of calories purchased in all but one of the sites (Vasiljevic et al. 2018). Clearly, the relationship between calorie labeling and portion selection is complex.

Provision of clear information about the number of servings or size of the portion served is another way in which labeling could be used to moderate intake. The effect of portion labeling on intake in response to increasing portion size was tested in a series of studies (Spanos et al. 2015; Reily and Vartanian 2016). The pilot study found that providing serving size information attenuated the PSE, but only when the large portion was labeled as providing four servings and not when labeled as providing two servings (Spanos et al. 2015). The subsequent study compared intake across portions of pasta that were not labeled, labeled as small or large, or labeled and shown in comparison to a reference portion. In contrast to the pilot study, results showed no influence of portion size labels on the PSE (Reily and Vartanian 2016).

The inconsistency of findings relating calorie and portion labeling to portion selection and intake makes it difficult to interpret how effective this strategy will be in countering the PSE. Few studies have tested how labeling affects the relationship between the amount served and measured intake, and the available studies are small in scale. Field studies testing the impact on the PSE of labeling, both alone and in combination with other strategies for portion control, are needed.

Training in Portion Control

Conveying information about appropriate portions through education, which requires active learning, is an approach that has become an integral part of most dietary weight loss programs. Moreover, training in portion control is often recommended in public health messages for managing energy intake and body weight (e.g., Rolls 2014; CDC 2016; NIDDK 2016). However, few studies have investigated the effects of portion size education on intake from large portions. In one study, the PSE was compared between a control group and group that received a single training session that included information related to portion control. Results showed no differences in intake between the groups (Cavanagh et al. 2014).

It is not surprising that a single session in portion-control education was insufficient to counter the PSE; more extensive training would likely be needed to induce a behavioral change. The Portion-Control Strategies Weight Loss Trial extended portion instruction to a full year. This included standard advice to eat less, use of pre-portioned foods, and portion selection using measuring tools and food energy density (Rolls et al. 2017). To test whether this prolonged training attenuated the PSE, Zuraikat et al. (2018a) compared the response to portion size of women who had completed the trial to untrained control women with either normal weight or overweight. On four different occasions, participants came to the laboratory to consume a lunch of multiple foods that varied in portion size across visits. Although trained participants and both groups of untrained controls all consumed more food by weight when served larger portions, the trained women consumed fewer calories across meals than untrained controls. This was achieved not by reducing the amount of food consumed but by eating a greater proportion of the lower-energy-density foods served at the meals (Zuraikat et al. 2018a). Results suggest that prolonged training in portion-control strategies can be an effective method to moderate energy intake from large portions. Moreover, training should highlight preferential selection of lower-energy-dense foods, as this is a more sustainable strategy than eating less and has been shown previously to moderate energy intake from large portions (Rolls et al. 2010).

Portion-Control Tools

A number of tools have been created to help consumers determine how much to eat. For example, instruments to improve accuracy of portion estimation are often used in portion-control training; however, the efficacy is difficult to assess, since intake is rarely measured and effects can vary across the different portion-estimation tools (Pedersen et al. 2007; Kesman et al. 2011; Rolls 2014; Huber et al. 2015; Faulkner et al. 2016; Almiron-Roig et al. 2016). Moreover, use of many of these portion-control tools is unlikely to be sustained over time (Spence et al. 2015).

The tool that has received the most attention for managing portions is smaller dishware, particularly plates. The proposition is that consumers will use dishware size as an anchor to determine an appropriate amount to select and eat (Wansink 2004; Wansink and van Ittersum 2013). The notion of a solution as simple as reducing the size of tableware to manage the PSE still dominates much thinking in the field. For example, a Cochrane systematic review concluded that larger tableware and packages encourage increased intake in comparison to smaller sizes (Hollands et al. 2015). The authors suggest that "policies and practices that successfully reduce the size, availability and appeal of larger-sized portions, packages, and tableware could contribute to people selecting and consuming less in the immediate and short term" (Hollands et al. 2015, p. 2). However, another systematic review found no consistent effect of dishware size on intake, suggesting that policy recommendations related to dishware size may be ineffective or premature (Robinson et al. 2014). It is not clear that dishware size will lead to a better understanding of appropriate portions or have long-term effects on intake or body weight; such data are needed before evidence-based policy advice is implemented. In addition, a focus on dishware size could distract from the major issues related to portion size: the types and amounts of foods and beverages served. This was demonstrated empirically by a study finding that individuals provided with smaller plates cut down on the proportion of vegetables, rather than high-energy density items, when serving themselves from a buffet (Libotte et al. 2014).

If the focus shifts from the size of the plate to what is on it, there is a tool that shows promise for managing portions. Dietary recommendations from several countries (National Health Service (UK) (NHS 2016), the National Health and Medical Resource Council (Australia) (NHMRC 2017), and the Health Promotion Board (Singapore) (HPB 2018)), including MyPlate in the USA, divide the plate into the proportions of food groups that should comprise the meal and, more generally, the diet (USDA 2018b). Half the plate should be filled with vegetables and fruits. Although more research on the effect of proportional plates is needed, there are positive initial findings. In a two-week study, adults with obesity who were invited to use a proportional dishware set along with calibrated serving spoons served themselves larger portions of vegetables and found the tools acceptable for continued use (Almiron-Roig et al. 2016). In addition, several studies have shown that using a proportional plate for six months was associated with significant weight loss (Pedersen et al. 2007; Kesman et al. 2011; Huber et al. 2015). By promoting increased proportions of vegetables and fruits, these plates can help reduce meal energy density and energy intake. Longer-term trials are needed to determine whether use of proportional plates can lead to sustained changes in intake and body weight. Best results will likely be observed when pairing proportional plates with additional strategies to reduce dietary energy density, such as increasing the palatability of low-relative to high-energy density foods (Roe et al. 2016; Zuraikat et al. 2018a).

Mixed results from standard approaches to managing portions, such as portion labeling, education, and tools, make it difficult to draw conclusions on the efficacy of these strategies to limit intake. What positive findings do exist suggest that efficacy is related to the impact of the strategy on dietary energy density. For example, portion-control training led women to moderate energy intake through preferential selection of lower-energy-density foods (Zuraikat et al. 2018a). Likewise, proportional plates could reduce intake by prompting individuals to fill half of their plate with vegetables and fruits, thereby reducing meal energy density.

Strategies for Managing Portions: Leveraging the Properties of Food

The most effective portion management strategies will not simply reduce the amount consumed, but will improve diet quality and reduce overall dietary energy density (Casazza et al. 2015; Rolls 2009, 2010, 2017; Rolls et al. 2014b; Smethers and Rolls 2018). The possibility that portion size can be used strategically to reduce dietary energy density and energy intake was tested empirically in a study that shifted the proportions of foods on the plate, either by adding more vegetables or by substituting them for the meat and grain components (Rolls et al. 2010). Both strategies demonstrated that larger portions can be used positively to increase vegetable intake. Overall meal energy intake was reduced, but only when the increased serving of vegetables replaced other more energy-dense meal components to lower meal energy density (Fig. 5). Studies in preschool children also indicate that reducing meal energy density through increasing the proportion of vegetables and fruits served increases intake of these foods and reduces overall energy intake (Leahy et al. 2008a, c, Spill et al. 2011a, b).

Papers that have reviewed the evidence on how to manage large portions have not given sufficient consideration to dietary energy density modifications (Vermeer et al. 2014; Benton 2015; Hollands et al. 2015; Marteau et al. 2015). Portion size and energy density combine to determine energy intake. While the amount of food served influences intake, research also shows that people have a tendency to eat a consistent weight of food when the portion served is unchanged (Rolls 2009). This was demonstrated in a study covertly varying portion size and energy density of meals served over two-day periods (Rolls et al. 2006b). Indeed, there was a main effect of portion size, such that less food was consumed when 1530 g was served per day compared to when 2040 g was served. However, when comparing intake between conditions in which the amount of food served was held constant but energy density differed by 25%, it was found that the weight of food consumed

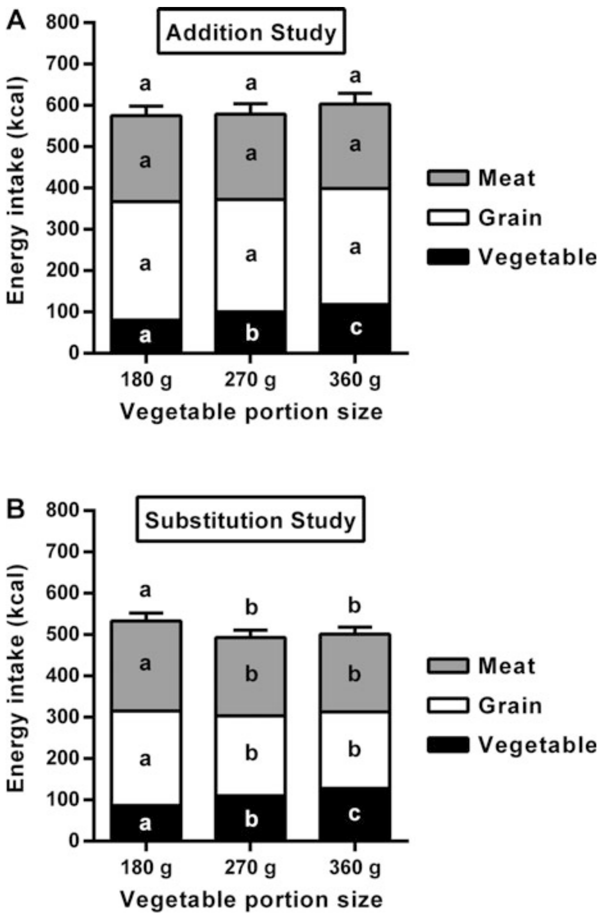

Fig. 5 (**a**) Increasing the portion size of vegetables served at a meal while keeping other components constant results in increased vegetable intake without increasing energy intake. (**b**) Substituting lower-energy-density vegetables for higher-energy-density meal components leads to increased vegetable intake and reduces overall meal energy intake. (Figure reprinted from Rolls et al. 2010, with permission from Oxford Academic)

was similar across days, despite differences in energy density (e.g., for standard portions: 2279 ± 67 g/2d vs 2251 ± 76 g/2d consumed). Thus, varying energy density results in a proportional change in energy intake when similar amounts are served and even larger changes when portion size is varied concurrently. This response emerges early in life as shown in studies in preschool children (Leahy et al. 2008a, b; Rolls and Leahy 2010; Kling et al. 2016; Smethers et al. 2019b) and persists even when the energy density of the diet is varied over multiple days (Rolls et al. 2006b; Leahy et al. 2008c; Smethers et al. 2019b). Taken together, when portions are large, energy intake can be reduced by lowering the energy density of the meal, and this reduction can be sustained over time. It is noteworthy that palatability does not need to be sacrificed when reducing energy density. Experimental studies increasing the proportion of vegetables and fruits in recipes, as well as reducing fat and sugar, have lowered meal energy density by 30% without declines in ratings of palatability (Rolls 2009). This is important given the influence of palatability on the PSE (Roe et al. 2016; Zuraikat et al. 2018a).

These findings demonstrate the importance of energy density in the relationship between portion size and energy intake. Advice urging people simply to eat less overall is an oversimplification since intake of low-energy-density, nutrient-rich foods is too low. Instead, despite some additional complexity in the message, individuals need to be educated on how to lower the energy density of their diet so they can eat satisfying portions. This, in practice, means limiting intake of foods high in energy density and encouraging consumption of low-energy-density foods such as vegetables, fruits, and other fiber- and water-rich foods and generally following the advice in dietary policies (HHS and USDA 2015; WHO 2018).

Portion Control in the Context of Weight Loss

Thus far, the discussion of strategies for managing food portions has focused on changes in acute intake; however, the ultimate goal is to aid in weight management. Portion-control strategies have been studied in the context of behavioral weight loss programs in order to determine their impact on body weight (Rolls 2014).

Using Pre-portioned Foods to Aid Weight Loss

While education and tools provide information on what is an appropriate amount to eat, liquid meal replacements, meal bars, and frozen main dishes provide a structured meal plan, helping to manage the influence of cues from the food and environment (Rolls 2014). Clinical evidence supports use of meal replacements to moderate intake and reduce body weight, and the research related to these prepackaged foods and liquid meal replacements has been reviewed previously (Wing and Jeffery 2001; Heymsfield et al. 2003; Heymsfield 2010; Rolls 2014; EFSA 2015; Raynor and Champagne 2016). Randomized clinical trials find that consuming pre-portioned foods in place of a self-selected diet can lead to successful weight loss as well as maintenance of weight loss, even when portion-controlled and self-selected diets are matched for energy content (summarized in Wing and Jeffery 2001; Heymsfield 2010; Rolls 2014). Although pre-portioned foods have been effective for weight management, the mechanisms underlying the success of pre-portioned foods for moderating intake remain to be identified. Effects could be driven by decreasing exposure to large portions or providing structure in the current food environment (Wing 1997; Rolls 2014).

Do Different Portion-Control Strategies Vary in Their Influence on Body Weight?

As reviewed above, much of the previous research on portion control for weight loss has focused on the use of pre-portioned foods and beverages (Wing and Jeffery 2001; Heymsfield et al. 2003; Heymsfield 2010; Rolls 2014). More recently, trials have evaluated whether instructing individuals in a variety of strategies for managing food portions can affect weight status. The PortionControl@Home weight loss trial highlighted the challenges associated with sustainability of portion-control training (Poelman et al. 2015). Provision of instruction in strategies such as portion-control cooking skills showed greater early success in reducing BMI than standard advice. By the one-year follow-up, however, there was no difference in BMI reductions between the groups (Poelman et al. 2015). It could be the case that certain strategies would be more effective or sustainable than others over time; however, that information could not be determined from this trial.

To determine whether certain portion-control methods were more effective than others, the year-long Portion-Control Strategies Trial compared weight loss across three groups of women with overweight or obesity. They were (1) taught to structure their diet around pre-portioned foods and provided vouchers for those foods, (2) provided tools to manage food portions and advised to use energy density to determine how much to eat, or (3) given standard advice to eat less, select nutritious foods, and increase physical activity (Rolls et al. 2017). The pre-portioned foods group achieved the greatest level of weight loss across the groups in the first three months; on average, women in this group lost 5.1 ± 0.4 kg compared to 3.8 ± 0.4 kg for the other two groups (Fig. 6; Rolls et al. 2017). Other trials also found that provision of prepackaged foods was associated with greater weight loss compared to a self-selected diet over similar periods of time, such as two (Hannum et al. 2004, 2006) and three months (Rock et al. 2016). In the Portion-Control Strategies Trial, however, the greater weight loss in the pre-portioned foods group compared to the other groups was not maintained beyond the first three months. Consequently, the magnitude of weight loss (4.5 ± 0.5 kg across groups) at the end of the 12-month trial did not differ across groups (Rolls et al. 2017). Since all three strategies led to clinically significant levels of weight loss (~6% of initial body weight), weight management programs should encourage whichever strategies participants find most sustainable.

The efficacy of pre-portioned foods in promoting weight loss early in the Portion-Control Strategies Trial could have been because they were easy to adopt without

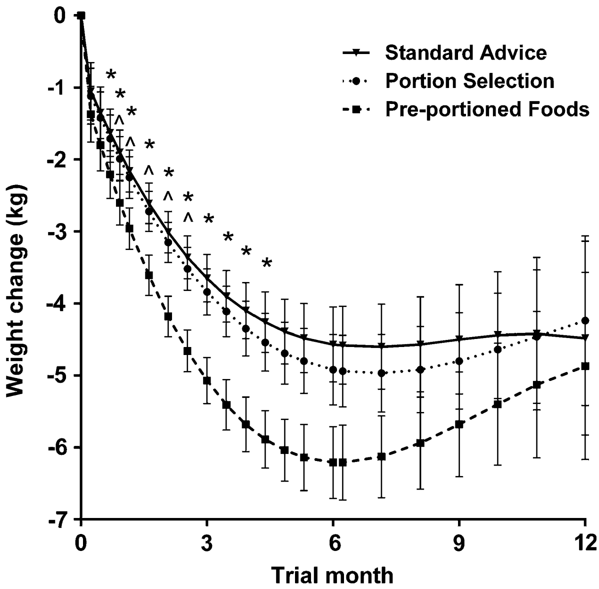

Fig. 6 Trajectories of weight loss in response to instruction in different portion-control strategies, including using pre-portioned foods, using tools and energy density for portion selection, and standard advice to eat less. The pre-portioned foods group achieved the greatest level of weight loss in the first three months of the trial; however, by the end of the trial, no differences were observed across groups. Notably, all strategies led to clinically significant weight loss. (Figure reprinted from Rolls et al. 2017 with permission from Springer Nature)

training or because vouchers for meals provided free food. The rate of weight loss paralleled the number of cost-reducing vouchers provided and declined as vouchers were tailored off. Incentives to help continued use of pre-portioned foods could improve long-term effectiveness. It is also notable that strategies related to reducing energy density showed promise for sustainability (Rolls et al. 2017). For example, all groups in the Portion-Control Strategies Trial significantly increased their reported use of fat-reduction strategies (from baseline) until the end of the trial. These data align with findings from a follow-up study in which the PSE was compared between a subset of women who completed the trial and untrained controls (Zuraikat et al. 2018a). Women who completed the Portion-Control Strategies Trial moderated their energy intake compared to controls, but they did so by reducing meal energy density and not by eating less. These results further emphasize the importance of energy density in managing intake from large portions. Developing an understanding of why use of some strategies for managing food portions persists over longer periods of time (e.g., reducing energy density) and why use of others does not will be crucial in developing both effective and sustainable methods to manage energy intake and body weight.

Managing Portions in the Current Eating Environment

The previous sections summarized various strategies for managing food portions. While some show promise, it is not clear that they can be sustained in the current obesogenic environment characterized by large portions of energy-dense foods.

Several ambitious studies have tested the effectiveness of managing portions in natural environments.

One study in England recruited nine worksites to reduce portions of main meals, side dishes, desserts, and cakes available in their cafeterias by a minimum of 10% (Hollands et al. 2018). This study provided insight into the challenges associated with trying to modify the eating environment: three of the sites did not reach criteria to be included in the assessment, and in the remaining six sites, implementation varied widely. Furthermore, there was no significant reduction in energy intake when all six sites were combined, though several sites did show some decline in energy purchased. Data indicated that reductions in portion sizes of targeted foods may have led to increases in energy purchased from foods not intervened upon. Interviews with the worksite managers also highlighted potential barriers to implementing changes in portion size; for example, many foods come prepackaged, and there is a risk that consumers will perceive a loss of value (Hollands et al. 2018). For portion size reductions in restaurants to be both effective and well-received, a series of incremental reductions over time may be needed.

While the previous trial implemented a standard approach of reducing food portions, another trial aimed to use portion size strategically to influence eating behaviors. In that study, conducted in three restaurants, the proportion of vegetables to meat served was varied: vegetable portions were increased, and meat portions were decreased from standard amounts (Reinders et al. 2017). Similar to results in a controlled environment (Rolls et al. 2010), substituting larger vegetable portions for a higher-energy-density meal component (meat) was associated with increased vegetable intake. Notably, consumers were equally satisfied with their meals following the shift from larger meat to larger vegetable portions (Reinders et al. 2017). Meal energy intake was not assessed in the restaurant, but this study suggests that shifting the proportions served, such as increasing the proportion of lower-energy-density vegetables, could nudge consumers toward meeting current dietary recommendations while lowering dietary energy density and maintaining satisfaction.

These studies demonstrate the inherent challenges associated with modifying the eating environment to help manage portions; however, initial findings suggest that such changes could be feasible and effective in moderating intake. Leveraging the effects of portion size by shifting the proportions served may be more effective than simply reducing the size of portions. Increasing the proportion of lower-energy-density foods while simultaneously decreasing the portion served of high-energy-density foods could also be met with less resistance from consumers.

Summary and Conclusions

The effect of portion size on intake is robust across different foods, settings, and individuals. Increased energy intake from large portions is sustained over prolonged periods and is likely a factor contributing to weight gain and obesity (Young and

Nestle 2002, 2012; Kant and Graubard 2006; Berg et al. 2009). Given these relationships, along with the prevalence of oversized portions of energy-dense foods, development of effective strategies to counter the PSE has been at the forefront of public health research.

Results of studies testing approaches to control food portions are variable. Provision of information on appropriate portions, such as through labeling or education, does not consistently attenuate the PSE. Similarly, reducing dishware size has limited effects (Robinson et al. 2014). An exception may be plates that encourage larger proportions of fruits and vegetables; these show promise, since they can prompt reductions to dietary energy density. Indeed, by far the most consistent and effective method to moderate energy intake from large portions has been to reduce meal energy density, which has a substantial effect on energy intake (Rolls 2009).

Both controlled experimental trials and studies in natural environments have shown that portion size can be used strategically to reduce meal energy density and intake (e.g., Rolls et al. 2010; Reinders et al. 2017). By serving large portions of lower-energy-density meal components while simultaneously reducing portions of more energy-dense alternatives, individuals can consume satisfying amounts of food while moderating energy intake. Indeed, evidence from a randomized controlled weight loss trial and subsequent follow-up study suggests that strategies related to reducing energy density may be more sustainable than other methods for managing food portions, such as simply eating less (Rolls et al. 2017; Zuraikat et al. 2018a).

While certain strategies have been shown to be effective on their own, intervening on the PSE from multiple approaches will likely increase the magnitude and sustainability of effects on energy intake. Starting at the level of the food, methods to reduce energy density can be encouraged. This could be achieved directly, through overtly or covertly modifying common recipes by increasing the proportion of water-rich fruits and vegetables (Rolls et al. 2010; Blatt et al. 2011), or indirectly, through education (Zuraikat et al. 2018a), or tools like MyPlate (USDA 2018b). Similarly, given the roles of bite size and eating rate in the PSE (Burger et al. 2011; Almiron-Roig et al. 2015; Zuraikat et al. 2018c), intake could be moderated by modifying food properties to increase oral processing time (Bolhuis et al. 2014; Ferriday et al. 2016; McCrickerd et al. 2017b). At the level of the individual, training to increase responsiveness to internal cues of hunger and satiety could supplement food-level changes. Environmental changes, such as labeling or prompting the use of “doggy bags” in restaurants, could further increase the likelihood that individuals do not overeat from large portions. Strategies shown to have efficacy in the laboratory need replication in field settings to confirm effectiveness. As successful interventions continue to be identified, efforts to test strategies in combination should be a priority as this approach has the potential to mitigate the PSE.

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The Impact of Eating Rate on Energy Intake, Body Composition, and Health

35

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Abstract

The modern food environment is often characterized by an increasingly assessable diet of inexpensive, energy-dense, and highly palatable foods. Extensive evidence indicates the eating rate of foods (g/min or kcal/min) is associated with energy intake, body composition, and the associated risk of food-based noncommunicable diseases. Moderating eating rate during food intake offers a simple but effective strategy to regulate energy consumption and body weight. Research evidence from population and experimental studies demonstrates that eating at a slower rate can produce sustained changes in *ad libitum* energy intake, influence body composition, and moderate our metabolic response to ingested nutrients. Understanding which factors combine to influence eating rates affords new opportunities to design "slower" foods that can reduce the risk of over-consumption and support better long-term energy control. This chapter summarizes the role of eating rate in energy intake and body composition, provides an overview of development of eating behaviors in infancy and childhood, and describes the individual and food-based factors that can influence eating rate and its metabolic impact. The chapter provides a summary of research that has intervened to slow eating rate and demonstrates opportunities to support energy intake reductions using texture-led changes to eating rate.

Introduction: Impact of Eating Rate on Energy Intake and Body Composition

Obesity is a disorder of energy balance that is driven by overconsumption of calories relative to energy expenditure (Hall and Guo 2017) and is associated with a range of metabolic disorders responsible for much of the food based non-communicable diseases and ill-health that burden our society (Hruby et al. 2016). The increasing prevalence of obesity has led many to speculate that the food environment may be promoting greater energy intakes through the increased availability of inexpensive, energy-dense, and highly palatable foods. Attention has been focused on educating people to regulate their food intake by promoting healthy eating alongside reshaping the food environment. Interventions focused on eating rate have attracted attention as a simple and effective strategy to better regulate food intake and body weight (Bellack 1975). The rate of eating can be summarized as the g/min or kcal/min of energy consumption during a meal and has been suggested to act as an indicator of appetite avidity and satiety sensitivity (Llewellyn et al. 2008), wherein a slower eating rate results in reduced food intake within a meal. Previous research has demonstrated the efficacy of slower eating to reduce food intake (Bolhuis et al. 2014a; Forde et al. 2013b; McCrickerd et al. 2017). The rate a person eats is thought to be the result of the combination of their internal drive to eat and the food texture environment they choose to consume (Forde et al. 2019). This is supported by extensive reports from epidemiological research which consistently show that faster self-reported eating rates are associated with increased food intake, increased body weight (Maruyama et al. 2008; Sasaki et al. 2003), and a higher risk of obesity and cardio-metabolic disease (Lee et al. 2013; Mochizuki et al. 2012; Nagahama et al. 2014; Sasaki et al. 2003). Therefore, understanding what drives faster eating rates creates opportunities to identify moderators of this behavior and the potential to support long-term changes to energy intake and body weight.

This chapter summarizes the evidence supporting the role of eating rate in promoting energy intake and higher body weight and its association with non-communicable diseases. The chapter will provide an overview of the individual and food-based factors that can influence eating rate and describe the metabolic impact of faster eating rates on health and body composition. Finally, we summarize research that has demonstrated opportunities to intervene on eating rate at both the individual and food environment level to support reductions in energy intake.

Relationship Between Eating Rate, Energy Intake, Obesity, and Non-communicable Diseases

Epidemiological Evidence for an Association Between Eating Rate, Body Composition, and Health

In population research the rate of eating is often self-reported as slow, medium, or fast. This self-reported eating rate measure has been widely reported in the epidemiological literature (Sasaki et al. 2003), and shown to have good reliability (Maruyama et al. 2008). Epidemiological studies have consistently shown that individuals that self-report a higher eating rate are at greater risk of overweight and obesity (Maruyama et al. 2008; Sasaki et al. 2003; van den Boer et al. 2017a). For instance, compared with adults who report slower eating, those who ate at a faster rate were 1.8- to 2.1-fold more likely to be overweight or obese in a large Japanese cohort (Maruyama et al. 2008). Longitudinal studies have shown that self-reported faster eating can also predict long-term weight gain and obesity (Gerace and George 1996; Tanihara et al. 2011). For example, those reporting faster eating gained 9.9 pounds over 7 years compared to 6.8 pounds among those consistently reporting a slower eating rate (Gerace and George 1996). In a separate population, faster eaters gained 1.1 kg more over an 8-year period than those self-reporting as slow to medium-eaters (Tanihara et al. 2011) suggesting an association between eating at a faster rate and greater prospective weight gain. Faster eating rate has also been positively associated with a greater incidence of type-2-diabetes biomarkers including interleukin-1β and interleuin-6 (Mochizuki et al. 2012), and the onset of type-2-diabetes (Sakurai et al. 2012), among otherwise healthy men even after adjusting for energy intake and BMI (Mochizuki et al. 2012). These findings indicate that insulin resistance (Otsuka et al. 2008) and weight gain may stem from consistently consuming greater energy by eating at a faster rate. Individuals that self-report eating faster have also been shown to have a higher risk of metabolic syndrome (Zhu et al. 2015), and non-alcoholic fatty liver disease (Lee et al. 2016). Faster eating is also strongly associated with markers of the metabolic syndrome including higher blood lipid profiles and greater waist circumference (Lee et al. 2013; Nagahama et al. 2014). These associations have been observed in both Asian and non-Asian populations, despite differences in diet and ethnicity.

Empirical Evidence of an Association Between Eating Rate, Body Composition, and Health

Across studies there is a large variation in the strength of associations between faster eating rates and noncommunicable diseases. Many of these discrepancies may be dependent on the accuracy of self-reported eating rate, and whether this accurately reflects observed differences in real life. Recent studies have confirmed that self-reported eating rate reflects differences in measured eating rates at an individual rather than a group level, indicating the findings from epidemiological comparisons of eating rate would hold true when measured (Petty et al. 2013; van den Boer et al. 2017a).

In laboratory studies eating rate has been objectively measured using a range of approaches including behavioral coding of video recordings, timers, bite counting devices or computerized software to track food disappearance from the plate (i.e., Universal eating pattern monitor). A large body of laboratory-based evidence supports a link between faster eating rate and an increased acute energy intake (Andrade et al. 2008; Forde et al. 2013b; Martin et al. 2007; Scisco et al. 2011; Zijlstra et al. 2009). Eating faster has been associated with increased food intake by increasing the rate of energy ingestion (kcals/min) during a meal (Spiegel and Jordan 1978). Individuals consume greater energy when instructed verbally to eat at a faster rate (Andrade et al. 2008) or when guided by a computerized task to increase their rate of intake (Martin et al. 2007; Scisco et al. 2011). In both cases, verbal or visual instructions that slow the rate of eating also led to a reduction in energy intake. Participants that were instructed to eat for an extended duration of 21-minutes decreased their *ad libitum* meal intake by an average of 67 kcals compared to a faster eating comparison group (Andrade et al. 2008). A meta-analysis of 21 studies confirmed that when participants eat at a faster rate they increase their overall energy intake, with a small- to medium-sized effect of 0.45 (Robinson et al. 2014).

Differences in Eating Rate and Microstructure by Weight Status

Whether eating rate is a cause or consequence of higher body weight has been a research question for many years, with numerous studies exploring whether people with a higher body weight eat with a distinctive microstructure to support faster eating rates. Eating microstructure encompasses behaviors such as average bite size (g/bite), chews per bite, total oral exposure (minutes), and total bites, and is best summarized as overall eating rate by weight (g/min) or energy intake rate (kcals/min). Results from some early comparative work by Ferster and colleagues showed that individuals with obesity tended to take larger bites and eat at a faster rate than a control group of lean individuals. The conclusion was that individuals with obesity would consume less if they slowed their intake by taking smaller bites (Ferster et al. 1962). Subsequent experimental studies however have been equivocal in their findings, with some confirming these observed differences in eating styles (Gaul et al. 1975; Park and Shin 2015), while others have found no differences in eating styles between individuals from different weight status subgroups (Spiegel 2000; Spiegel et al. 1993). Part of the lack of agreement in these results can be attributed to differences in the measures of eating rate, but it is also likely that if differences exist, they are likely to be nominal and may be partially due to the higher energy needs associated with increased body weight. Normal eating microstructure is typically characterized by a deceleration in eating rate towards the end of a meal, characterized by longer gaps between bites which signal the onset of satiation. Previous research has suggested that individuals with obesity retain a constant linear eating speed of eating throughout the meal which has been proposed to reflect an absence or distorted perception of satiety (Zandian et al. 2009).

Based on extensive evidence from both epidemiological and empirical studies, faster eating rates appear to have a significant role in promoting greater energy intakes acutely and have been associated with increased prospective weight gain over time. To date there is little consistent evidence to support the idea that faster eating rate is solely linked to a higher weight status, and wide variations in eating rate have been observed across all weight classes.

Factors that Can Influence an Individual's Eating Rate

The rate at which a meal is consumed has been described as a combination of an individual's drive to eat and the properties of the foods they choose to consume (Forde et al. 2019). Here we summarize the development of eating behaviors during childhood, and the main factors that have been reported to influence eating rate, summarizing factors related to the (i) person, (ii) food properties, and (iii) food environment, and the interaction between these factors.

Development of Eating Behaviors During Childhood

Eating rate is a heritable phenotypic with a heritability index of 0.62, making it one of the highest heritability estimates reported among appetitive traits, with a greater score than disinhibition, palatability, or neophobia (Llewellyn et al. 2008). From an early age, infants from 2 to 4 weeks old that were observed to have a greater sucking voracity later had a faster eating rate and greater prospective weight gain over time (Agras et al. 1987, 1990). Eating at a faster or slower rate may reflect both an individual's drive to eat and their early life experience with foods. Pre-weaning parental feeding practices such as breast feeding have been shown to stimulate better early life orofacial muscle and skeletal development in the developing infant when compared to bottle feeding (Viggiano et al. 2004), though no clear longer-term impact on orofacial muscle and skeletal development was found between breast or bottle feeding.

Early life exposure to a wide variety of food textures is important to promote diversity in food preference and a broader texture acceptance (Coulthard et al. 2009). In the development of eating behaviors both bite force and mastication abilities are influenced by early-life texture experiences (Wang and Ge 2015) which in turn support the consumption of harder and more complex textures in later childhood (Gisel 1988). One recent study tracked infant texture acceptance longitudinally alongside oral development between 6 and 18 months (Demonteil et al. 2019). This study demonstrated that chewing behavior begins to emerge and stabilize at approximately 8 months and is well established by 10 months, coinciding with the acceptance of harder and more complex textures. However, it remains unclear which elements of early life texture experiences and oral development influence the emergence of differences in eating rate, or how differences observed during infancy track from later childhood and adulthood.

Infants with greater sucking voracity gain weight at a faster rate, and in a similar way children that tend to eat faster have also been shown to gain weight at a faster rate over time (Berkowitz et al. 2010). These differences in eating rate and the associated microstructural patterns of eating may track into later childhood, and have been shown to have a sustained impact on the energy intake and prospective weight gain over time (Berkowitz et al. 2010; Okubo et al. 2017). Recent findings from the Growing up in Singapore to Healthy Outcomes birth cohort (GUSTO) demonstrate that among 4.5-year-old children, those that eat at a faster rate and for a longer duration consumed an average of 75% more energy within an *ad libitum* meal, than those that ate slower. Children who ate faster had a consistently higher energy intake and this was associated with increased BMI z-score and indices of whole-body adiposity (Fogel et al. 2017b). Those children that showed a faster rate of eating at 4.5 years still had a faster eating rate and greater increases in BMI z-scores and adiposity at 6 years, indicating the stability of this behavior and links to prospective weight changes (Forde et al. 2019). In this study, children that ate at a faster rate did so by taking larger bite size, chewing less *per* gram with a reduced oro-sensory exposure time *per* bite (Fogel et al. 2017a). This has been described as an "obesogenic" eating style that strongly associates with increased energy intake and not exclusively limited to children with overweight or obesity, but was also seen among children with BMI z-scores in the upper normal range (Fogel et al. 2017a, b). Taken together, these findings highlight the early emergence and consistency of eating rates in childhood, which associate with both increased energy intake and more rapid weight and adiposity gains during the preschool years.

Throughout childhood, parents often use feeding practices during meal time to encourage or restrict a child's food intake (Faith et al. 2004). Research has shown that within-meal frequency of parental feeding practices is associated with faster eating rates and greater energy intakes (Drucker et al. 1999; Fogel et al. 2018a). Longitudinal data also show that within-meal parental feeding practices, such as instructions to speed up or slowdown, restrictions around food choice, encouragement and coercive prompts to eat, have also been associated with faster eating rates and a higher BMI z-score suggesting a bidirectional relationship between the parent's feeding practices and child's eating behaviors (Fogel et al. 2018a; Fries et al. 2019; Quah et al. 2019). Faster eating rates have also been associated with stronger appetitive traits, enjoyment of food, food responsiveness and lower satiety responsiveness and slowness of eating, possibly reflecting a heightened responsivity to the food environment and a decreased sensitivity to satiety cues. Eating faster has been shown to mediate associations between greater food enjoyment, lower slowness in eating, lower food fussiness, and higher energy intakes, suggesting that eating rates associated with increased obesity risk may be underpinned by appetitive traits, and may be one of the behavioral pathways through which these appetitive traits promote greater energy intakes (Fogel et al. 2018b). More broadly, children with lower inhibitory control also tend to select multiple food servings, served themselves more and consume their meal at a faster rate, indicating that eating rate may be an important behavioral manifestation of this trait which can increase the risk of overweight or obesity (Fogel et al. 2019).

The early feeding practices and the food environment a child is exposed to play an important role in shaping their eating behaviors, and may exacerbate a stronger appetite response and poorer inhibitory control in an energy rich food environment. This can manifest through the early emergence of habitually faster eating rates that can exert a sustained influence on energy intake and increase prospective weight and adiposity gains during childhood, increasing the risk of obesity and metabolic dysfunction in later life.

Individual Factors that Can Influence Eating Rate

Eating rate has been shown to consistent at an individual level, across several different food products such that a tendency to eat faster for one meal is often generalized to faster eating across many other products (Guy-Grand et al. 1994). A recent study measured eating rate in participants who consumed the same meal during four separate *ad libitum* test sessions, and repeated this comparison across four separate feeding trials with a similar design (McCrickerd and Forde 2017). Results show that eating rate meal to meal was highly stable for each individual, with a person's eating rate during their first meal significantly predicting both their eating rate and energy intake during subsequent meals (McCrickerd and Forde 2017) (Fig. 1). This suggests that eating rate is a consistent and "automatic" behavior that is stable over time (Ioakimidis et al. 2011) and predictive of within-meal energy intake. Eating rate within an individual tends to be consistent but varies considerably between individuals (Ketel et al. 2019), with wide variations in eating rate have been observed among young children (Fogel et al. 2017b), and adults (Devezeaux de Lavergne et al. 2015; Zijlstra et al. 2010). Children described as faster eaters (9.33 g/min) were reported to eat approximately twice as fast as those children described as slower eaters (4.43 g/min), independently of the foods being consumed (Fogel et al. 2017b). Similarly, adults described as faster eaters (17.4 g/min) consumed about twice as fast as those described as slower

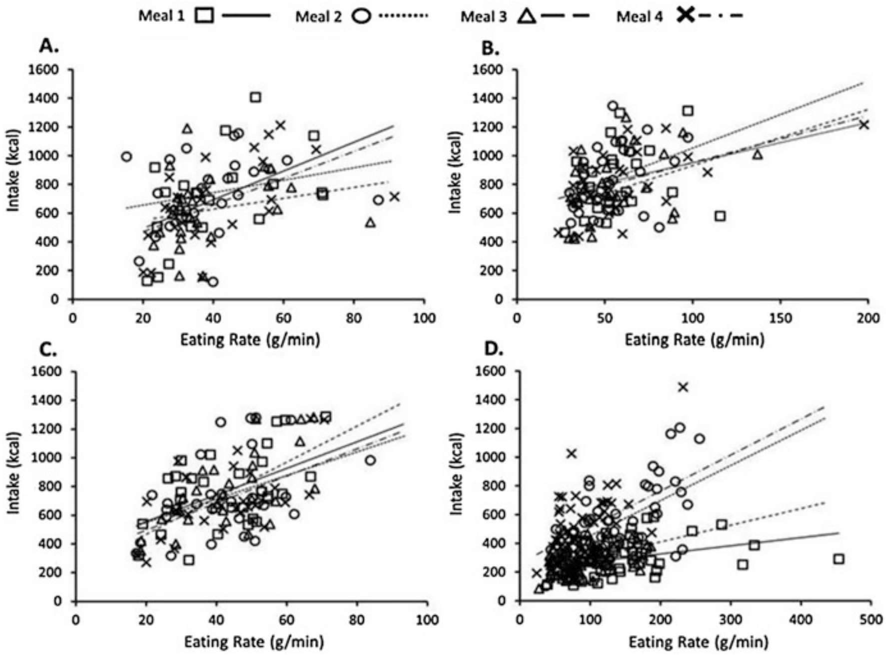

Fig. 1 Scatter plots of individual eating rates and energy intake across each of the four test meals consumed in (**A**) Study 1, (**B**) Study 2, (**C**) Study 3, and (**D**) Study 4. The lines represent the regression line of best fit for each meal. (From McCrickerd and Forde 2017)

eaters (7.8 g/min), for both hard and soft versions of the same test food (sausages) (Devezeaux de Lavergne et al. 2015).

Large differences in eating rate are consistently observed across genders, with one early study showing that independently of body size, females take more frequent bites with a smaller average bite size compared to men when consuming the same test food (Hill and McCutcheon 1984). Males have a larger average bite size for liquid, semisolid, and solid foods, and eat at a faster rate for solid foods, compared to women (Ketel et al. 2019; Park and Shin 2015). Males also have a higher maximal bite force (Palinkas et al. 2010), saliva flow rate (Percival et al. 1994), and cheek and lip compression strength (Clark and Solomon 2012), compared to women. These gender differences in oral anatomy and masticatory performance are plausible due to male's larger energy requirements which are linked to a higher lean muscle mass and resting metabolic rate. A recent study showed that across both genders, adults with higher lean muscle mass and basal metabolic rate had a higher eating rate (Henry et al. 2018), suggesting that eating faster may be an adaptive behavioral response to greater energy requirements.

Changes in oral health and dentition may also influence masticatory performance and studies have shown that older consumers tend to chew solid foods for longer, with more chews per bite compared to the young adults (Ketel et al. 2019; Mioche et al. 2004). Older consumers may experience a decline in their masticatory performance including oral health, dental status, jaw muscle strength, and bite force which, in turn, can lead to a lowering of their eating rate, changes in food choice, and the requirement for more chews *per* bite (Ketel et al. 2019). Masticatory performance and oral health status can therefore have a significant impact on food choice, enjoyment, and nutritional status (Schwahn et al. 2013). The total number of functional teeth has been suggested to affect masticatory efficiency (Boretti et al. 1995; Van der Bilt 2011). In adults, the loss of teeth posterior to the canines is significantly correlated with a reduction of masticatory efficiency (Hatch et al. 2001). Dental rehabilitation has been shown to be effective in reducing oral pain and can enhance chewing ability, and masticatory performance has been shown to improve following restorative dental treatment and prostheses (Allen and McMillan 2002).

In addition to age and gender, ethnic differences in cultural feeding practices may influence habitual oral processing behaviors. In one study Chinese participants were observed to have a lower average bite size and slower eating rate when compared to Dutch participants of a similar age across a range of different test foods (Ketel et al. 2019). Differences in eating behavior between the two ethnicities may be due to the differences in oral physiology and anatomy, with some reports suggesting differences in oral cavity volume (Xue and Hao 2006). Cultural differences in eating habits and food consumption contexts can also influence microstructural patterns of eating, with one study observing a smaller bite size and slower eating rate when the same test food was consumed using chopsticks compared to eating with a spoon or hands (Sun et al. 2015). These findings highlight that differences in eating rate can be influenced by individual differences in age, ethnicity, gender, and metabolic energy requirements in addition to cultural eating practices and textures encountered by consumers in their food environment.

The Influence of Food Texture on Eating Rate and Energy Intake

Texture is the dynamic sensation that arises from the combination of structural, mechanical, and surface properties of foods and beverages detected through the senses of vision, hearing, and touch. In addition to its contribution to sensory perception, a food's texture can also influence the oral processing behaviors required to form a swallowable bolus (Wee et al. 2018) and in this way can play an important role in moderating eating rate and regulating energy intake during a meal. We eat at a slower rate and consume less energy to satiation when provided with more textured versions of the same foods and this has been demonstrated for solid, semisolid, and liquid food textures (Bolhuis et al. 2014a; Forde et al. 2013b; Zijlstra et al. 2008, 2010).

The relationship between food and eating rate can be further explained by the oral breakdown path (Hutchings and Lillford 1988), which summarizes the breakdown process of a food into a swallowable bolus along three dimensions of degree of structure, lubrication, and time (Hutchings and Lillford 1988). When a food is consumed, it has to be first broken down in oral cavity to smaller particle sizes, lubricated with saliva, and agglomerated into a bolus before it becomes safe to swallow (Campbell et al. 2017). Several studies have shown that instrumental measures of food structure are directly linked to degree of oral processing, and differences in eating rate (Wee et al. 2018). Of all the macronutrients, proteinaceous foods have been reported to more often have a stiffer structure than the carbohydrate- and fat-rich foods; prolonging oro-sensory exposure time and reducing eating rate (Wee et al. 2018). Foods with greater innate lubrication, such as water and/ or fat content, tend to have faster eating rates and a faster time to swallow (Forde et al. 2017; van den Boer et al. 2017b; Viskaal-van Dongen et al. 2011).

Numerous recent studies have compared the eating rates of foods across a wide variety of different textures, macronutrient and energy contents (Forde et al. 2013a, 2017; Viskaal-van Dongen et al. 2011; van den Boer et al. 2017b). Harder (stiffer structure), thicker and chewier (less lubricated) foods (e.g., Tok, a Korean rice cake) require more chews and take a longer oro-sensory exposure time to form a swallowable bolus, producing a slower rate of eating than softer, thinner, and less chewy foods (e.g., cooked white rice). Eating rates of many solid foods have been observed in the range of <10–120 g/min, whereas for semisolids and liquids this range extends up to 600 g/min (Forde et al. 2013a, 2017; van den Boer et al. 2017b). Previous findings have shown that average bite size, chews per bite, and oro-sensory exposure time are strongly correlated with *ad libitum* energy intake (Bolhuis et al. 2014a, b). Slowing eating rate using food texture can be used to support a reduction in energy intake, though not all approaches to slowing eating rate have demonstrated this effect. Slowing down overall eating rate by increasing the pauses between bites was shown to be ineffective as a mean to reduce energy intake (Hermans et al. 2017). This suggests food structure manipulations which slow down eating rate naturally are likely to be more effective than approaches that require consumers to consciously adjust their natural eating habits to include prolonged pauses between bites.

Across a series of studies, researchers have explored the potential for texture-based differences in eating rate to reduce *ad libitum* energy intake while maintaining meal liking and post-meal fullness (Bolhuis et al. 2014a; Forde et al. 2013b; McCrickerd et al. 2017). In one example energy intake was compared across pureed and whole versions of the same savory meal with greater energy intake observed in the pureed meal condition and no significant difference in meal liking or post-meal appetite feelings (Forde et al. 2013b). Texture differences in meal components were used to produce a natural reduction in eating rate of approximately 20% to produce an average reduction in *ad libitum* energy intake of 12%. In a follow up study, slightly harder and softer versions of a hamburger and rice salad meal were served to participants in a cross-over design and intake at lunch and later energy compensation at dinner was recorded (Bolhuis et al. 2014a). Results showed participants consumed on average 13% less energy at lunch, and tended not to compensate for this reduced meal size later in the day to produce a total energy reduction of approximately 11% over the course of a full day, directly as a result textures differences served at lunch. More recently, across two studies researchers have explored the impact of texture-based reductions in eating rate in moderating energy consumption at breakfast when combined with reductions in energy density (study 1) and portion size (study 2).

Results again showed that the least energy was consumed when the thicker ("slow") meal was consumed at a lower energy density and in a smaller portion size (McCrickerd et al. 2017). These findings highlight opportunities to apply texture-based reductions in eating rate to support reductions in energy intake, which can be further enhanced when combined with reductions in energy density and portion size (McCrickerd et al. 2017). Importantly, across all studies, participants reported feeling equally full despite the decrease in energy intake and all foods were rated as hedonically equivalent as study participants ate in response to the textures served. Findings to date suggest that a 20% reduction of eating rate can lower *ad libitum* energy intake by between 10% and 15%, while sustaining food liking and post-meal satisfaction (McCrickerd and Forde 2017; McCrickerd et al. 2017). Further research is needed to establish whether such texture-based reductions in eating rate and energy intake persist over time to support sustained energy reductions and subsequent weight loss (Forde 2018a).

Harder food textures can be applied to reduce intake, but the reverse is also true as softer food textures that are easier to consume can promote greater consumption within and across meals. A texture- and energy density-modified "cottage pie" was shown to enhance energy intake in a crossover trial and proposed as an effective "food first" approach to support for individuals who struggle to meet their required energy needs (Pritchard et al. 2014). In a recent in-patient randomized controlled crossover study, Hall and colleagues found that when given 2 diets matched for total calories, macronutrients, and fiber, adults consumed significantly more energy *ad libitum* (~500 kcal/day) and gained more weight when consuming an ultraprocessed versus a less processed diet. Both diets were iso-energetic and matched for macronutrients; however, eating rate was significantly slower when participants were on the less processed diet, consuming 17 fewer calories *per* minute compared to ultraprocessed diet (Hall et al. 2019). These findings indicate that differences in food texture moderated participants eating rate and had a sustained impact on daily energy intakes that was sufficient to effect a change in body weight. The texture of industrially produced ultraprocessed foods was consistently softer and easier to chew and swallow, thereby increasing both eating rate and the overall energy consumed within and across meals. Future studies are required to better evaluate whether modern food processing can also be applied to enhance food texture in ways that can slow eating rate and support reductions in energy intake over time.

A food's flavor represents the integrated response to the smell, taste, and texture cues that emerge during consumption, and has also been shown to influence the rate of food intake within a meal. In one example, odor quality and intensity has been shown to influence the average bite size taken when consuming a semi-solid food (de Wijk et al. 2012). Flavor intensity may also indicate a higher nutrient content and influence eating microstructure (Forde 2016). Food palatability has also been shown to stimulate appetite, and enhance initial eating rate and through this facilitate greater food intake (Yeomans 1996). During the early stages of a meal, people tend to eat at a faster rate and can sometimes eat more when a food is perceived to have greater palatability (Bellisle and Le Magnen 1980). Palatability can influence intake by stimulating appetite and increasing the desire to consume a food through what is termed “appetition,” and through this promote faster eating rates and intake. This effect has primarily been observed during the first phases of a meal (Bellisle and Le Magnen 1980; Yeomans 1996). However, not all studies have shown an effect of increased palatability on food intake via faster eating, and it is likely this effect is dependent on meal context and the type of food consumed (Guy-Grand et al. 1994).

Elements of the Food Environment that Interact with Eating Rate to Promote Energy Intake

Portion size acts as a visual reference for the appropriate consumption amount (Marchiori et al. 2014), and larger portions have been shown to promote a larger average bite size and promote faster eating rates. Previous studies show that increased portion size is associated with a liner increase in bite size (Almiron-Roig et al. 2015; Burger et al. 2011), and larger bite sizes have been shown to increase eating rate and food intake (Forde et al. 2013a; Spiegel et al. 1993). In small-portion conditions, eating rate is reduced more quickly over a shorter period, whereas eating rate is faster and more consistent in larger portion conditions, up to an estimated threshold of approximately ~540 g (Almiron-Roig et al. 2015). This may be due in part to a natural tendency for “plate-cleaning” behavior where individuals plan to consume the full portion served. Seeing a larger portion may therefore prime the consumers and trigger individuals to maintain their initial eating rate for a longer duration within a meal in an effort to finish the portion and satisfy a predefined hunger goal (Burger et al. 2011). Interestingly, foods that are perceived as thicker and chewier are also often believed to be more filling (Forde et al. 2013a; Hogenkamp et al. 2011) which has been shown to result in the selection of smaller portions (McCrickerd et al. 2014). Texture cues such as increased viscosity have also been shown to slow the rate of consumption for semisolid foods (Zijlstra et al. 2009), suggesting this texture can influence both portion selection and eating rate during consumption (McCrickerd and Forde 2016). In this way, sensory cues pre-consumption such as texture or flavor may act as a cue to reduce portion selection and meal size due to their association with greater satiety. In a similar way, the well-established portion size effect whereby people consume more food in the presence of larger portions, has been shown to be larger for softly textured foods (Roe et al. 2016). Others have shown that energy intake is higher for high energy density foods that are eaten at a faster rate (Karl et al. 2013; McCrickerd et al. 2017). This further confirms that a food’s texture can interact with other elements of the meal (energy density/portion size) to impact both the rate of intake and the total amount of energy consumed to satiation.

Social facilitation can influence food intake by extending the duration of a meal (de Castro 1994), and through this may also influence eating rate. Individuals tend to eat faster and consume more when eating with multiple people and when their companions eat at a faster rate (Herman et al. 2003). People have been shown to replicate the eating behaviors of their eating companions, for example mimicking bite frequency by taking a bite within 5 s of their eating companion (Hermans et al. 2012).

This can influence eating rate when both eating speed, duration and overall intake speed become synchronized through a process of behavioral mimicry. The early meal termination of an eating companion has also been shown to indirectly alter the food intake of others (van den Boer and Mars 2015). In this way individuals often adjust their eating speed and food intake to that of their eating companions where their eating behaviors are triggered not by their desire to eat or the properties of the foods, but by cues from their eating environment.

What Is the Impact of Eating Rate on Metabolism?

As described earlier, eating at a slower rate has been shown to lower energy intake within a meal, but further studies have also demonstrated the impact of eating speed on post-meal fullness and hunger (Andrade et al. 2008; Zijlstra et al. 2009). The satiety response is defined as the intensity and duration of the absence of hunger post-meal and is mediated by the complex interplay between gastric emptying and a cascade of postprandial hormonal responses to the ingested food (Forde 2018b). In the hours' post-meal, there is a steady increase in the concentration of the orexigenic hormone ghrelin which produces sensations of hunger which when coupled with low levels of anorexigenic peptides that promote fullness such as peptide YY (PYY) and glucagon-like peptide-1 (GLP-1) (Benelam 2009). Research has shown that intravenous infusion of ghrelin in humans enhances appetite and increases the energy intake by 28% (Wren et al. 2001), whereas the intravenous infusion of PYY (the biologically active form) has been reported to inhibit food intake (Batterham et al. 2002). In a similar way, rate of eating has been shown to influence the excursion of satiety hormones when a longer chewing duration can stimulate greater anorectic hormone production. When food is chewed 40 times instead of 15 times, participants report feeling greater fullness and the additional chewing stimulates a longer postprandial suppression of ghrelin and reduced later energy intake. By contrast, the excursion of postprandial GLP-1 and cholecystokinin (CKK) levels were increased when the same quantity of food was chewed 40 times, though these responses were somewhat blunted among participants with obesity suggesting that extending chewing time may not have the same beneficial effect on satiety across all populations (Li et al. 2011). In another study, PYY and GLP-1 responses were increased during the early to mid-postprandial period when a fixed portion meal was consumed over 30 min compared to consumption of the same meal in a 5 min period (Kokkinos et al. 2010). Together, these findings indicate that eating more slowly and with more chews *per* bite both extends the meal duration and can promote an increased subjective experience of satiety which is supported by hormonal signaling of satiety producing less hunger and more fullness *per* calorie consumed. This effect seems to be primarily driven by the extended oral processing time as simply spacing the meal out for longer does not seem to produce the same impact on satiety. To test this, participants were asked to consume a meal normally or split into seven smaller equal meals that were consumed at intervals within a fixed time. There was a large variation in eating duration but little variation in eating rate when consuming the same fixed-portion meal and the result shows that spacing the meal for longer did not alter subjective feelings of satiety, though there were small differences in CKK and pancreatic polypeptide (PP) response (Karl et al. 2011). The finding illustrates the important contribution mastication makes to both the onset of satiation and the subsequent feeling of fullness post-meal for an equivalent calorie load.

Another important contribution to post-meal satiety comes from gastrointestinal transit time between meals (Juvonen et al. 2009). Foods with higher viscosity tend to be require a longer oro-sensory exposure time and slower eating rate, which has been suggested to stimulate a stronger cephalic phase response (de Graaf 2012). The putative mechanism is that a higher food viscosity stimulates a prolonged oro-sensory exposure time and lower eating rate and could also contribute to delayed gastric emptying and through this contribute to a greater satiety response (Juvonen et al. 2009; Marciani et al. 2001). An early example of the impact of food form and eating rate on post-meal satiety showed that 500 g of apple juice can be consumed 11 times faster than a calorie-equivalent 500 g of apples (~2 vs. 17 min), and post-meal satiety was significantly higher from apples in the solid form (Haber et al. 1977). Recent studies have shown that despite reductions of 10–15% in *ad libitum* energy intake, people feel equally full after a harder (slower) version of a food was consumed compared to the softer (faster) food equivalent (Bolhuis et al. 2014a; Karl et al. 2013; Zhu et al. 2013a; Zijlstra et al. 2008). In one study, Zhu and coworkers showed that a high viscosity semisolid meal produced a slower eating rate compared to a standard viscosity version of the same semisolid meal, with reductions in post-meal appetite and delayed gastric emptying following the high viscosity meal (Zhu et al. 2013a). Results suggest that relatively subtle but perceptible increases in viscosity can stimulate a stronger satiety response *per* calorie consumed. Consistent with this finding, participants report a greater expected and perceived "fullness" following consumption of equi-calorie meals that were naturally consumed at a slower eating rate (Ferriday et al. 2016) (Fig. 2). Slowing the eating rate of food intake is therefore likely to contribute to a stronger satiety response for an equivalent calorie load, and may be a simple but effective way to add fullness to meals without the necessity to add further energy.

The impact of a slower eating rate seems to be predominantly driven by the extended oro-sensory exposure time a food spends in mouth during consumption. One study has compared the oral and gastric contributions to post-meal satiety and concluded that longer oro-sensory exposure which was produced by modified sham feeding exerted a larger impact on inhibiting later appetite and intake compared to an equivalent increase in gastric volume delivered through nasogastric infusion (Wijlens et al. 2012). This highlights the importance of eating rate and the oro-sensory contribution to food intake, which plays an important role in signaling the arrival of calories and the associated perception of post-meal fullness. Eating rate can also be considered as the speed of transition of calories through the oral cavity and is the product of both the eating rate and energy density of the food being consumed (Stubbs et al. 1995). This combined measure has been referred to as the energy intake rate (EIR) (kcal/min) of a food (Forde et al. 2013a) and can act as an indicator of consumption rate of calories within a meal (van den Boer et al. 2017b). A

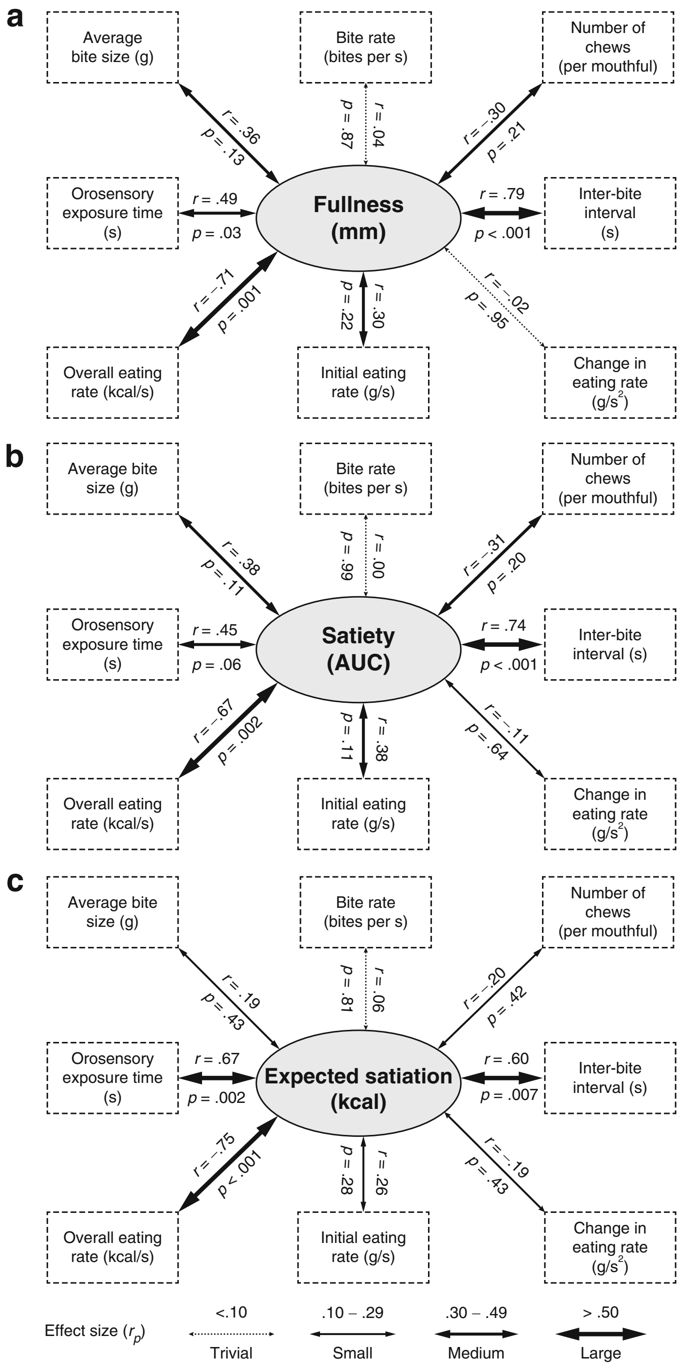

Fig. 2 Partial correlations between oral processing behaviors and (**a**) perceived fullness, (**b**) satiety, and (**c**) expected "fullness" after controlling for baseline composite fullness (r_p). Effect sizes are denoted by the width of each arrow. (From Ferriday et al. 2016)

comparison of the energy intake rate of a wide range of foods demonstrates there is a large natural variation in the rate of calorie intake across commonly consumed foods, with potential to significantly reduce energy consumption rate by considering both the energy density and eating rate of a food. Future research is needed to demonstrate the potential for lower energy intake rate foods to support sustained and meaningful reductions in dietary energy intakes over an extended period, as most studies to date have only measured acute energy intake.

In addition to effects on appetite, eating rate has also been shown to influence postprandial glycemic and insulin responses (Sun et al. 2015). The postprandial glycemic response is the change in blood glucose concentration induced by a food for the first 120-min post-ingestion. When the same carbohydrate source (rice) was chewed 30 instead of 15 times, the postprandial glycemic response was shown to increase by approximately 18% (Ranawana et al. 2014). Significantly higher plasma glucose, insulin, and glucose-dependent insulinotropic peptide (GIP) concentrations were reported when the same food (pizza) was chewed 40 rather than 15 times *per* mouthful (Zhu et al. 2013b). A longer chewing duration may support reductions in energy intake but can also produce a larger glycemic and insulin response. Eating rates impact on post-ingestive metabolism is likely mediated by the degree of oral breakdown, where longer chewing produces a reduced bolus particle size and offers a greater substrate surface area for digestive enzymes to produce a heightened metabolic response. The impact of bolus particle size on glycemic response has previously been reported in both *in vitro* (performed outside of a living organism) (Ranawana et al. 2010b), and *in vivo* (performed on or in a living organism) studies (Ranawana et al. 2010a) and demonstrated that smaller particle size produces an increased surface area for enzymatic saliva and a faster glucose absorption rate and higher glycemic response. When the oral phase of digestion is skipped and carbohydrates are consumed without chewing, blood glucose responses are attenuated, highlighting the importance of eating rate and degree of chewing in moderating the metabolic response to ingested carbohydrates (Read et al. 1986).

Another important metabolic effect of eating rate is its contribution to the thermic effect of food intake through what is termed “diet-induced thermogenesis” (DIT). DIT is defined as the increase in energy expenditure associated with the digestion, absorption, and storage of foods, which accounts for 10–15% of the total daily energy expenditure (Levine 2004). The extent of diet-induced thermogenesis (DIT) is dependent on the speed of meal consumption and research has shown that small changes in DIT (10-20 kcal/day) can result in 0.5–1 kg of weight gain over the course of a year (Lean and Malkova 2016). A higher DIT response was recorded when the same meal was eaten more slowly compared to when it was eaten rapidly (Hamada et al. 2014), whereas others have noted an increase in oxygen uptake and splanchnic blood flow following the slower consumption of a meal (Madsen et al. 2006; Hamada et al. 2014). Eating the same calories slower has been shown to induce an increase of 15 kcal in DIT (Hamada et al. 2016) although others have failed to replicate this effect (Laboure et al. 2002). As with satiety and glycaemia, DIT was larger following oral feeding compared to intra-gastric feeding (Jonge et al. 1991).

Eating Rate as Target for Intervention

Given the extensive evidence supporting the impact of eating rate on energy intake, body composition and metabolic response to ingested nutrients, eating rate has been identified as a modifiable risk factor for obesity and a potential target for behavioral intervention. Advising individuals with obesity to slow their eating could be beneficial for managing caloric intake and since 2009 the American Obesity Society has recommended to "slow eating speed to better regulate energy intake" (Mechanick et al. 2009). Several approaches have been applied to reduce eating rate using external cues, such as providing feedback to reduce the eating rate via electronic devices or vibrio-tactile sensation (Ford et al. 2010; Galhardo et al. 2012; Hamilton-Shield et al. 2014). These approaches have yielded some success in energy intake regulation in the short-term, demonstrating an effect on eating speed, energy intake and in some cases body weight. In one example, adolescents who were instructed to extend their inter-bite interval using an egg-timer have successfully reduced their eating rate and energy intake (Salazar Vazquez et al. 2016). However, of the initial cohort of 54 adolescents only 14 (25%) adhered to the use of the egg-timer to slow bite rate and completed the study after a year; suggesting there may be significant challenges with adherence with such an intervention. What is less clear is the extent to which an individual's eating behaviors can be "retained" to produce longer term and sustainable changes to eating rate. An early example of an eating rate intervention required women within a weight control program to lower their eating rates by receiving advice to pause between bites, and to cut foods into smaller pieces. This approach yielded some initial success but the change in eating rate was not maintained over time (Spiegel et al. 1991). In a recent 8-week family-based behavioral therapy intervention ("RePace"), children who reduced their eating rate through mealtime instruction and guidance from their parents showed a reduction in eating pace, energy intake and BMI (Faith et al. 2019). However long-term motivation for continuous feedback on eating behavior remains untested, and may be required to maintain changes to eating behaviors after the initial intervention period.

Individuals adapt their eating rates based on the food form and texture of a food that is being consumed (Wee et al. 2018). For example, eating rate varies when consuming a "hard slow" food *vs*. a "soft fast" food as a result of texture and consistency served. Changing the form of a food or modifying its texture can serve as a more natural and sustainable strategy to lower eating rate in the long term. Previous research has shown that consumption of semisolid, solid, and liquid foods can impact satiation and satiety response to ingested nutrients (Mattes 2005), and harder food form can reduce overall food intake (Mourao et al. 2007). Apple slices have been shown to suppress appetite for longer than apple puree, which in turn had a stronger impact than the same calories consumed as an apple juice (Flood-Obbagy and Rolls 2009). Across a series of *ad libitum* feeding studies, the efficacy of a food texture intervention to slow down the eating rate and reduce the overall energy intake has been shown (Bolhuis et al. 2014a; Forde et al. 2013b; McCrickerd et al. 2017). Texture difference between pureed and whole versions of the same savory meals have been shown to effectively reduce eating rate by an average of

20%, which resulted in a reduction of 12% in *ad libitum* energy intake (Forde 2018a). Questions remain about the long-term efficacy of this approach and whether it is sufficient to reduce the eating rate of individual foods or necessary to modify the texture of every food at every meal to produce the same effect.

Experimental evidence provides support that eating rate is a meaningful target for obesity intervention beyond conventional dieting and calorie reduction approaches. Challenges still remain in our understanding of the best approach to changing eating rate in the longer term and beyond a controlled experimental setting. External cues and prompts have been shown to produce clinically meaningful results, although they may present challenges for longer term adherence, and it remains unclear whether these changes are simply guiding rather than re-training the eating behavior. Texture-led changes to eating rate therefore offer an exciting opportunity to adapt an individual's response to the structural properties of the food being consumed in a way that maintains the associated eating experience and satiety from food intake. Further opportunities exist to combine texture-led changes to eating rate with the development of energy reduced foods that maintain their hedonic appeal and keep pleasure central to the eating experience. Using this approach, it may be possible to apply food-based approaches to change eating behaviors and moderate the rate of energy intake. These interventions are also likely to influence the metabolic response to the food consumed.

Conclusion

This current chapter provides a consolidated overview of current evidence regarding the importance of eating rate in regulating energy intake and metabolism, while offering new opportunities for the reduction of risk associated with obesity and non-communicable diseases. Eating rate is a product of both an individual's drive to eat and the food environment they choose to consume. This eating behavior is a modifiable risk factor for food based chronic conditions that is malleable, and has been shown to produce sustained changes in energy intake and body composition over time. The joint-approach of food texture and reductions in energy density offers an effective yet largely unexplored opportunity to influence energy intake in a manner that can sustain the food acceptance and keep eating enjoyment central to the intervention. Wholesale changes to the energy intake rate of the food environment are likely to have a population-wide impact from early childhood through to sustaining nutrient intakes in later life. This offers a food first approach to combating obesity and other food based chronic conditions, and future research should focus on improving our understanding of the long-term implications of energy intake reductions on human health and well-being.

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The Role of Milk and Dairy Products in the Development of Obesity and Cardiometabolic Disease

36

Anestis Dougkas and Ditte Hobbs

Contents

Abstract

The prevalence of obesity has increased rapidly. Obesity is a key risk factor for type 2 diabetes (T2D) and cardiovascular disease (CVD), which are the leading causes of death globally. Dairy products contribute significantly to children's and adults' nutrient intake, yet due to relatively high saturated fat content, the health

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benefits of dairy products have come under question. This chapter provides an overview of the current evidence mainly from systematic reviews and meta-analyses on dairy product consumption and risk of obesity, T2D, and CVD. The data review suggests that milk and certain dairy products are not related or inversely related to obesity in children. In adults, consumption of milk and dairy products improves body composition and enhances weight loss during energy restriction diets, while it has a neutral effect on body weight in maintenance diets. Prospective cohort studies suggest that the consumption of dairy products, with other regular or low-fat content, does not adversely affect the risk of T2D or CVD outcomes and may have a protective effect. The proposed mechanisms underlying the effect of dairy nutrients on obesity and cardiometabolic disease have not been clearly elucidated but include a beneficial role of calcium, dairy fat, and proteins on fat metabolism and excretion, appetite, and the metabolic activity of gut microbiota. There remain many uncertainties, including different effects of different types of dairy products and of different fat content. In conclusion, dairy product consumption, as part of a balanced diet, may protect against the risk of obesity, T2D, and CVD.

Keywords

Milk · Dairy · Obesity · Cardiovascular diseases · Type 2 diabetes · Children · Adults

Introduction

Over the last decades, unhealthy diets, alcohol abuse, and lack of physical activity have led to increased prevalence of overweight and obesity globally, and the trend is particularly alarming in children and adolescents (Seidell and Halberstadt 2015). Obesity can lead to serious health consequences including major noncommunicable chronic diseases (NCDs) with cardiovascular disease (CVD) and type 2 diabetes (T2D) being among the major NCDs in the adult population (WHO 2013). Strategies to reduce the burden of obesity and cardiometabolic disorders include modification of risk factors such as improving food habits at societal and individual levels (Mozaffarian 2016). Thus, consumption of a well-balanced diet within the context of a healthy lifestyle is considered to be the most important prevention strategy (WHO 2013). Certain dietary patterns, such as the Mediterranean or Dietary Approaches to Stop Hypertension (DASH) diet, have been associated with a significantly reduced risk of developing obesity and cardiometabolic diseases (Schwingshackl et al. 2018). Those diets include intake of key food groups such as vegetables, fruits, whole grains, and dairy products and small amounts of red or processed meats, refined grains, and sugar-sweetened foods or drinks (WHO 2003; EFSA 2017). Most dietary guidelines in Western countries recommend 2–4 servings/day of milk and dairy products depending on age and circumstances (WHO 2003). However, consumption is decreasing as advice on milk and other dairy products tends to be perceived as confusing by the public (Buttriss 2016) mainly due to their fat, sugar, and overall energy content (Roe et al. 2015). In addition, although a growing body of research has revealed that intake of milk and other dairy products may play a beneficial role in the regulation of body weight and cardiometabolic disorders (Gijsbers et al. 2016), the potential benefits of milk and dairy remain an issue of debate and controversy within the scientific community (Lanou and Barnard 2008; Michaëlsson et al. 2014; Thorning et al. 2016; Brouwer-Brolsma et al. 2018).

Classification and Prevalence of Obesity, CVD, and T2D in Children and Adults

Obesity is a significant risk factor and contributor to increased morbidity and mortality, first and foremost from cardiovascular diseases and diabetes but also from cancer, osteoarthritis, liver and kidney disease, sleep apnea, and depression (Pi-Sunyer 2009).

According to the World Health Organization (WHO), overweight and obesity are defined as abnormal or excessive fat accumulation, which presents a risk to health and is often measured by the body mass index (BMI), a person's weight (kg) divided by the square of the person's height (m^2). In adults, a BMI equal to or more than 25 indicates overweight, and a BMI of 30 or more indicates obesity (WHO 2018a). However, for certain groups of people like athletes (e.g., increased muscle mass) and older adults (e.g., loss of height), BMI is less reliable, and the waist-to-hip-ratio method is more useful to determine central adiposity (Garrido-Chamorro et al. 2009; WHO 2008 n.d.). In children, the level of fatness is categorized by comparing (plotting) their BMI against age- and gender-specific thresholds derived from a reference population (BMI z-score). Obesity in children is defined as a weight-for-height greater than 3 standard deviations above the WHO Child Growth Standards median (WHO 2018a).

The prevalence of obesity has reached epidemic proportions with around 1.9 billion adults (39%) being classified as overweight or obese, of which 650 million (13%) classified as obese (WHO 2018a). In 1975, 4% of children aged 5–18 years were classified as obese, while more than 340 million (18%) of the same age group were classified as overweight or obese in 2016 (WHO 2018a). Additionally, obesity affects children under the age of 5 with 41 million preschool children classified as overweight or obese in 2016 (WHO 2018a). It is particularly worrying that obesity is projected to increase further in many countries year on year (WHO 2018a).

Obesity and inactivity are leading risk factors for development of type 2 diabetes, which is a chronic disease that occurs when the pancreas does not produce enough insulin or when the body cannot effectively use the insulin it produces (WHO 2018b). Since insulin is responsible for regulating blood glucose levels, individuals with uncontrolled type 2 diabetes often have hyperglycemia, or raised blood glucose levels, which over time causes damage to the nerves and blood vessels in the body (WHO 2018b). The prevalence of type 2 diabetes has increased fourfold from 108 million in 1980 to 422 million in 2014, a trend that parallels the increase in global obesity rates (WHO 2018b).

Cardiovascular disease (CVD) is the term given to a group of arterial diseases which affect the supply of blood to the heart, brain, or peripheral regions of the body. It is the leading cause of death globally, accounting for 17.9 million deaths in 2016 (WHO 2018c). The two main types of CVD are coronary heart disease (CHD), when the blood supply to the heart is restricted, and cerebrovascular disease, when the blood supply to the brain is interrupted (Frayn and Stanner 2008). If the blood supply to the brain is blocked, it results in a stroke, which may cause irreversible damage to the brain tissue. These two forms of CVD were responsible for 85% of deaths from CVD in 2016 (WHO 2018c). There are a number of risk factors associated with the development of CVD, some of which are modifiable such as cigarette smoking, physical inactivity, high blood pressure, elevated total and LDL cholesterol, reduced HDL cholesterol, elevated triacylglycerol, and being overweight. Out of these risk factors, high blood pressure or hypertension poses the greatest risk for development of CHD and stroke and was estimated to be responsible for 18 million CVD deaths worldwide annually (Egan et al. 2019). A high saturated fat and intake of industrial sources of trans-fatty acids (TFAs) have been linked to an increased risk of CVD, and this effect is thought to be mediated predominately by increased plasma LDL cholesterol levels.

The Nutritional Diversity and Contribution of Dairy Products in Dietary Intake

The dairy food group is defined as milk, cheese, and yogurt and other dairy products that contain calcium (Ca), which are to be consumed as a source of calcium (USDA 2015). Butter, due to little or no calcium concentration, is not included in the dairy food group but in the fats group (USDA 2015). Milk and other dairy products are nutrient-rich, providing key nutrients, often under consumed in developed countries, that are beneficial for health at each life stage (Roe et al. 2015; Auestad et al. 2015). The dairy matrix can vary significantly according to the type of milk and other dairy products with regard to micronutrient, fat, lactose, and energy content (Thorning et al. 2017). The nutrition quality and value of milk depends on several factors such as animal breed, health and diet of the animals, husbandry practices, geographical location, and season of milking (NRC (U.S.) 1988). Table 1 presents the nutritional composition of milk and a selection of dairy products from the most recent food composition tables in the UK (Roe et al. 2015).

Milk is high in protein given that 20% of its energy value is provided by protein, rich in calcium, vitamin B12, riboflavin, and iodine and a source of potassium, phosphorus, and vitamin B5 (Roe et al. 2015). Cheese is also high in protein, and the high-fat varieties of cheese are a source of vitamin A and zinc, but both cheese and yogurt offer different amounts of protein, fat, sugars, micronutrients, and bioactive compounds (Roe et al. 2015). In addition, dairy products contribute significantly to children's intake of calcium (45%), iodine (34%), potassium (20%), vitamin B12 (20–40%), and vitamin A (20%) in developed countries (Auestad et al. 2015). The

Table 1 Nutrient composition per 100 g of selected milk and other dairy products (Roe et al. 2015)

	Milk			Yogurt			Cheese		
Per 100 g	Whole	Semi-skimmed	Skimmed	Plain	Plain low-fat	Fromage frais	Cheddar	Cottage cheese	Cheese spread
Energy (Kcal)	63	46	34	79	57	99	416	103	237
Protein (g)	3.4	3.5	3.5	5.7	4.8	5.8	25.4	9.4	11.3
Carbohydrate (g)	4.6	4.7	4.8	7.8	7.8	13.2	0.1	3.1	6.5
Fat (g)	3.6	1.7	0.3	3.0	1.0	2.9	34.9	6.0	18.6
Sat Fat (g)	2.3	1.1	0.1	1.9	0.7	1.9	21.7	3.2	12.9
Sodium (mg)	42	43	44	80	63	60	723	250	730
Potassium (g)	157	156	162	280	228	143	75	161	219
Calcium (mg)	120	120	125	200	162	140	739	127	498
Phosphorus (mg)	96	94	96	170	143	123	505	171	835
Iodine (μg)	31	30	30	63	34	17	30	24	29
Thiamin (mg)	0.03	0.03	0.03	0.06	0.12	0.11	0.03	0.05	0.05
Riboflavin (mg)	0.23	0.24	0.22	0.27	0.22	0.29	0.39	0.24	0.36

greatest increase in bone mineral content occurs during adolescents; thus calcium requirements are higher than at any other stage of life, while iodine has also been identified as an at-risk micronutrient among schoolgirls and pregnant women (Golden and Abrams 2014; Iodine Global Network 2017). Certain dairy products are high in fat and contribute to saturated fat, sodium, and total energy intake (Auestad et al. 2015). However, it is important to consider the diversity in nutritional composition of the various types of dairy products in the development of public health policies for fat and energy content reduction, due to their nutrient-rich and nutrient-dense package.

This chapter aims to provide an overview of existing systematic reviews and meta-analyses of mainly longitudinal and intervention studies with regard to the evidence relating to dairy products and obesity and cardiometabolic disorders in children, adolescents, and adults. It examines the reviews that look at the reported associations between subtypes of other dairy product (e.g., low vs. high fat) intakes and obesity or cardiometabolic risk factors. Potential mechanisms and their contribution to the understanding of the extent, which milk and dairy product consumption influences adiposity and cardiometabolic disorders, will be briefly discussed.

Research Methodology

Relevant publications of systematic reviews and meta-analysis in English were abstracted through three electronic databases, e.g., ISI Web of Science, PubMed, and Google Scholar, and a reference list of these reports in children, adolescents, and adults, published from their inception until June 2019. The keywords combined in the research strategy were as follows: "dairy," "milk," "cheese," "yogurt," "calcium," "obesity," "adiposity," "overweight," "body fatness," "body weight," "children," "type 2 diabetes," "cardiovascular diseases," "coronary heart disease," "heart attack," "stroke," "myocardial infarction," "ischemia," "cardiac arrest," "angina," "blood pressure," "cholesterol," "LDL cholesterol," "HDL cholesterol," "vascular function," "triglycerides," "insulin resistance," "insulin," "HOMA," and "glucose." Reviews, systematic reviews, and meta-analyses that assessed the impact of Ca on obesity and cardiometabolic diseases in children and adults through Ca supplementation were excluded.

Overview of Systematic Reviews and Meta-Analysis on Dairy Consumption and Obesity in Children and Adolescents

Several reviews, systematic reviews, and meta-analyses have been conducted using data from both observational and intervention studies that looked at the associations between milk and other dairy products and obesity in children and adolescents. Louie et al. (2011) were the first to systematically review the longitudinal association between dairy products and obesity using data from prospective studies. The size of the cohort ranged from 53 to 12,829, and the follow-up duration ranged from 8 months to 10 years. Among the ten studies that examined dairy consumption in children, three showed a protective association against increasing weight gain, and only one showed an increased risk of overweight and obesity among children with very high milk consumption. However, due to high heterogeneity of the studies, a meta-analysis was precluded. Dror (2014) revisited the topic by conducting a systematic review and meta-analysis of 22 studies combining cross-sectional, longitudinal cohort and intervention study designs. When all data were included in the meta-analysis, there was no association between dairy consumption and adiposity measures (average effect size: -0.07, [-0.32, -0.18], $P = 0.59$). However, age was a significant predictor of the effect size, and although there was no relation between dairy consumption and adiposity in preschoolers (approximately 2–5 years) and school-age children (approximately 6–11 years), an inverse relation was reported in adolescents (12–19 years) (average effect size: -0.26, [-0.38, -0.14], $P < 0.0001$). As authors stated, the inclusion of both observational and intervention studies led to high heterogeneity as seen in the I^2 statistics ($I^2 = 0.72$), in addition to the heterogeneity in the way dairy consumption (type of dairy and serving portions) and measures of adiposity (BMI, weight change, adiposity) have been defined in the studies.

Examining the evidence by study design, a meta-analysis of primarily seven cross-sectional studies (Wang et al. 2016) reported that children with the highest dairy consumption had lower risk of obesity relative to those with the lowest consumption with odds ratio (OR) of 0.54 (95% confidence interval (CI), 0.38 to 0.77). The degree of confidence is indicated by the range of estimates within which there is 95% chance that the true decrease in risk exists. Similar results were observed for milk consumption with the pooled ORs (95% CIs) being 0.87 (0.80–0.95) in children. However, most of the cross-sectional studies included in this meta-analysis conducted in Asian populations are receptive to reverse causality, which means that the presence of adiposity may influence individuals' dairy consumption habits. Prospective longitudinal studies represent a more robust source of evidence. In a recent meta-analysis of 10 prospective studies including 46,011 children and adolescents with the duration of follow-up ranging from 1 to 8 years, Lu et al. (2016) found that dairy consumption is inversely related to the risk of childhood obesity. Pooled analysis showed that relative to children and adolescents with the lowest dairy consumption, those with the highest dairy consumption were 38% less likely to be overweight/obese. In a dose-response regression model, this meta-analysis reported that each 1 serving/day increase in dairy consumption reduced body fat by 0.65% and the risk of overweight/obesity by 13%. Furthermore, a recent systematic review of randomized intervention studies (Kouvelioti et al. 2017), reported that 11 out of the 14 studies showed no effect of dairy consumption on body composition or body size, yet there was a beneficial effect on bone structure and development in children and adolescents. De Beer (2012) also found in a meta-analysis of 12 intervention studies that dairy consumption had beneficial effect on linear growth, with an effect size of 0.4 cm/year with a daily serving of 245 ml of milk in children aged 3–13 years. This analysis indicated a profound effect of milk on growth relative to the other dairy products, but given the short-term intervention period of most clinical trials, further research is needed.

Most of the studies and consequently systematic reviews and meta-analyses conducted in children and adolescents failed to report differences between different types of milk and other dairy products. In addition, analyses based on study design often lead to a strict selection and thus a limited number of studies included in the meta-analyses. Moreover, inclusion of both observational and intervention data increases the diversity and heterogeneity among studies. Therefore, a more comprehensive narrative review by including and examining all available individual studies dealing with dairy and obesity enables a more complete reflection on the totality of evidence from different study designs. A recent narrative critical review on the role of milk and other dairy products in the development of obesity summarized 94 epidemiological and intervention studies conducted over the last 28 years in children and adolescents (Dougkas et al. 2018). Briefly, looking at 43 cross-sectional and 31 prospective studies, a high relative to low or no consumption of milk and other dairy products has been consistently found to be not associated, or inversely associated, with obesity and indicators of adiposity in children and adolescents. Although there is insufficient comparative data on the relationship of whole- and low-fat dairy products and obesity, findings suggest that replacing whole milk with low-fat milk does not influence the neutral associations with body weight over time. Those results have been reinforced by the 17 of 20 randomly controlled dietary intervention studies, which represent the most robust source of evidence that dairy and mainly milk consumption as part of a weight maintenance diet have a neutral or inverse effect on body composition in children and adolescents. Inclusion of milk and other dairy product consumption under conditions of energy restriction did not enhance nor lead to adverse effect on weight loss. However, definitive conclusions cannot be drawn due to limited number of energy-restricted interventions in children and adolescents.

The majority of the studies did not separate the effect of different types of dairy products with most intervention studies including milk as part of the intervention. In terms of flavored milk, a review by Fayet-Moore (2015) showed that flavored milk intake has null association with weight gain or increased body fat in normal-weight children, yet contradictory results were found for overweight and obese children. Given the popularity of flavored milk among children and the added sugar it contains, Patel et al. (2018) recently showed an increase in energy intake with increased flavored milk intake, yet more intervention studies with obesity outcomes are needed. Although some studies and mainly observational studies reported some differences between individual dairy products, overall there is little evidence to suggest that the relationship varied by the type of dairy products (Dougkas et al. 2018).

Overview of Systematic Reviews and Meta-Analysis on Dairy Consumption and Obesity in Adults

Numerous systematic reviews and meta-analyses based on different study designs examined the association between milk and other dairy product consumption and obesity in adults, with few observing the role of subtypes of dairy products on various adiposity measures.

Wang et al. (2016) in a meta-analysis of mainly cross-sectional studies indicated that dairy product consumption may be inversely related to risk of obesity. In a dose-response analysis looking at studies that included only milk, there was a 16% decrease in risk of obesity for every 200 g/day increase in milk consumption. A meta-analysis of prospective cohort studies found a protective association of dairy consumption with obesity (Louie et al. 2011), yet it was subjected to unmeasured confounding based on the observational studies included. A more recent meta-analysis of 24 prospective studies suggested that dairy consumption was not associated with changes in body weight and inversely associated with changes in waist circumference (WC), risk of overweight, and abdominal obesity (Schwingshackl et al. 2016). Furthermore, high-dairy consumers had a reduced risk of abdominal obesity (OR (95% CI) 0.85 (0.76 to 0.95)) and risk of overweight (OR (95% CI) 087 (0.76 to 1.00)) relative to low-dairy consumers. No significant relationship was evident for risk of weight gain. There were no significant associations between either whole-fat or low-fat dairy consumption and changes in body weight, yet there was a significant reduction for adiposity only for whole-fat dairy products (Schwingshackl et al. 2016). Another extensive systematic review of observational studies concerning differences between whole-fat and low-fat dairy products suggested that evidence does not support the popular belief that dairy fat or high-fat dairy products contribute to obesity (Kratz et al. 2013). Eleven of the 16 studies found that the highest dairy fat or whole-fat dairy consumption was associated with lower increase in weight gain over the years compared with the lowest dairy consumption. Interestingly, authors noticed that the protective effect of whole-fat dairy consumption is related to the location of the studies with most EU-based studies (8 out of 9) suggesting an inverse association between dairy fat and obesity relative to the US-based studies (3 out of 7). This could be partly explained due to differences in husbandry practices (mainly industrialized in the US) that could influence the dairy fat composition and to unmeasured diet/lifestyle confounding factors (Kratz et al. 2013). For instance, dairy fat in the US is usually consumed as ice cream or dairy desserts, while the major source of whole-fat dairy in Europe is through plain cheese and unsweetened yogurts (Kratz et al. 2013).

Several randomized controlled trials have been conducted in adults, examining the effect of dairy products on body weight and other measures of adiposity with or without energy restriction (Table 2). A few systematic reviews and meta-analyses compiled those modest-sized studies of different populations and duration in order to increase the statistical power and the effect size estimates (Abargouei et al. 2012; Chen et al. 2012; Booth et al. 2015; Geng et al. 2018; Benatar et al. 2013). Abargouei et al. (2012) found a neutral effect of dairy consumption on body weight. Chen et al. (2012), in a more comprehensive meta-analysis, examined the evidence based on trial duration, with short studies being <1 year and long studies being ≥ 1 year duration. Dairy consumption reduced body weight in the short-term and energy-restricted intervention studies, yet there was a moderate weight gain in long-term or weight maintenance intervention studies. The potential benefits of dairy in long term might be hindered by the different compliance to the diets and its relation to the caloric deficit status (Chen et al. 2012). Another meta-analysis of intervention studies, which gave no advice on energy restriction, reported a modest weight gain

Table 2 Summary of systematic reviews and meta-analyses on dairy intake and body weight or other measures of adiposity

Reference	*n*	Subjects	Dairy food	Measures	Main outcomes
Abargouei et al. (2012)	14 RCTs	883	Total dairy intake, HFD, LFD, milk, cheese, yogurt, and other dairy foods	Body weight, body fat, lean mass, and WC	There was a neutral effect of dairy consumption on body weight Weight loss or gain were unaffected by increased dairy consumption without energy restriction Under energy restriction, weight and fat loss increased compared with that in the usual weight loss diets
Chen et al. (2012)	21 RCTs	2101	Total dairy intake, HFD, LFD, milk, cheese, yogurt, and other dairy foods	Body weight, body fat	Dairy consumption reduced body weight in the short-term (−0.47 kg; 95% CI, −0.90; −0.03 kg; I2 = 59.2%) and energy-restricted (−0.79 kg; 95%CI, −1.35; −0.23 kg; I2 = 38.5%) intervention studies. There was a moderate weight gain in long-term (0.66 kg; 95% CI, −0.14; 1.46 kg; I2 = 80%) or weight maintenance intervention studies (0.39 kg; 95% CI, 20.36; 1.13 kg; I2 = 89.7%)
Benatar et al. (2013)	20 RCTs	1677	Total dairy intake, HFD, LFD	Body weight, WC	There was a modest weight gain with increased low- (+0.82, 0.35–1.28 kg, $p < 0.001$) and whole-fat dairy food (+0.41, 0.04–0.79 kg, $p = 0.03$), yet WC did not change significantly (−0.07, −1.24–1.10 cm)

(continued)

Table 2 (continued)

Reference	*n*	Subjects	Dairy food	Measures	Main outcomes
Booth et al. (2015)	31 RCTs (Dairy) 20 RCTs (Ca)	2091 (Dairy) 2711 (Ca)	Total dairy intake, calcium	Body weight, body fat	Ca supplementation did not significantly affect body weight (20.17, 95% CI 20.70, 0.37 kg) or body fat change (20.19, 95% CI 20.51, 0.13 kg) compared with control Increased dairy consumption did not affect body weight (20.06, 95% CI 20.54, 0.43 kg) or body fat change (20.36, 95% CI 20.80, 0.09 kg) compared with control
Stonehouse et al. (2016)	27 RCTs	–	Total dairy intake, HFD, LFD, dairy supplements	Body weight, body fat, lean mass	Increased dairy consumption, as part of an energy-restricted regime, was significantly associated with weight and fat mass loss while limiting the loss of lean mass
Geng et al. (2018)	37 RCTs	184,802	Total dairy intake, HFD, LFD, milk, cheese, yogurt, and other dairy foods	Body weight, body fat, lean mass, and WC	Increased dairy consumption increased body weight (0.01 kg; 95% CI, −0.25; 0.26 kg; $I^2 = 78.3\%$), increased lean mass (0.37 kg; 95% CI, 0.11; 0.62 kg; $I^2 = 83.4\%$), and reduced body fat (−0.23 kg; 95% CI, −0.48; 0.02 kg; $I^2 = 78.2\%$) and WC (−1.37 kg; 95% CI, −2.28; −0.46 kg; $I^2 = 98.9\%$)

Ca, calcium; HFD, high-fat dairy products; LFD, low-fat dairy products; RCT, randomized clinical trial; WC, waist circumference

with increased low- and whole-fat dairy food (Benatar et al. 2013). Thus, encouraging dairy consumption without other changes in the diet could increase total energy of the intervention in those studies and possibly explain the weight gain. Furthermore, considering the whole-fat vs low-fat dairy, increased low-fat dairy consumption on an energy-restricted diet leads to a greater mean fat loss over 4 months (Booth et al. 2015). In the most recent meta-analysis of 37 randomized clinical trials (RCTs), Geng et al. (2018) found that increased dairy consumption increased body weight, increased lean mass, and reduced body fat and WC. In the subgroup analysis, dairy products facilitated reduction in body weight, body fat, and WC in adults with energy restriction but increased body weight without altering body composition in the absence of energy restriction.

Given that a limited number of studies looked at the effect of the individual type of dairy products on obesity, most systematic reviews and meta-analyses did not consider the effect of subtypes of dairy products on measures of adiposity. However, Schwingshackl et al. (2016) in their review of prospective cohort studies found that increased consumption of yogurt was related to reduced risk of obesity and favorable changes in body weight and waist circumference. That was in agreement with a more recent review of epidemiological studies, which showed an inverse association with BMI, body weight, WC, and body fat (Eales et al. 2016). In a pooled examination of the RCTs identified in the same systematic review, yogurt could facilitate weight reduction and improve body composition, but due to small size and use of obese population under energy restriction, generalizability and determination of causality cannot be demonstrated. Similarly, Sayon-orea et al. (2017) recently showed that despite the inconsistencies between the ten prospective studies, nine of which showed an inverse relationship between yogurt consumption and risk of obesity and changes in waist circumference and body weight. However, there is a need for better-quality randomized trials and more prospective studies to confirm the association between separated types of dairy products and risk of obesity.

Overview of Systematic Reviews and Meta-Analysis on Dairy Consumption and Cardiometabolic Diseases in Adults

Dairy and Type 2 Diabetes

A growing body of research suggests that milk and dairy consumption is associated with a reduced risk of T2D, possibly due to the beneficial effects of dairy products in obesity, which is an important risk factor for T2D, as well as the beneficial role of certain dairy components such as calcium, vitamin D, dairy fat, and specifically *trans*-palmitoleic acid.

In recent years, a number of meta-analyses (Table 3) or reviews of meta-analyses (Yu and Hu 2018; Alvarez-Bueno et al. 2018) have been published on dairy consumption and T2D. The results from all meta-analyses have consistently shown neutral or inverse associations for total and low-fat dairy products, with yogurt showing the strongest inverse association with T2D (Drouin-Chartier et al. 2016). No associations for whole-fat dairy, milk, and fermented dairy were observed in any of the meta-analyses (Drouin-Chartier et al. 2016). However, the results for cheese were conflicting, with an inverse association being reported by Aune et al. (2013) and Gao et al. (2013) but not by Gijsbers et al. (2016).

The most recent and comprehensive meta-analysis by Gijsbers et al. (2016) included 22 cohort studies with 579, 832 subjects and 43,118 T2D cases. The results were in line with previous meta-analyses and reported that total dairy was significantly linearly associated with a 3% lower risk of T2D per 200 g/day (RR 0.97; 95%

Table 3 Summary of systematic reviews and meta-analyses on dairy intake and risk of type 2 diabetes

Reference	*n*	Follow-up (y)	Age (y)	Dairy food	Main outcomes
Pittas et al. (2007)	5 cross-sectional studies	–	18–74	Total dairy, Ca, and vitamin D intake	High Ca doses (661–1200 mg/day) and vitamin D significantly reduced odds of T2D compared to low doses (219–600 mg/day) Consumption of 3–5 dairy portions/day significantly reduced odds of T2D compared to 1.5 dairy portions/day
Elwood et al. (2008)	4 cohort studies	8–20	–	Total dairy intake	Reduced relative risk of T2D in people with the highest compared with the lowest dairy intake (RR, 0.92; CI 0.86–0.97)
Tong et al. (2011)	7 cohort studies	5–20	39–57	Total dairy intake, LFD, and HFD consumption	Dairy product consumption significantly reduced risk of T2D The effect was higher with LFD (RR, 0.82; CI 0.74–0.90)
Aune et al. (2013)	17 cohort studies	5–23	20–75	Total dairy intake, HFD, LFD, milk, cheese, yogurt, and other dairy foods	Significant inverse association between total dairy intake (RR, 0.93; 95% CI 0.87–0.99 with ≥400 g/day), LFD (RR, 0.91; 95% CI 0.86–0.96 with ≥200 g/day), and cheese (RR: 0.92; 95% CI 0.86–0.99 with ≥50 g/day), and relative risk of T2D
Gao et al. (2013)	15 cohort studies/1 case control	5–23	21–79	Total dairy intake, HFD, LFD, milk, cheese, yogurt, and other dairy foods	Inverse linear association between total dairy (RR, 0.94; 95% CI, 0.91–0.97 for 200 g/day), LFD (RR, 0.88; 95% CI, 0.84–0.93 for 200 g/day), cheese (RR, 0.80; 95% CI, 0.0.69–0.93 and 0.93–0.97 for 30 g/day), and yogurt (RR, 0.91; 95% CI, 0.82–1.00 for 50 g/day) intakes and relative risk of T2D

(continued)

Table 3 (continued)

Reference	*n*	Follow-up (y)	Age (y)	Dairy food	Main outcomes
Gijsbers et al. (2016)	22 cohort studies	2.6–30	36–67	Total dairy intake, HFD, LFD, milk, cheese, yogurt, and other dairy foods	Inverse association between total dairy (RR, 0.97; 95% CI 0.95–1.00 with $\geq$200 g/day, $P = 0.04$), yogurt (RR, 0.83; 95% CI, 0.83–0.90 for 80 g/day, $P < 0.001$), and ice cream (RR, 0.81; 95% CI, 0.78–0.85 for 10 g/day, $P < 0.001$) intakes and relative risk of T2D. There were no associations between other types of dairy products and T2D risk
Khoramdad et al. (2016)	13 cohort studies	5.5–20	40–88	Milk, cheese, yogurt	Yogurt and cream had favorable effects, while cheese, low-fat milk, and ice cream had no effects on the risk of diabetes. Although there was 11% reduction in the risk of obesity with milk consumption, the relationship was not statistically significant
Khoramdad et al. (2016)	14 cohort studies	5–10	20–79	Total dairy, HFD, LFD	Inverse association between total dairy (RR, 0.88; 95% CI 0.80–0.96) and LFD (RR, 0.81; 95% CI, 0.68–0.96) intakes and relative risk of T2D. There were no associations between HFD and T2D risk
Alvarez-Bueno et al. (2018)	22 cohort studies	4–30	20–88	Total dairy intake, HFD, LFD, milk, cheese, yogurt, and other dairy foods	Inverse association between total dairy (RRs range: 0.86–0.91), LFD (RRs range: 0.81–0.83), LF milk (RR: 0.82), and yogurt (RRs range:0.74–0.86) consumption and incidence of T2D. Dose-response analysis

(continued)

Table 3 (continued)

Reference	*n*	Follow-up (y)	Age (y)	Dairy food	Main outcomes
					reported that each unit increment in total dairy and LFD consumption decreased risk of T2D

T2D, type 2 diabetes mellitus; BMI, body mass index; Ca, calcium; CVD, cardiovascular disease; HFD, high-fat dairy products; FMD, fermented dairy products; LFD, low-fat dairy products; RR, relative risk

CI, 0.95; 1.00; $P = 0.04$), low-fat dairy was associated with a 4% lower risk per 200 g/day (RR 0.96; 95% CI, 0.92; 1.00; $P = 0.072$), and yogurt was associated with a 15% lower risk of T2D (RR 0.86 compared with 0 g/day; 95% CI, 0.83; 0.90; $P < 0.0001$) (Gijsbers et al. 2016). In this study, no associations were found with whole-fat dairy, fermented dairy, milk, and cheese. In 2018 the authors updated their meta-analysis to include an additional four cohort studies (Drouin-Chartier et al. 2016). The updated meta-analysis included a total of 26 cohort studies and showed total and low-fat dairy were associated with 3% and 4% lower risk of T2D per 200 g/day, respectively. Yogurt continued to show the strongest inverse association with T2D (Drouin-Chartier et al. 2016).

The evidence on the association between dairy products and T2D from systematic reviews and meta-analyses was recently summarized by Alvarez-Bueno et al. (2018). They reported evidence supporting the association of dairy product consumption with lower risk of T2D, with the association being more robust for yogurt and low-fat dairy.

Dairy and Cardiovascular Diseases (Coronary Heart Disease and Stroke)

A number of meta-analyses or reviews of meta-analyses on total dairy consumption or specific dairy products such as milk, cheese, or yogurt on CHD (Guo et al. 2017; Drouin-Chartier et al. 2016; Chen et al. 2017; Boeing et al. 2017; Gille et al. 2018; Alexander et al. 2016; Qin et al. 2015) and stroke (Drouin-Chartier et al. 2016; de Goede et al. 2016; Chen et al. 2017; Yu and Hu 2018; Alexander et al. 2016; Pimpin et al. 2016) have been published.

Drouin-Chartier et al. (2016) conducted a review of meta-analyses investigating the associations between dairy products and CHD. Overall, they found that consumption of total dairy, full-fat dairy, low-fat dairy, milk, cheese, and yogurt was not associated with risk of CHD. These findings were supported by the results of a recent meta-analysis by Guo et al. (2017). The authors included 29 cohort studies, with 938,465 participants and 93,158 mortality, 28,419 CHD, and 25,416 CVD cases, and reported no associations between total (whole-/low-fat) dairy and milk with mortality, CHD, or CVD. However, the authors reported an inverse association with total fermented dairy (20 g/day), which included sour milk products, cheese, or yogurt with mortality (RR 098; 95% CI, 0.97–0.99) and CVD risk (RR 0.98; 95% CI, 0.97–0.99). This meta-analysis was later updated with an additional four cohort studies, and the authors confirmed that total dairy and milk were not associated with incident CHD (Soedamah-Muthu and de Goede 2018).

In terms of the associations between individual dairy products and CHD, Gille et al. (2018) suggested there is moderate evidence for an inverse association between cheese consumption and CHD. In the meta-analysis by Guo et al. (2017), a moderate inverse association with fermented dairy and CVD and all-cause mortality, but not with CHD, was observed.

In recent years, several meta-analyses on dairy consumption or individual dairy foods and the association with incident stroke have been published. In 2016, de Goede et al. conducted a systematic review and dose-response meta-analysis of milk and other dairy foods in relation to stroke risk. The authors reported that milk intake was inversely associated with stroke risk (RR = 0.93; 95% CI, 0.88–0.98; $P = 0.004$), especially in Asian countries (RR 0.82; 95% CI, 0.75–0.90). In addition, cheese intake was marginally inversely associated with stroke risk (RR 0.97; 95% CI, 0.94–1.10 per 40 g/day). Laursen et al. (2019) investigated substitutions between individual dairy products and risk of stroke and found that low-fat yogurt substituted for whole-fat yogurt was associated with a higher rate of ischemic stroke (hazard ratio (HR) 2.58; 95% CI 1.11–5.97 per serving/day). In addition, whole-fat yogurt as a substitution for cheese, butter, buttermilk, or milk was associated with a lower rate of ischemic stroke (HR 0.33–0.36/serving/day).

In the most comprehensive systematic review and meta- analysis, Fontecha et al. (2018) recently compiled all the available evidence examining the association between milk and other dairy product consumption and cardiovascular diseases. According to this review, there was no association between total dairy products, either in whole or low fat, and CVD or heart failure and stroke. However, there was an inverse association between dairy consumption and ischemic heart disease and myocardial infraction. With regard to separate types of dairy products or with different dose responses, milk consumption showed no association with CVD or stroke, while cheese, fermented milk, or fermented dairy products showed an inverse association with stroke. This was further supported by the pooled results of the meta-analysis on RCTs, which showed no adverse effect of dairy consumption on cardiometabolic risk markers, including blood pressure and total and LDL cholesterol.

Plausible Mechanisms by Which Milk and Dairy Nutrients Could Moderate Obesity and Cardiometabolic Diseases

A number of plausible mechanisms have been suggested by which milk and other dairy products affect energy balance and body composition (Dougkas et al. 2011). The most prevalent mechanism is related to Ca as an anti-fat-generating component of dairy products and its mediating effect on within-cell Ca metabolism. According to this mechanism, a decrease in dietary calcium intake, via stimulating the circulating calcitropic 1, 25-hydroxyvitamin D and parathyroid hormone, increases the concentration of ionized Ca in human fat cells, thereby inhibiting fat breakdown and increasing fat formation, leading to increased fat storage (Zemel 2002). Additionally, this stimulation of the calcitropic hormones decreases fat oxidation (fat burning) (Xue et al. 2001). Gonzalez et al. (2012) conducted a meta-analysis on the effect of chronic high Ca intake on fat burning and showed an 11% increase in fat burning (standardized mean difference, 0.42; 95% CI, 0.14, 0.69, $P = 0.003$) with an increase in dietary Ca by 800 mg/day. The effects were more pronounced among habitual low-Ca consumers (<700 mg/day). However, while the mechanism on the fat cell lipid metabolism has been supported by animal and cell-culture studies, a few human studies have refuted the theory that dietary Ca affects fat cell metabolism, energy expenditure, and fat burning (Dougkas et al. 2011). Another mechanism related to the anti-fat-generating effect of dietary Ca, which gained support from recent human studies, is on its impact on fecal fat excretion (Denke et al. 1993). This mechanism is attributed to Ca's capability to reduce fat absorption from the gastrointestinal tract via the formation of insoluble fatty acid soaps, leading to a negative energy balance (Jandacek 1991). In a meta-analysis of 15 studies conducted by Christensen et al. (2009), an increase in consumption of both dietary and supplemental Ca of 1241 mg/day increased fecal fat excretion by 5.2 g/day (95% CI: 1.6, 8.8) relative to those with habitually low dietary Ca intake (<700 mg/day). According to the authors, this excretion could be translated into a 1.9 kg body fat or 2.2 kg of body weight loss over a year. Finally, Tordoff (2001) introduced the appetite calcium theory, according to which Ca influences appetite through the low blood ionized Ca concentration, which triggers the appetite for high Ca-rich foods or through changes in the taste recognition. This could further impact the calcitropic hormones or the level of the appetite-suppressing hormones after Ca ingestion (Tordoff et al. 1998). However, further investigation is required as the results remain inconsistent.

The beneficial role of milk and other dairy product consumption in the regulation of body weight and composition might have a favorable impact on selected biomarkers of the cardiometabolic diseases (i.e., glycemia, insulinemia, cholesterol, lipid profile, and blood pressure) and therefore on reducing the risk of T2D and CVDs. For instance, the mediating effect of Ca on lipid profile through the decrease in fat absorption in the intestines influences positively the blood lipid profile and LDL and total cholesterol, as it has been observed following cheese relative to butter intake (Kjølbæk et al. 2017). Additionally, the null effect of cheese on plasma cholesterol could be hypothetically attributable to its higher protein and probiotic content. Thus, focusing on a single dairy component rather than the whole dairy matrix or foods could provide a limited portrait of the protective effects of milk and other dairy products on risk of obesity and cardiometabolic disorders.

There is evidence of a greater effect of dairy products compared with supplemental Ca on risk of body weight gain, which could be attributable to the synergistic effect of Ca with other components present in dairy such as proteins, lactose, and several other bioactive compounds (Dougkas et al. 2011). Dairy proteins, such as whey and casein, have been related to appetite and food intake regulation through mediating gastric emptying and gut motility via increased concentration of total amino acids and appetite-related gastrointestinal hormones (Dougkas et al. 2011). Onvani et al. (2017) examined in a meta-analysis of 13 intervention studies the effect of dairy products on satiety (sense of fullness) and showed that consumption of 500 ml of dairy products significantly increased feelings of fullness (mean difference, 7.9; 95% CI, 0.6, 15.3) and decreased food intake in a follow-up meal. It has also been shown that milk proteins stimulate insulin secretion, which could also affect appetite and food intake regulation, skeletal muscle metabolic function, and muscle mass maintenance during weight loss regimes (Layman and Walker 2006). In addition, the properties of milk proteins related to insulin production are responsible for the relatively low glycemic index of milk and regulating glycemic fluctuation via stimulating the secretion of incretins (gut peptides that stimulate insulin secretion) and elevating the concentration of certain amino acids (Visioli and Strata 2014). Furthermore, the increased mean gastric emptying time after consumption of whole-fat and fermented milk relative to low-fat milk could speculatively assist in glycemic control and thus T2D (Visioli and Strata 2014). However, it remains uncertain whether and how milk and dairy products improves fasting glucose and insulin sensitivity; thus further research seems prudent.

Whey protein has also been linked with improved blood pressure, although the evidence of the relative impact of milk proteins on blood pressure and vascular function remains inconclusive (Fekete et al. 2016). Potential mechanisms include the role of bioactive peptides such as tripeptides that are formed through the actions of the gut microbiota and gut enzymes, which are abundant in fermented dairy products. Those tripeptides have been related to blood pressure, but other peptides have also been linked to putative properties related to prevention of blood clot formation (Visioli and Strata 2014).

Certain types of fat in milk, such as medium-chain fatty acids (MCFA) and conjugated linoleic acid (CLA), have been shown to inhibit the production of fat within the fat cells and increase fat burning (Ing and Belury 2011). MCFA has also been shown to exert antibacterial activity and to improve body composition without negatively impacting cardiometabolic risk factors and the presence of cholesterol in the blood (Fontecha et al. 2018). Dairy products are also a major source of saturated fatty acids (SFA), and this has been related to an increased risk of CVD. However, not all SFAs have the same impact on cardiometabolism (Fontecha et al. 2018). For instance, oleic, stearic, rumenic, and trans-palmitoleic acids have neutral or favorable impact on some cardiometabolic indicators such as HDL cholesterol, insulin secretion, abundance of triglycerides in blood, and blood pressure (Visioli and Strata 2014).

Fermented dairy products, such as yogurt, could be implicated in the beneficial effect of dairy on the risk of overweight and obesity through manipulating the composition and metabolic activity of the gut microbiota (Marette and Picard-Deland 2014). Certain bacteria that are used as probiotics in fermented dairy products, such as *Lactobacillus acidophilus* and *Bifidobacterium bifidum*, have been proposed to be beneficial for certain diseases (Sayon-orea et al. 2017). Suggestive mechanisms of the role of probiotics could implicate reduction of chronic inflammation by enhancing adaptive immune responses, intestinal barrier function, lipid profiles, and appetite regulation (Pei et al. 2017). Consumption of fermented dairy products have also been linked with increased colonic production of acetate, butyrate, and total short-chain fatty acids (SCFAs), which contribute favorably to the effects of MCFAs, increase insulin sensitivity, increase fat burning, and decrease fat storage (Canfora et al. 2015). However, further research is needed to elucidate the plausible mechanisms by which milk and other dairy products and components influence the regulation of body weight and cardiometabolic diseases.

Overall Conclusions

The totality of evidence based on systematic reviews and meta-analyses conducted in children and adolescents suggest that milk and other dairy products, as part of a weight maintenance diet, are not associated or are inversely associated with body fatness. With regard to adults, the majority of prospective cohort studies showed either a neutral or inverse association between total dairy consumption and body weight gain. Although inconsistencies exist, consumption of low-fat milk and dairy products showed neutral associations, while whole milk and dairy showed inverse associations with adiposity measures. Evidence from meta-analyses based on intervention studies showed that milk and dairy consumption as part of an energy-restricted regime enhances further weight and body fat loss in overweight and obese participants.

The evidence from prospective cohort studies published to date has suggested that the consumption of dairy products, with other regular or low-fat content, does not adversely affect the risk of T2D or CVD outcomes (CHD and stroke) and may have a protective effect. Evidence based on prospective studies indicates that yogurt is most strongly related to a lower T2D risk. However, further research is needed to better understand the role of the different types of dairy foods in childhood and adulthood obesity and their effect on T2D and CVD risk.

There are a number of supportive mechanistic data by which milk, dairy products, and calcium could moderate absorption, storage, and usage of fat, appetite, and the metabolic activity of the gut microbiota. Relatively little is known about the mechanisms underlying the effects of dairy products on T2D and CVD outcomes. In all cases, more work and robustly designed long-term randomized intervention studies are needed to clarify the underlying mechanisms of action for both obesity and cardiometabolic diseases.

Milk and dairy products (excluding butter) are nutrient-rich and contribute significantly to the intake of many nutrients in the diet and are the greatest contributor of calcium, iodine, and a number of B group vitamins. The relatively high saturated fat content raises some concerns with regard to the cardiovascular system, yet dairy matrix can be a stronger determinant of health effects than saturated fat content. On this basis, there is limited and no definitive evidence to support a concern to limit the consumption of milk and other dairy products by children, adolescents, and adults on the grounds that they may promote obesity and increase the risk for cardiometabolic disease.

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Eating, Drinking, and Well-Being

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Contents

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Abstract

The aim of the present chapter is to present a conceptual framework for examining associations between eating, drinking, and well-being. The approach is exemplified by considering two topics which have received considerable attention, namely, the effects of consumption of breakfast and ingestion of caffeine. It is argued that other aspects of diet can be considered in a similar way once the volume of research reaches appropriate levels. The first feature of the current approach to well-being is that it is multifactorial. Research on diet and health has confirmed the view that there is more to health than the absence of disease. Being able to function efficiently, both mentally and physically, is an important part of well-being. Similarly, the absence of negative affective states (negative mood, stress, anxiety, and depression) and the presence of positive emotions (positive affect, happiness, and life satisfaction) have long been recognized as key features of well-being. Previous research has investigated the relationship between diet and well-being, with some topics such as the effect of a healthy diet (e.g., consumption of breakfast, fruit and vegetables, and oily fish) or a bad diet (e.g., junk food) being widely studied. Other aspects of eating and drinking require further attention (e.g., eating super-foods such as broccoli; effects of BMI; emotional eating; and consumption of foods which change the gut microbiome – prebiotics and probiotics). There are three major problems with most of the previous research. First, the different dietary topics are often studied in isolation, which clearly misrepresents the real-life situation. Secondly, well-being is influenced by other established predictors (psychosocial factors such as stress, social support, personality, and coping styles; health-related behaviors such as exercise; and sleep), and these are rarely controlled for. Thirdly, most of the research involves cross-sectional studies. What is now needed are multivariate, longitudinal studies of eating, drinking, and well-being. Such research will elucidate underlying biological mechanisms and develop practical approaches of preventing and managing negative effects and maximizing positive ones.

Introduction

This chapter will discuss different conceptual frameworks for investigating associations between eating, drinking, and well-being. Key issues will be covered by focusing on specific topics where there has been extensive research. This approach is sensible as other aspects of nutrition and well-being have received less coverage and more research is required to extend our knowledge to food and drink more generally. The main areas focused on are the consumption of breakfast and ingestion of caffeine. Not only has there been extensive research on these topics, but there are also areas where the issue of their impact on well-being has been addressed. The aim is not to provide extensive literature reviews but to demonstrate key features of different approaches to the study of diet and well-being. The above section shows that a focused approach to eating, drinking, and well-being is desirable at this stage.

In part this reflects uncertainty about definitions and approaches to the study of well-being. Two different conceptualizations are covered here, one reflecting a holistic view of well-being and the other a more specific conceptualization of the well-being process.

A Holistic Approach to Well-Being

Background Research

This approach, first described in detail by Smith (2005a), developed from the realization that there is more to being healthy than being free from disease. Research on nutrition has often investigated associations with different types of disease, but there have also been studies relating diet to both physical and mental functions. The term "well-being" is sometimes replaced by "quality of life" or by the concepts of being able to function well and having a positive mood state. In the area of nutrition, the term "functional food" refers not only to the beneficial effects related to chronic disease but to the potential for improved well-being. The relationship between diet and both negative and positive mental health has also been examined, often indicating subtle changes in mood rather than the presence of clinical conditions. These approaches apply across the life-span with different functions receiving attention at certain ages (e.g., education outcomes in childhood/adolescence; performance at work in adults; and cognitive decline in the elderly).

Smith (2005a) described how the above approach could be used in empirical research, and the possible benefits of high fiber diets were the initial subject matter. The basis of this approach came from previous research on the effects of food and drink on cognitive function and mood. Initial interest in this area came from research on the effects of lunch on sustained attention and subjective alertness. Laboratory studies showed that one is less able to concentrate after consumption of lunch and that alertness is reduced at that time. However, ingestion of caffeine removed the post-lunch dip, and further research has shown that a general benefit of ingesting caffeinated drinks is to reduce the impairments observed in other low alertness states (e.g., working at night). These results have been confirmed in research from several other laboratories (see Smith 2002, for reviews of these early studies).

Consumption of breakfast has been associated with better memory for lists of words and a more positive mood (see Smith 2011a, for a review). This effect has been explained in terms of glucose having a positive effect when the brain is deprived of glucose by the nighttime fast. Glucose may have other functional benefits, and it has been shown to improve simulated driving performance. Again, other laboratories have also demonstrated similar beneficial effects of breakfast consumption and glucose.

Other studies have examined the effects of regular patterns of consumption. A number of our studies show that consumption of breakfast is associated with subjective reports of better health. Similarly, the severity and frequency of minor illnesses may be lower in those who regularly consume breakfast. Most of these studies have involved small sample sizes, but they are supported by results from research with large, representative community samples. This epidemiological research showed that breakfast consumption was related in a linear dose-response pattern to subjective health. While such research suggests associations between diet and well-being, it is difficult to imply causality from these cross-sectional studies. However, initial studies such as these have led to subsequent intervention studies which alter digestion which then leads to changes in well-being. This approach has led to intervention studies manipulating the fiber content of breakfast cereal. Short intervention studies revealed that consumption of high fiber breakfast cereal led to increased energy levels. Subsequent research has shown that supplementing breakfast cereal with inulin, a fiber that occurs naturally in vegetables such as onions, leeks, and chicory, can improve memory in the short term (Smith 2019) and increase alertness, possibly due to prebiotic changes to gut flora, after 2 weeks of ingestion.

Breakfast, Health, and Cognitive Function

Breakfast and Nutritional Requirements

Breakfast provides vitamins and minerals necessary to meet nutritional requirements (Rampersaud et al. 2005). Ready-to-eat breakfast cereal can improve the diet by providing fortified micronutrients and by reducing fat levels. Indeed, it has been shown that breakfast consumers have better quality diets, with more fiber and nutrients and fewer calories than those who skip breakfast. Rampersaud et al. (2005) showed that children who eat breakfast have higher daily intakes of calcium, fiber, vitamin C, vitamin A, riboflavin, iron, and zinc compared to non-consumers. It is recommended that we consume whole grains, fruits and vegetables, and low-milk products. Many popular breakfast foods increase intake of such food groups. Breakfast often contributes up to 30% of whole-grain intake, which reduces the risk of coronary heart disease and diabetes.

Breakfast and Weight Management

It has been shown that the risk of obesity is four times greater in breakfast skippers compared to those who eat breakfast (Ma et al. 2003). Research has also shown that breakfast consumers have lower BMIs and are less likely to gain weight. Similar results have been found for children and adolescents. Breakfast may also help weight management by influencing satiety.

Breakfast and Physical Health

Breakfast consumers have lower levels of cholesterol. Metabolic syndrome is linked with being obese and having an increased risk of coronary artery disease and diabetes. Diets rich in whole grains and dairy products (found in many breakfasts) lead to a reduced risk of metabolic syndrome (Baxter et al. 2006). Dietary fiber found in breakfast cereals also improves digestion, and whole-grain wheat may have a prebiotic effect. Breakfast consumption may also influence the immune system, and research has found higher numbers of NK cells and a lower number of T cells in those who did not consume breakfast.

Breakfast and Cognitive Function

Extensive laboratory research, largely using young adults as volunteers, has shown that consumption of breakfast is associated with improved episodic memory (see Smith 2018, for a review). Studies of children have been reviewed by Hoyland et al. (2009), and they conclude that breakfast improves cognition, especially memory. This effect is most easily demonstrated in groups with poor nutrition. Research using a sample of high school students showed that breakfast improved visual-spatial memory in males. School breakfast programs can have positive effects which may be due to increased school attendance.

Breakfast and Mood

Consumption of breakfast is associated with an acute increase in positive mood (see Smith 2011a, for a review). Such effects have been observed with different types of breakfast, a range of breakfast cereals, and cereal bars. They have been found in studies of children and adolescents.

Huang et al. (2010) analyzed data from a Korean national representative sample ($N = 15{,}340$) to examine associations between breakfast and health-related quality of life. Breakfast skippers had significantly lower well-being scores on the Short Form-36 scale (a standard measure of well-being), reflecting reduced vitality, reduced mental health, poorer general health, and more problems with social functioning and emotional roles.

Other research has found that those who consumed a cereal breakfast each day had lower levels of perceived stress and were less emotionally distressed and depressed than those who ate breakfast less frequently (see Smith 2011a, for a review). Regular breakfast consumers had a healthier diet, drank less alcohol, and were less likely to be smokers than breakfast skippers. However, the relationship between cereal breakfast consumption and health did not reflect differences in these other health-related behaviors. Smith (2010) replicated these benefits of regular breakfast consumption with a sample of children. These findings were also confirmed in an intervention study with breakfast cereal consumption being associated with greater alertness, fewer minor symptoms and bowel problems, lower depression, emotional distress and fatigue, and fewer cognitive problems. Other research shows that the effects of breakfast on well-being appear to be most pronounced with breakfast cereal in combination with dairy products.

Effects of Breakfast on Real-Life Cognitive Function and Safety

The major benefits of breakfast consumption are to be seen in the areas of weight management, nutritional intake, and health. Studies of children demonstrate that breakfast consumption may improve school attendance and cognition which can then lead to greater academic achievement. Less is known about the real-life behavioral implications of consuming breakfast for adults. Chaplin and Smith (2011) examined effects of breakfast consumption on the health and safety of a sample of 870 nurses. The results showed that cognitive errors, accidents, and injuries were more frequent in those who skipped breakfast. In addition, stress at work was greater in those who rarely ate breakfast. Further research investigating real-life activities outside of the workplace is now required. This future research should involve interventions rather than cross-sectional analyses.

The results described in this section come from studies examining a range of different breakfast types in many different countries. Results appear to generalize across these different contexts which makes breakfast consumption an appropriate topic to use as a template for future research on other aspects of nutrition.

The next section presents a profile of the effects of caffeine that lead to the holistic profile of its effects on well-being.

Caffeine, Health, and Cognitive Function

Acute Effects of Caffeine on Cognitive Function and Mood

Ingestion of doses of caffeine between 100 and 300 mg can increase alertness and attention. Research has identified effects that occur in low alertness situations where caffeine improves performance on tasks requiring sustained attention. Other effects can be seen even in alert individuals and show that caffeine improves the encoding of new stimuli. Episodic memory tasks are usually unaffected by caffeine, whereas working and semantic memory show a benefit. These memory effects are usually smaller than those seen in attention tasks (see Smith 2002, 2011b for reviews of caffeine and cognitive function).

In terms of mood changes, the main effect of caffeine is to increase alertness, especially when volunteers are fatigued. Some research has also shown that caffeine makes the person feel happier and more sociable. Caffeine can increase anxiety if given in doses over 300 mg (Lieberman 1992) or to sensitive individuals. The effects described above are robust and found when caffeine is given to withdrawn consumers, those who have recently consumed caffeine, or to non-consumers. Many studies have involved giving a single large dose of caffeine which does not reflect how we consume it, but research has found that the behavioral changes seen after a single dose of 200 mg caffeine were also observed after four separate doses of 65 mg spread over the day (which gave an identical final caffeine level to the large single dose).

Caffeine and Sleep

Large amounts of caffeine consumed in the evening can stop people going to sleep and reduce their sleep duration. Most caffeine drinkers stop their consumption earlier in the day to prevent this. Indeed, it is often difficult to find evidence supporting the view that high consumption per se will affect sleep. For example, Sanchez-Ortuno et al. (2005) conducted a survey of French workers and found that drinking up to seven cups of coffee a day was not associated with a decreased duration of sleep.

Other research has used caffeine to reduce the negative effects of sleep loss. The American Academy of Sleep Medicine (Bonnet et al. 2005) has concluded that caffeine can increase wakefulness, as measured by sleep latency tests. Caffeine also removes or reduces the performance decrements seen in sleep-deprived individuals doing attention and working memory tasks. Caffeine also increases the subjective alertness of sleep-deprived individuals. Recommended doses of caffeine for sleep-deprived individuals are usually 200–300 mg because side effects can occur with higher doses (e.g., 600 mg).

Caffeine and Physical Performance

Research on this topic has been reviewed by the International Society of Sports Nutrition (Goldstein et al. 2010). They concluded that caffeine can improve performance of trained athletes when the dose is between 3 and 6 mg/kg. Caffeine is ergogenic for endurance exercise, such as time trial performance, soccer, and rugby. Effects of caffeine on strength-power performance are less clear.

Beneficial Effects of Habitual Consumption of Caffeine on Performance

There has been less research on the regular consumption of caffeine consumption than on its acute effects. Strongest evidence for beneficial effects of regular caffeine consumption on cognition comes from a study which examined the association between habitual caffeine consumption and performance in a representative sample of over 9000 adults. Caffeine consumption showed a dose-response relationship with performance, and the benefits were greatest in those who had consumed the most over a long period of time. Caffeine has also been shown to improve simulations of real-life activities (e.g., driving, Horne and Reyner 1996; simulated assembly line work, Muehlbach and Walsh 1995; simulated complex work, Streufert et al. 1997).

Caffeine and Real-Life Performance and Safety

Smith (2005b) examined the association between regular caffeine consumption and safety and performance in the workplace. The first study revealed that consumption of more caffeine was associated with greater alertness over the day and reduced slowing of reaction time. A second study found associations between higher caffeine consumption and fewer accidents and errors at work. Overall, the results from this study suggest that caffeine may have benefits for safety and performance efficiency at work. A similar study examined safety and cognitive function in non-working samples (Smith 2009). Overall, the results showed that in a non-working population, greater caffeine consumption was associated with better cognitive functioning. This benefit of caffeine was not associated with negative health costs.

Tse et al. (2009) studied the effects of caffeine on cooperative social behavior. Caffeine reduced negative affect and increased social support. Research has suggested that high consumption of energy drinks is associated with antisocial or risky behavior (Miller 2008; O'Brien et al. 2008). These cross-sectional studies could reflect reverse causality, with those who frequently take risks choosing to drink energy beverages.

Caffeine and Driving

Results from studies using driving simulators have shown that caffeine generally reduced the impaired driving performance seen in fatigued drivers. Philip et al. (2006) examined the effects of sleepiness and caffeine on real-life driving. Sleepiness increased lane crossing, an effect reduced by 200 mg of caffeine. These results suggest that the effects of caffeine observed with artificial tasks may apply to real-life behavior.

Driving performance can be impaired by factors such as alcohol. Liquori and Robinson (2001) found that caffeine may improve reaction time and increase subjective alertness after alcohol but does not completely counteract the alcohol-induced impairment of driving.

Smith (cited by Smith 2009) examined road traffic accidents in a community sample ($N = 6648$). 2.2% of caffeine consumers were involved in a road accident whereas 3.6% of non-consumers of caffeine reported an accident. Logistic regression analyses, adjusting for confounders, showed that consumption of caffeine nearly halved the risk of being involved in a road traffic accident (OR = 0.58 CI 0.35, 0.98). This result confirms the positive benefits of caffeine for road safety and accident prevention.

Caffeine and Prevention of Cognitive Decline in the Elderly

Animal research shows that caffeine consumption may prevent memory decline (Cunha and Agostinho 2010). Epidemiological studies have also examined whether there is an association between habitual level of caffeine consumption and dementia. A systematic review and meta-analysis (Santos et al. 2010) showed a trend toward a protective effect of caffeine for cognitive function in the elderly, with caffeine consumers being less likely to develop dementia.

Mental Health

The literature shows that in samples with low levels of trait anxiety, caffeine only increases anxiety after large amounts that would rarely be ingested. Other research has examined effects of caffeine consumption in those with high levels of anxiety. Caffeinism refers to symptoms associated with very high caffeine intake (often over 1000 mg a day) that are very similar to severe chronic anxiety (Greden 1974). However, caffeinism appears to be a specific condition, and there is little evidence for correlations between caffeine intake and anxiety in psychiatric outpatients (Eaton and McLeod 1984). Research has also investigated whether caffeine exacerbates the anxiety produced by other stressors. Shanahan and Hughes (1986) found that caffeine increased anxiety induced by a stressful task, but other research (e.g., Smith et al. 1997) has not shown interactive effects between caffeine and stressors such as noise.

Caffeine intake has been associated with lower depression scores and even a reduced risk of suicide (see Lara 2010 for a review). This effect of caffeine on depression may have other beneficial effects on health. Depression often leads to immunosuppression which can lead to an increased susceptibility to infectious disease, and Smith (cited by Smith 2009) found that caffeine consumption was also associated in a dose-response fashion with fewer upper respiratory tract symptoms.

Caffeine and Children and Adolescents

Caffeine is now added, sometimes in large amounts, to soft drinks that are consumed by children and adolescents. Older research on the behavioral effects of caffeine on children confirm many of the findings seen in adults (see Temple 2009, for a review). Effects of caffeine in studies of children are often smaller than those in studies of adults, which may reflect the smaller doses consumed by the children. It is widely agreed that caffeine intake by pregnant women should be kept below 200 mg, although there is no evidence showing that caffeine consumption during pregnancy or childhood influences the development of the brain.

Health Effects of Caffeine Consumption

A cost-benefit analysis of the effects of caffeine usually involves comparing beneficial behavioral outcomes and costs with any possible negative long-term health effects. It has been suggested that caffeine is associated with many chronic health problems, but most of the effects are not significant when confounders are controlled (Nawrot et al. 2003). In contrast, there are now suggestions that caffeine consumption may lead to health benefits. For example, Daly (2007) has shown that research on caffeine has been important in defining the role of phosphodiesterases, adenosine receptors, and calcium release channels in biological processes. Caffeine and related analogues are potential therapeutic agents for intervention in asthma, diabetes, cancer, and Alzheimer's and Parkinson's diseases.

Conclusions About Caffeine and Well-Being

Research on the positive behavioral effects of caffeine has established a robust profile of the changes in performance and mood that occur acutely after ingestion. Regular caffeine consumption has also been shown to improve well-being and may contribute to better health and safety. A cost-benefit analysis (Doepker et al. 2016) even suggests that earlier views of negative health effects of caffeine are incorrect and that regular consumption may improve both acute and long-term health. Negative effects of caffeine have been reported, and these often reflect consumption of large amounts (>1000 mg a day) or sensitivity of the individual (Smith 2002).

The next section examines well-being in a slightly different way and considers the microstructure of the well-being process linking predictors, appraisals, and positive or negative outcomes.

The Well-Being Process

Recent approaches to the well-being of working adults have measured it with the Smith Well-Being Questionnaire (SWELL – Smith and Smith 2017) or the Well-Being Process Questionnaire (WPQ – Williams et al. 2017a, c; Williams and Smith 2016, 2018). These surveys have also been used in studies of the well-being of students (Williams et al. 2017b). These measuring instruments cover predictors of both positive (positive affect, happiness, and life satisfaction) and negative outcomes (stress, fatigue, anxiety, and depression). Other measuring instruments focus on the well-being outcomes without considering established predictors.

The well-being process model was based on the Demands-Resources-Individual Effects (DRIVE) model (Mark and Smith 2008), which was originally used in research on occupational stress (see Fig. 1).

The model requires measurement of negative characteristics such as stressors, resources to cope with challenges, such as support and control, and individual differences such as personality and coping style. The model allowed for the addition of new variables, with positive outcomes, such as happiness, positive affect, and life satisfaction being included in later research. Such positive outcomes are often called "well-being." However, the well-being process includes both negative and positive characteristics (e.g., demands, support, and control), appraisals (life satisfaction and perceived stress), individual differences (e.g., negative coping and positive personality), and outcomes (e.g., happiness and anxiety/depression). Recent research has led to new variables being added to the model (e.g., burnout and work-life balance; resilience and training attitudes; ethnicity; and psychological contract fulfillment).

An important feature of these surveys is that they use short scales which are highly correlated with the longer established questionnaires from which they were

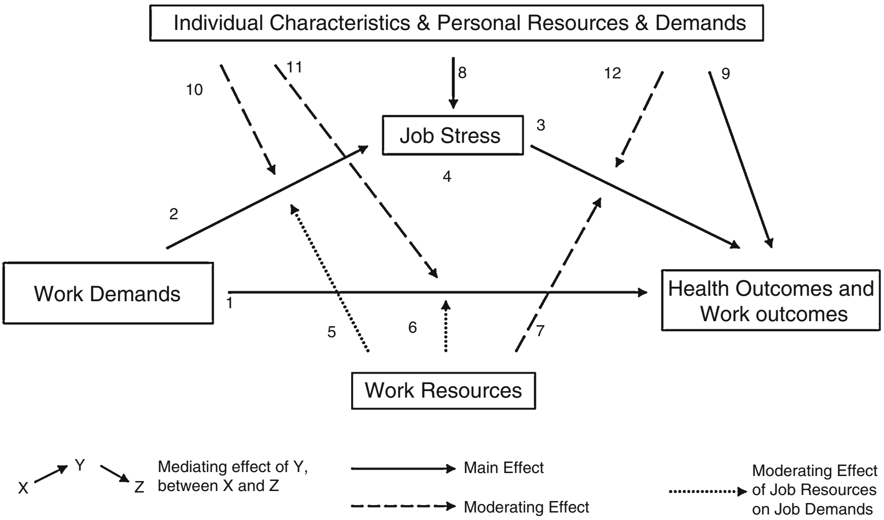

Fig. 1 The demands-resources-individual effects model (Mark and Smith 2008)

derived. For example, asking a person to rate how anxious or depressed they feel using a 10-point rating scale ranging from "not at all" to "very much so" leads to results which are highly correlated with longer established anxiety and depression scales (e.g., the Hospital Anxiety and Depression Scale – Zigmond and Snaith 1983). These short scales have been shown to have good validity and reliability. They have been widely used in cross-sectional studies and also been used in longitudinal studies which can give a better idea of the direction of causality. In the context of this chapter, it is now important to examine whether aspects of eating and drinking, such as consumption of breakfast and ingestion of caffeine, are associated with positive and negative well-being outcomes and whether any effects remain significant when established predictors of well-being are covaried.

The next section describes results from a study of students ($N = 268$) who completed the WPQ (see Appendix 1) and also provided information on the frequency of breakfast consumption and caffeine use (the Diet and Behavior Survey – Richards et al. 2015a – see Appendix 2).

The univariate correlations showed that caffeine consumption was correlated with negative outcomes ($r = 0.22$), as was skipping breakfast ($r = 0.23$). Skipping breakfast was also negatively associated with positive outcomes ($r = -0.23$). However, caffeine consumption was also associated with established predictors of negative well-being (negative coping, $r = 0.22$; positive personality, $r = -0.14$). Similarly, skipping breakfast was associated with established predictors of the positive and negative outcomes (negative coping, $r = 0.19$; social support, $r = -0.13$; positive personality, $r = -0.23$). Regressions including caffeine, skipping breakfast, and the established predictors of positive and negative outcomes showed that there were no significant effects of caffeine or skipping breakfast when personality, coping, exposure to stressors, and social support were adjusted. Further research is now required to replicate and extend these preliminary findings. One approach that is certainly required is to take a multivariate approach to eating and drinking behavior. Often nutrients or meals and drinks are studied in isolation which is not representative of real life. Indeed, many aspects of diet are highly correlated, and without a multivariate approach, it is possible to come to erroneous conclusions based on univariate analyses. The importance of considering correlated psychological characteristics has been demonstrated above. Smith and Richards (2018) demonstrated the importance of adjusting for correlated aspects of diet. Their research examined the association between consumption of energy drinks and academic performance of adolescents. The initial univariate analyses suggested that those who frequently consumed energy drinks were more likely to have poorer attainment. However, consumption of energy drinks was part of a junk food diet, and when this was statistically controlled, the association between energy drinks and attainment was no longer significant.

The Way Forward

There has been considerable research on diet and behavior (see Gómez-Pinilla 2008; Kristjánsson et al. 2010; Northstone et al. 2012), but there are a number of reasons why it has been difficult to interpret the findings and apply them to real-life settings. First, most studies take a univariate approach and consider a dietary variable in isolation. If the study is investigating acute effects then one also needs to address whether these will occur with repeated ingestion and with consumption of other food and drink. Cross-sectional studies are causally ambiguous; for example, does breakfast influence mental health or does mental health influence the likelihood of consuming breakfast? Instead, longitudinal studies, preferably with an intervention, are needed to determine causal relationships. Epidemiological research on diet and behavior often fails to control for important personal and lifestyle characteristics. For example, Smith (1999) suggested that consumption of breakfast may be a good indicator of a generally healthy lifestyle rather than just having specific effects.

Research has identified several different dietary effects that require further analysis and investigation. Beneficial effects of breakfast (Kleinman et al. 2002; Lesani et al. 2016; Lien 2007; Littlecott et al. 2016), fruit and vegetables (Blanchflower et al. 2013; Lin and Morrison 2002; Mujcic and Oswald 2016; Smith and Rogers 2014), the Mediterranean diet (McMillan et al. 2011), a vegetarian diet (NHS 2015), grazing (Hewlett et al. 2009), super-foods (e.g., broccoli; NHS 2015), and pre- and probiotics (Spector 2015) have been identified. Negative effects have been related to junk food (Niemeier et al. 2006; Zahra et al. 2014), energy drinks (Richards et al. 2015b), high levels of caffeine (Smith 2002), emotional eating (Gower et al. 2008; Han and Pistole 2014; Michels et al. 2012), dietary restraint (Brunstrom et al. 2005), and a high BMI (Booth et al. 2014). Secondary analyses of existing databases can determine whether these effects are still significant when psychosocial and lifestyle variables are taken into account. However, we have no existing data which allows us to determine whether effects remain when other dietary effects are controlled. It is now easy to do this using a well-established methodology which can be applied to primary, secondary, and university education, those of working age, and the elderly.

The present approach is similar to that taken in a recent study by Tan et al. (2018). They argue that little is known about multiple health behaviors across age groups and the underlying mechanisms are unclear. The model they used was a Compensatory Carry-Over Action Model which postulates that different aspects of diet are interrelated and are driven by shared underlying mechanisms such as quality of sleep. Their study was cross-sectional and only involved adults of different ages. Use of longitudinal studies with children can lead to clearer identification of causal mechanisms and cognitive fatigue, rather than sleep, maybe the underlying mechanism. There are other plausible CNS mechanisms that underlie such dietary effects (Yeomans 2017). Yeomans reviewed animal and human research and concluded that repeated consumption of high fat or high fat/high sugar diets leads to specific impairments in the functioning of the hippocampus, which causes reduced cognitive performance.

Conclusion

The research described in the first part of the chapter showed that consumption of breakfast and caffeine leads to increased well-being. These reviews used a holistic approach to well-being considering health, functionality, and also positive and negative affective states. More recent approaches have examined a well-being process that starts with established predictors (stressors, social support, coping, and personality) and adjusts for the impact of these when investigating the impact of what we eat and drink. This last approach is relatively new, and future research must investigate whether the impacts of diet on behavior are still significant when confounding factors (psychosocial factors, lifestyle, and other dietary effects) are controlled. Longitudinal studies must also be carried out to provide a better indication of causality. In addition, educational interventions, such as those using film media, need to be evaluated, and this has the potential to be used for dissemination and to increase the impact of future results. Research should address all ages, and it is important to use a method which can be applied across the lifespan and is applicable to vulnerable subgroups (e.g., those with special educational needs and those with other existing disease).

Appendix 1: The Student Well-Being Process Questionnaire

The following questions contain a number of single-item measures of aspects of your life as a student and feelings about yourself. Many of these questions will contain examples of what thoughts/behaviors the question is referring to which are important for understanding the focus of the question but should be regarded as guidance rather than strict criteria. Please try to be as accurate as possible, but avoid thinking too much about your answers; your first instinct is usually the best.

1. I have been feeling in good spirits (e.g., I feel optimistic about the future, feel good about myself, and feel confident in my abilities.).
Disagree strongly 1 2 3 4 5 6 7 8 9 10 Agree strongly
2. Overall, I feel that I have low self-esteem (e.g., At times, I feel that I am no good at all, at times I feel useless, I am inclined to feel that I am a failure.).
Disagree strongly 1 2 3 4 5 6 7 8 9 10 Agree strongly
3. On a scale of one to ten, how depressed would you say you are in general? (e.g., feeling "down," no longer looking forward to things or enjoying things that you used to)
Not at all depressed 1 2 3 4 5 6 7 8 9 10 Extremely depressed
4. I have been feeling good about my relationships with others (e.g., getting along well with friends/colleagues, feeling loved by those close to me).
Disagree strongly 1 2 3 4 5 6 7 8 9 10 Agree strongly
5. I feel able to relax when I want to.
Disagree strongly 1 2 3 4 5 6 7 8 9 10 Agree strongly
6. I feel energetic and interested when I need to be.
Disagree strongly 1 2 3 4 5 6 7 8 9 10 Agree strongly
7. I don't really get on well with people (e.g., I tend to get jealous of others, I tend to get touchy, I often get moody.).
Disagree strongly 1 2 3 4 5 6 7 8 9 10 Agree strongly
8. Thinking about myself and how I normally feel, in general, I mostly experience positive feelings (e.g., I feel alert, inspired, determined, attentive.).
Disagree strongly 1 2 3 4 5 6 7 8 9 10 Agree strongly
9. In general, I feel optimistic about the future (e.g., I usually expect the best, I expect more good things to happen to me than bad; It's easy for me to relax).
Disagree strongly 1 2 3 4 5 6 7 8 9 10 Agree strongly
10. I am confident in my ability to solve problems that I might face in life (e.g., I can usually handle whatever comes my way; If I try hard enough, I can overcome difficult problems, and I can stick to my aims and accomplish my goals.).
Disagree strongly 1 2 3 4 5 6 7 8 9 10 Agree strongly
11. I feel that I am laid-back about things (e.g., I do just enough to get by, I tend to not complete what I've started, I find it difficult to get down to work.).
Disagree strongly 1 2 3 4 5 6 7 8 9 10 Agree strongly
12. I am not interested in new ideas (e.g., I tend to avoid philosophical discussions, I don't like to be creative, I don't try to come up with new perspectives on things.).
Disagree strongly 1 2 3 4 5 6 7 8 9 10 Agree strongly
13. Overall, I feel that I have positive self-esteem (e.g., On the whole I am satisfied with myself, I am able to do things as well as most other people, I feel that I am a person of worth.).
Disagree strongly 1 2 3 4 5 6 7 8 9 10 Agree strongly
14. I feel that I have the social support I need (e.g., There is someone who will listen to me when I need to talk, there is someone who will give me good advice, there is someone who shows me love and affection.).
Disagree strongly 1 2 3 4 5 6 7 8 9 10 Agree strongly

15. Thinking about myself and how I normally feel, in general, I mostly experience negative feelings (e.g., I feel upset, hostile, ashamed, and nervous.).
Disagree strongly 1 2 3 4 5 6 7 8 9 10 Agree strongly
16. I feel that I have a disagreeable nature (e.g., I can be rude, harsh, and unsympathetic.).
Disagree strongly 1 2 3 4 5 6 7 8 9 10 Agree strongly

Coping Style

Problem Focused

17.When I find myself in stressful situations, I take a problem-focused approach (e.g., I take one step at a time, I change things about the situation or myself to deal with the issue, I don't let my feelings interfere too much.).
Disagree strongly 1 2 3 4 5 6 7 8 9 10 Agree strongly

Seeks Social Support

18.When I find myself in stressful situations, I look for social support (e.g., I talk to someone to get more information, I ask someone for advice, I talk to someone about how I'm feeling.).
Disagree strongly 1 2 3 4 5 6 7 8 9 10 Agree strongly

Blame Self

19.When I find myself in stressful situations, I blame myself (e.g., I criticize or lecture myself, I realize I brought the problem on myself.).
Disagree strongly 1 2 3 4 5 6 7 8 9 10 Agree strongly

Wishful Thinking

20. When I find myself in stressful situations, I wish for things to improve (e.g., I hope a miracle will happen, I wish I could change things about myself or circumstances, I daydream about a better situation.).
Disagree strongly 1 2 3 4 5 6 7 8 9 10 Agree strongly

Avoidance

21. When I find myself in stressful situations, I try to avoid the problem (e.g., I keep things to myself, I go on as if nothing has happened, I try to make myself feel better by eating/drinking/smoking.).
Disagree strongly 1 2 3 4 5 6 7 8 9 10 Agree strongly
22. I prefer to keep to myself (e.g., I don't talk much to other people, I feel withdrawn, I prefer not to draw attention to myself.).
Disagree strongly 1 2 3 4 5 6 7 8 9 10 Agree strongly
23. I feel that I have an agreeable nature (e.g., I feel sympathy toward people in need, I like being kind to people, I'm cooperative.)
Disagree strongly 1 2 3 4 5 6 7 8 9 10 Agree strongly
24. In general, I feel pessimistic about the future (e.g., If something can go wrong for me it will, I hardly ever expect things to go my way, I rarely count on good things happening to me.).
Disagree strongly 1 2 3 4 5 6 7 8 9 10 Agree strongly
25. I feel that I am a conscientious person (e.g., I am always prepared, I make plans and stick to them, I pay attention to details.).
Disagree strongly 1 2 3 4 5 6 7 8 9 10 Agree strongly
26. I feel that I can get on well with others (e.g., I'm usually relaxed around others, I tend not to get jealous, I accept people as they are.).
Disagree strongly 1 2 3 4 5 6 7 8 9 10 Agree strongly

27. I feel that I am open to new ideas (e.g., I enjoy philosophical discussion, I like to be imaginative, I like to be creative.).
Disagree strongly 1 2 3 4 5 6 7 8 9 10 Agree strongly
28. Overall, I feel that I am satisfied with my life (e.g., In most ways my life is close to my ideal, so far I have gotten the important things I want in life.).
Disagree strongly 1 2 3 4 5 6 7 8 9 10 Agree strongly
29. On a scale of one to ten, how happy would you say you are in general?
Extremely unhappy 1 2 3 4 5 6 7 8 9 10 Extremely happy
30. On a scale of one to ten, how anxious would you say you are in general? (e.g., feeling tense or "wound up," unable to relax, feelings of worry or panic).
Not at all anxious 1 2 3 4 5 6 7 8 9 10 Extremely anxious
31. In general, how would you rate your physical health?
Extremely poor 1 2 3 4 5 6 7 8 9 10 Extremely good
32. Overall, how stressful is your life?
Not at all stressful 1 2 3 4 5 6 7 8 9 10 Very stressful
Please consider the following elements of student life and indicate overall to what extent they have been a part of your life over the past 6 months. Remember to use the examples as guidance rather than trying to consider each of them specifically:
33. Challenges to your development (e.g., important decisions about your education and future career, dissatisfaction with your written or mathematical ability, struggling to meet your own or others' academic standards).
Not at all part of my life 1 2 3 4 5 6 7 8 9 10 Very much part of my life
34. Time pressures (e.g., too many things to do at once, interruptions of your school work, a lot of responsibilities).
Not at all part of my life 1 2 3 4 5 6 7 8 9 10 Very much part of my life
35. Academic dissatisfaction (e.g., disliking your studies, finding courses uninteresting, dissatisfaction with school).
Not at all part of my life 1 2 3 4 5 6 7 8 9 10 Very much part of my life
36. Romantic problems (e.g., decisions about intimate relationships, conflicts with boyfriend's/girlfriend's family, conflicts with boyfriend/girlfriend).
Not at all part of my life 1 2 3 4 5 6 7 8 9 10 Very much part of my life
37. Societal annoyances (e.g., getting ripped off or cheated in the purchase of services, social conflicts over smoking, disliking fellow students).
Not at all part of my life 1 2 3 4 5 6 7 8 9 10 Very much part of my life
38. Social mistreatment (e.g., social rejection, loneliness, being taken advantage of).
Not at all part of my life 1 2 3 4 5 6 7 8 9 10 Very much part of my life
39. Friendship problems (e.g., conflicts with friends, being let down or disappointed by friends, having your trust betrayed by friends).
Not at all part of my life 1 2 3 4 5 6 7 8 9 10 Very much part of my life
Please state how much you agree or disagree with the following statements:
40. There is a person or people in my life who would provide tangible support for me when I need it (e.g., money for tuition or books, use of their car, furniture for a new apartment).
Strongly disagree 1 2 3 4 5 6 7 8 9 10 Strongly agree
41. There is a person or people in my life who would provide me with a sense of belonging (e.g., I could find someone to go to a movie with me, I often get invited to do things with other people, I regularly hang out with friends.).

Strongly disagree 1 2 3 4 5 6 7 8 9 10 Strongly agree

42. There is a person or people in my life with whom I would feel perfectly comfortable discussing any problems I might have (e.g., difficulties with my social life, getting along with my parents, sexual problems).

Strongly disagree 1 2 3 4 5 6 7 8 9 10 Strongly agree

Appendix 2: Breakfast and caffeine questions from the Diet and Behavior Survey

In the last 6 months:

1. How often did you eat breakfast? (Please tick one box.)

Every day	Most days (3–6)	Once or twice a week	Once a month	Never
☐$_1$	☐$_2$	☐$_3$	☐$_4$	☐$_5$

2. How often did you drink coffee?

Every day	Most days (3–6)	Once or twice a week	Once a month	Never
☐$_1$	☐$_2$	☐$_3$	☐$_4$	☐$_5$

3. How often did you drink tea?

Every day	Most days (3–6)	Once or twice a week	Once a month	Never
☐$_1$	☐$_2$	☐$_3$	☐$_4$	☐$_5$

4. How often did you drink cola (Coca-Cola, Pepsi, other cola)?

Every day	Most days (3–6)	Once or twice a week	Once a month	Never
☐$_1$	☐$_2$	☐$_3$	☐$_4$	☐$_5$

5. How often did you drink energy drinks like Red Bull, Monster, etc.?

Every day	Most days (3–6)	Once or twice a week	Once a month	Never
☐$_1$	☐$_2$	☐$_3$	☐$_4$	☐$_5$

The next set of questions asks about how much you eat and drink (Put 0 if you don't eat or drink that product):

6. Energy drinks _______ cans a week.
7. If you drink energy drinks, which brand do you usually drink? ___________
8. Colas________________cans a week.
9. Coffee_______________cups a week.
10. Tea_______________cups a week.

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Exercise and Diet

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Matthew M. Schubert and David R. Broom

Contents

Abstract

The interaction between exercise and diet is crucial for human energy balance and body weight regulation. Ensuring appropriate energy availability is crucial for optimal performance in athletes and active people. Active individuals tend to tightly regulate energy balance as their bodies have adapted to the demands of training to ensure adequate energy is available. They would benefit from a balanced diet, with potentially higher protein intakes to support training demands.

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Certain nutritional ergogenic aids may also benefit training and performance. Regarding individuals seeking to optimize body composition, exercise alone may not always be sufficient due to compensatory changes in energy intake and non-exercise physical activity. However, regardless of weight loss, exercise has a myriad of positive benefits that will improve overall health. Exercise improves appetite responses to fixed meals, leading to earlier meal termination and satiety. Exercise has been shown to be effective for weight loss and maintenance regardless of adiposity or sex. Exercise is a crucial component of weight maintenance, assisting individuals in keeping off the weight they have lost. In conclusion, exercise and diet are closely linked and important contributors to human health.

Introduction

In all organisms, body weight and composition are regulated by energy balance. Energy balance, simply put, consists of energy intake (EI) through food and drink and energy output through energy expenditure (EE). Energy is expended through resting metabolic rate (RMR) (the amount of energy the body expends at rest), thermic effect of food (the increase in metabolism post-meal during digestion), and through physical activity (PA) and exercise. In the context of the present chapter, "physical activity" will refer to any activity requiring the use of skeletal muscles performed above resting levels, while "exercise" denotes voluntary physical activity completed for health benefits that is structured and planned. When energy intake exceeds energy output, weight gain and increased deposition of fat mass occur. When energy output exceeds energy intake, then (theoretically), weight is lost. Unfortunately, modern society has made it quite easy to "tip" the energy balance equation in the direction of weight gain. For example, low-cost, high-calorie foods easily offset the energy expenditure of 30–60 min of exercise (Holliday and Blannin 2014), and technological advances have led to less leisure-time and occupational physical activity (Troiano et al. 2008). Regardless, exercise is promoted as a means of weight control and weight loss in addition to its myriad of well-known health benefits (Booth et al. 2012). Of particular interest to researchers in the last ~50–100 years is the interaction between exercise and diet. In fact, there are two main areas of interest in this regard. The first is the interaction of exercise and diet for sporting performance in athletes and athletic individuals. The second area of interest is how exercise and diet interact with regard to their impacts on health in the general population. The purpose of this chapter is to briefly discuss these similar but divergent topics to provide readers with a succinct overview of the exercise-diet interactions for optimal athletic performance and for optimal health.

Exercise, Diet, and Sport

Interest in the study of the interaction between diet and athletic performance is almost as old as the Olympic movement itself. In particular, the field of sports nutrition started growing exponentially in the 1960s, with the use of the needle muscle biopsy technique to study how the carbohydrate (CHO) content of the diet preceding exercise could alter exercise endurance or fuel utilization (Bergstrom et al. 1967; Hultman 1967). These studies, and others conducted in the 1960s and 1970s, gave rise to the concept of CHO loading before endurance exercise competitions, in order to "top off" muscle glycogen stores. The field of sports nutrition grew out of these and other studies, leading to the development of specific journals (i.e., the *International Journal of Sport Nutrition and Exercise Metabolism*) and position statements on the topic by professional organizations such as the American College of Sports Medicine (ACSM), British Association of Sport and Exercise Sciences (BASES), Sports Dietitians Australia (SDA), Dietitians of Canada, and the American Dietetics Association (ADA).

The Relationship Between Physical Activity, Body Weight, and Energy Intake

Research first published over 60 years ago presented data from individuals working at a jute mill in Bengal (Mayer et al. 1956). Body weight, EI, and EE were recorded in 213 men. The men were then grouped according to their occupational PA into sedentary, light work, medium work, heavy work, and very heavy work. The individuals in the sedentary category had higher body weights than all other activity categories; furthermore, EI presented as a J-shaped curve, with sedentary and heavy/very heavy work categories having similar levels, while light- and medium-category workers had less. Thus, this data was the first to show a proportional increase in EI with EE, what Mayer termed the "normal activity range" (Mayer et al. 1956). This range has since been coined the "zone of regulation" by John Blundell (2011). In this zone, the relationship between EI and EE is coupled and closely regulated, and body weight is stable. Below this zone, there is an uncoupling of EI and EE, which is believed to attribute to increases in body weight (see Beaulieu et al. (2018) for an updated review on this topic).

Several recent papers have replicated the original findings of Mayer et al. First, in 2016, Beaulieu and colleagues completed a systematic review of cross-sectional studies which again revealed a J-shaped curve between activity level and EI (Beaulieu et al. 2016). Furthermore, Shook et al. analyzed data from over 400 young adults over the course of a year (Shook et al. 2015). As with the original study of Mayer, these authors found a linear relationship between body weight and physical activity level and a J-shaped curve between EI and physical activity level. Additionally, those in the highest quintile of PA had an ~11% reduced risk of a gain in fat mass of $>3\%$ over the course of the year, while those in the lowest quintile had a 1.8–3.8 greater risk of gaining $>3\%$. This study also concluded that the optimal level of PA to achieve energy balance was $\geq$7100 steps per day (Shook et al. 2015).

Research has also attempted to disentangle the rationale behind these observations. It is believed that active individuals may be more sensitive to satiation (meal termination) and satiety (post-meal suppression of hunger, increased fullness, and inhibition of further eating). For example, a study by Beaulieu et al. found that after ingesting a high-energy preload, moderately and highly active individuals reduced their EI at an ad libitum (Latin for as much as desired) lunch to a greater degree than after a low-energy preload, and this observation was absent in low-active individuals (Beaulieu et al. 2017a, b). Horner et al. reported that active individuals had faster gastric emptying of a test meal than inactive individuals but found in a separate study that active men reported lower levels of "liking" for food in the fed state (Horner et al. 2015, 2016). Finally, there may be evidence that, because highly trained individuals are more accustomed to the stress of exercise, the responses of appetite-related hormones (i.e., ghrelin, peptide YY, glucagon-like peptide 1, leptin, etc.) in these individuals may not be as pronounced as untrained individuals (Schubert et al. 2014).

Are There Optimal Diets for Performance?

A number of different diets have been put forward as means to improve athletic performance. Given the diversity of athletic events, it is clear there can be no "one-size-fits-all" approach. Furthermore, given that an athlete's preparation can include several phases, such as preparation, pre-competition, and competition, the nutritional demands imposed by such activities are considerably different. In order for the body to ambulate or perform PA through muscular contraction, adenosine triphosphate (ATP) is needed. ATP is supplied from an interrelated series of metabolic pathways and energy stores including non-oxidative (oxygen-independent, including phosphagen and glycolytic) and oxidative (oxygen-dependent, fat, and carbohydrate oxidation) pathways (Brooks et al. 2005). The phosphagen system provides for rapidly available energy for muscular contraction, but its stores are limited to ~10 s. The anaerobic glycolytic pathway provides rapid catabolism of glucose and muscle glycogen and primarily supports short duration (10–180 s), high-intensity exercise. In activities lasting longer than ~2 min, oxidative metabolism is the predominant energy pathway. Substrates for oxidative metabolism are mainly muscle and liver glycogen and intramuscular and adipose tissue triglycerides, with amino acids playing a smaller role. It is important that the reader understands that no one system is ever the sole source of energy and that the contribution of energy pathways and the crossover between pathways are influenced by a number of factors, including but not limited to intensity, frequency, duration, and type of training; sex; individual training/fitness level; environmental conditions; and prior nutrient intake and availability of substrates (Brooks et al. 2005).

Instead of a specific dietary plan, current sports nutrition guidelines instead focus on ensuring that athletes exceed minimum energy requirements by achieving sufficient energy availability. Energy availability is dietary intake minus the energy expenditure of exercise, adjusted for fat-free mass (FFM) (Thomas et al. 2016). Initial data were collected in females and suggested an optimal level of energy intake that is equivalent to 45 kcal per kilogram of fat-free mass per day and that levels below 30 lead to a number of adverse consequences to health and performance (Loucks et al. 1998). When individuals fail to meet nutritional requirements to maintain optimal bodily function, this has been termed relative energy deficiency in sport (RED-S), which is described in detail elsewhere (Mountjoy et al. 2014).

Past nutritional guidelines for athletes and active individuals were necessarily broad. Currently, guidelines are becoming more individualized and also account for the different types of training. For example, the recent ACSM-ADA position stand published specific guidance for CHO intake in individuals undergoing light-, moderate-, and high-volume/intensity training programs (Thomas et al. 2016). A recent review paper also explored the topic of dietary manipulation for endurance sport athletes, an area of recent interest (Burke et al. 2018). Protein intake is also essential for supporting optimal health in athletes and active people, and their suggested intakes are considerably higher than the current US recommended daily allowance (RDA) of 0.8 grams per kilogram of body mass. Protein supports muscle growth and repair and therefore is important during the postexercise recovery period (Thomas et al. 2016). Guidelines for fat intake suggest ranges between 20 and 35% of total daily energy intake for most athletes. Some research suggests that individual athletes who follow high-fat, low-carbohydrate diets have a better ability to oxidize fat as a fuel during low- and moderate-intensity exercise, but the ability of fat adaptation to sustain the demands of high-intensity exercise is unclear (Burke 2015; Burke et al. 2017, 2018). There is also evidence that high-fat diets may be beneficial for short-term changes in body composition in athletes and nonathletes, but again, the ability of high-fat diets to support high-intensity training remains controversial and unclear (Burke 2015; Volek et al. 2015).

Nutritional Guidance Before, During, and After Training and Competition

Achieving optimal nutrition before, during, and after training or competition is crucial for performance and recovery. CHO has deservedly seen much attention for its role in performance and training. It is an essential fuel for the brain and central nervous system, and a highly flexible substrate can be used across a range of intensities because it can be used both anaerobically and aerobically. CHO is also a more efficient energy store than fat, as it provides a greater yield of ATP per liter of oxygen. Finally, body carbohydrate stores are relatively limited (~2000 kcal for a ~70 kg male, sufficient for ~2 h of moderate- to vigorous-intensity exercise) but can be easily manipulated through dietary intake (Brooks et al. 2005). This last point is key, as research has indicated that beginning exercise with high levels of CHO, or maintaining CHO through feeding during exercise, improves performance during prolonged (90 or more minutes) or intermittent high-intensity exercise at workloads greater than 75% of VO_2max (peak cardiovascular fitness) (Coyle et al. 1986). Conversely, CHO depletion leads to increased perceived exertion, decreased cognitive performance, and reduced work rate. For specific guidelines on CHO use around exercise, readers are referred to sport nutrition texts or relevant position statements (Thomas et al. 2016).

Protein is essential in the process of muscle protein synthesis (MPS) and thus is often co-consumed with CHO pre- or postexercise, since many foods consumed by active individuals contain both nutrients. Increasing protein may also be beneficial when individuals are in an energy deficit or dieting in order to "cut weight" pre-competition. For example, in a 16-week study of male athletes, a group consuming 2.4 grams per kilogram of body mass per day protein gained 1.2 kg of lean mass while losing 4.8 kg of body fat, whereas the control group consuming half the dose had no change in lean mass and lost 3.7 kg of body fat (Longland et al. 2016). These changes in body composition occurred on a diet with a 40% reduction in habitual EI plus exercise training 6 days per week (Longland et al. 2016). Further meta-analyses support higher protein intakes for greater gains in muscle hypertrophy (muscle size) and muscle strength (Loenneke et al. 2016; Schoenfeld et al. 2013). In sum, a recent position stand has concluded that most exercising individuals should strive for protein intakes of 1.4–2.0 grams per kilogram of body mass per day, so therefore a 75 kg individual should eat between 105 and 150 grams of protein daily. Individuals in heavy training that are simultaneously consuming hypocaloric (low-energy) diets may be best served by increasing their protein intake to 2.3–3.1 grams per kilogram of body mass per day (Jager et al. 2017).

In the current sports nutrition literature, there is perhaps no more controversial macronutrient than dietary fat. On paper, the large stores of lipid within the body (~93,000 kcal in a 70 kg male with 15% body fat) provide the energy for approximately 3 and half days of continuous work at moderate-vigorous intensities. However, availability and use of lipids as a muscular fuel is not as tightly controlled as CHO metabolism. Cross-sectional and short-term studies have indicated that consumption of high-fat/low-CHO diets (60–70% + fat) is able to increase rates of fat oxidation, sometimes as much as two to three times greater but at the cost of CHO oxidation due to a downregulation of enzymes involved in CHO oxidation. Furthermore, as stated previously, fat has a higher oxygen demand per ATP unit production, which is disadvantageous when considering most high-intensity endurance events or longer duration events that may present opportunities for "breakaways" (i.e., marathons, ultramarathons, Ironman triathlons, etc.) (Burke 2015). Nonetheless, fat is an important part of the human diet, and consumption of healthy unsaturated fats should be promoted as part of the active person's diet.

Table 1 provides an example of what a diet following these guidelines might look like in an active adult male who has normal weight and is training ~6 h per week.

Nutritional Supplements and Ergogenic Aids

Nutritional supplements are an incredibly lucrative industry, with prevalence among athletes ranging from 37 to 90% (Thomas et al. 2016). Athletes and active people use supplements as ergogenic aids, to achieve a metabolic, mechanical, psychological, or physiological advantage to improve performance. However, supplements are poorly regulated, and differences in quality and ingredients between brands and within batches of the same supplement have been reported (Desbrow et al. 2018). This lack of oversight increases the risk for adverse effects or that an individual may

Table 1 Example of an active individual's energy and macronutrient needs based on existing sports nutrition guidelines

Male, 28 years old. 180 pounds (81.63 kg), 15% body fat
15% body fat = 0.15∗180 = 27 pounds (12.24 kg) fat mass 180–27 = 153 (69.39 kg) pounds of fat-free mass
Total energy intake per day = 69.39 kg fat-free mass ∗ 45 kcal per kilogram fat-free mass per day = 3122 kcal per day minimum to support optimal energy availability
Carbohydrate intake per day = ~5 grams per day per kilogram body weight ∗ 81.63 kilograms = 422 grams per day of carbohydrate = 1688 kcal per day of carbohydrate Normal-sized whole wheat bagel = 49 grams of carbohydrates Medium-sized baked potato = 37 grams of carbohydrates 1 cup of white rice = 45 grams of carbohydrates 1 cup of cola-flavored soft drink = 26 grams of carbohydrates
Protein intake per day = 2 grams per day per kilogram body weight ∗ 81.63 kg = 163.26 grams per day of protein = 653 kcal per day of protein 100 grams (3.5 ounces) chicken breast has ~30 grams of protein ~250 grams (8 ounces) whole-fat milk has ~8 grams of protein
Fat = 25% of total energy intake = 0.25∗3122 = 781 kcals per day of fat = 86.72 grams per day of fat 1 cup of sliced avocado = 21 grams of fat 1 cup of canned tuna in water = 7 grams of fat

inadvertently test positive for a banned substance. It is beyond the scope of this chapter to discuss the ethics and legalities of supplement use, and the time and space it would take to discuss every purported supplement has been given attention in numerous texts. However, brief discussion of a few supplements that have a sound evidence base and are presently legal for use in competitive sports will follow. Readers are referred to the US Anti-Doping Agency's extensive supplement database for further information (https://www.usada.org/substances/supplement-411/). Any decision regarding supplement use in athletes should be taken carefully and only after a thorough risk-benefit analysis by the athlete, their coach, and support team (i.e., sports dietitian).

Caffeine is ubiquitous in the human diet, consumed through tea, coffee, cola drinks, chocolate, and many other foodstuffs. Once banned up to a certain threshold by the International Olympic Committee and World Anti-Doping Agency, caffeine use is now permitted in competition (though it is still prohibited by the National Collegiate Athletic Association, a positive test would require a very high dosage). Caffeine is an adenosine receptor antagonist, binding to adenosine receptors and blocking the uptake of adenosine; this action decreases feelings of fatigue (Fredholm et al. 1999). It also can reduce perception of effort and muscle pain and increase muscle contraction (Doherty and Smith 2005; Kalmar 2005; Motl et al. 2003). Caffeine has been shown to improve muscle strength and power, as well as endurance performance in doses ranging from 1.5 to 9 milligrams per kilogram of body mass (Ganio et al. 2009; Warren et al. 2010). From a practical standpoint, a typical drip cup of coffee has ~80 milligrams of caffeine. Therefore, an individual who weighed 80 kg would have to drink 2–3 cups to achieve a dose associated with performance improvements. Anhydrous caffeine, energy drinks, coffee, and caffeine-containing chewing gum have all been found to improve performance, and performance is typically improved when ingestion is 45–90 min before exercise (Hodgson et al. 2013; Paton et al. 2010; Quinlivan et al. 2015). Longer (90+ min) duration endurance events may also benefit from caffeine consumption during exercise (Cox et al. 2002), and many sports gels/bars incorporate small amounts of caffeine.

Creatine is the best-selling supplement as well as the supplement most-often purchased by college athletic programs. Creatine increases intramuscular stores of creatine and phosphocreatine, thereby increasing the energy-producing potential of the phosphagen energy pathway (Buford et al. 2007). There is also some evidence that creatine may contribute to enhanced glycogen storage and muscle protein synthesis (Tarnopolsky 2010). The increased stores of phosphocreatine allow for improved repeated bouts of high-intensity exercise performance and shortened periods of recovery, such as weight-lifting or repeated sprinting (Buford et al. 2007). It also can improve training capacity, leading to greater muscle strength and hypertrophy which is the term used for an increase in muscle size (Tarnopolsky 2010). Guidelines for creatine supplementation indicate 0.3 grams per kilogram of body mass per day for at least 3 days ("loading" phase) followed by 3–5 grams per day to maintain elevated levels (Buford et al. 2007). In this case, that same 80 kg individual would ingest 24 grams of creatine per day in the loading phase before tapering off to 3–5 grams per day in the maintenance phase.

Buffering agents, such as sodium bicarbonate and beta-alanine, increase the ability of the muscle to tolerate acidic changes in pH. Sodium bicarbonate increases the bicarbonate pool in the blood and acts as an extracellular buffer (Carr et al. 2011a). Beta-alanine increases muscle carnosine levels in the muscle, providing an intracellular buffer (Trexler et al. 2015). Sodium bicarbonate recommendations are to ingest 0.3 grams per kilogram of body mass 120–150 min before exercise, and the co-ingestion of a pre-event high-carbohydrate meal can reduce gastrointestinal side effects (Carr et al. 2011b). For the same 80 kg individual, this would equal to 24 grams of sodium bicarbonate, which is equal to 2 tablespoons of your household variety baking soda. Beta-alanine supplementation suggests a 2–4 week protocol, with 4–6 grams per day (Trexler et al. 2015), which is equivalent to a teaspoon or slightly more. Buffering agents improve exercise capacity in events driven by increased rates of anaerobic glycolysis, such as repeated sprinting or high-intensity exercise lasting 1–10 min in duration (Trexler et al. 2015).

A final ergogenic aid that has received recent attention is nitrate, often consumed as a concentrated food source through beetroot juice. Nitrate supplementation increases plasma nitrite concentrations, which then increases nitric oxide. This vasodilator can then lead to a number of effects in the muscle and vasculature than can reduce the oxygen cost of exercise (improved efficiency) (Bailey et al. 2009).

Physical Activity, Exercise, Diet, and Health

The benefits for individuals achieving the global physical activity guidelines (World Health Organization 2010) are overwhelming due to the irrefutable epidemiological and experimental evidence that an active lifestyle aids in the prevention and treatment of noncommunicable diseases (Booth et al. 2012). Exercise training and increasing lifestyle PA are suggested methods for weight management leading to an increase in daily EE intended to promote an energy deficit and weight loss. However, and as highlighted in the introduction to this chapter, the regulation of energy balance is dynamic whereby individual components interact. Adjustments to activity-induced EI could elicit compensatory changes in other components of energy balance that could attenuate the prescribed energy deficit and subsequent weight loss.

Compensatory changes in appetite and EI are potential reasons why exercise often produces weight loss that is less than expected theoretically (Thomas et al. 2012). This has led to debate concerning the effectiveness of exercise in weight management and unfortunately misrepresentation of PA and exercise in the mainstream media. Headlines including "How exercise can make you pile on the pounds?" (*Daily Mail*, 22nd June 2015) and "Why exercising for weight loss just doesn't work?" (*The Telegraph*, seventh August 2017) misrepresent or misconstrue research findings. Regrettably, this can confuse an already misinformed public and damages the efforts of healthcare professionals. Using Google™ and searching for a response to "Will exercise make me fat?" return approximately 11,800,000 hits in 0.55 s. While many will be irrelevant, the sheer volume is worrying. Respected academic journals have also fallen foul and published sensationalist headlines with an editorial in the *British Journal of Sports Medicine* stating: "It is time to bust the myth of physical inactivity and obesity: you cannot outrun a bad diet" (Malhotra et al. 2015). This promoted further inaccurate headlines in the mainstream and social media. This poor representation of PA and exercise clearly contributes to uncertainty regarding the role of PA and exercise for weight management.

When healthcare professionals fail to promote PA and exercise in the populations that need it, the impact of this misinformation can be very damaging. Notwithstanding the independent health benefits of exercise, a sound understanding of how exercise affects appetite and EI is needed to devise effective weight loss strategies. The aim of the second part of this chapter is to summarize the scientific literature examining the effect of exercise on appetite control, EI, and weight management.

The Effect of Acute Exercise on Appetite Control and Energy Intake

Healthcare professionals and people with obesity believe that exercise will increase your appetite. Studies have consistently shown that a single bout of aerobic exercise does not lead to an automatic increase in hunger or EI to restore energy balance (Donnelly et al. 2014). Scientific research has shown that high-intensity aerobic exercise (~70% VO_2max) can suppress hunger during and for a short period (up to 2 h) after exercise (Broom et al. 2007, 2017). Similar findings have been found for resistance training (Broom et al. 2009). This phenomenon has been termed "exercise-induced anorexia" (King et al. 1994), and although an oversimplification because the control of appetite is complex, this is in part due to the suppression of the hunger hormone known as acylated ghrelin which was discovered by a group of

Japanese researchers (Kojima et al. 1999). Consequently, acute exercise appears to be effective in eliciting an immediate energy deficit (King et al. 2017).

Healthcare professionals and people with obesity also believe that exercise will make you eat more at the next meal. This is also not necessarily true, since King et al. found that brisk walking for 60 min did not increase hunger and that there were no differences in absolute energy intake at a morning (1.5–2 h post walk) and afternoon meal (5–5.5 h post walk) (King et al. 2010). However, the relative energy intake (energy intake – (walking energy expenditure – resting energy expenditure)) was reduced highlighting that walking resulted in an acute negative energy deficit. Similar findings have been demonstrated following swimming (King et al. 2011) as individuals fail to compensate for the increased EE through increased EI. These appetite and energy intake responses have also been established in people with obesity, highlighting the ability of exercise to induce a short-term energy deficit without any compensatory effects on appetite regardless of weight status (Douglas et al. 2016).

Scientists tend to focus on the mean change for a group without presenting the individual variability in exercise-induced compensatory eating behavior which is arguably more important. While, on average, there is no change in postexercise EI, postexercise compensatory eating behavior is highly heterogeneous with some individuals partially compensating for acute increases in EE via increased EI (approximately 50% – although research on this issue is sparse), while others show no evidence of compensation (Hopkins et al. 2014). Although typically insufficient to fully offset the additional EE, compensatory eating can therefore moderate the capacity of exercise to create an immediate energy deficit in some individuals (particularly in the presence of highly palatable, energy dense foods).

The Effect of Medium-Term Exercise (2 to 12 Weeks) and Long-Term Exercise (>12 Weeks) on Appetite Control and Energy Intake

When exercise has been performed over longer periods (>2 weeks), studies often report no change in hunger or EI (Donnelly et al. 2014). However, exercise is typically unsupervised, and the total EE is low meaning it is unlikely that the energy deficit is sufficient to elicit physiological and behavioral compensation. A limitation with studies is that EI is commonly measured using self-report, but this approach lacks the sensitivity required to detect small yet meaningful changes in EI. In contrast, when EI has been measured objectively following medium-term exercise, evidence suggests that compensatory changes in EI may play an important role in mediating exercise-induced weight loss.

King et al. reported highly variable body weight responses (−14.7 to +1.7 kg) to 12 weeks of supervised aerobic exercise (2500 kcal per week) in people with overweight and obesity (King et al. 2008). Based on the relationship between actual and predicted weight loss, participants were retrospectively classified as responders or nonresponders. Mean ± standard deviation weight loss in the nonresponders was only 1.5 ± 2.5 kg, while the responders lost 6.3 ± 3.2 kg. Importantly, EI increased by 268 ± 455 kcal per day in the nonresponders, while daily hunger increased by approximately 7%. In contrast, EI decreased by 130 ± 485 kcal per day in the responders, and hunger remained constant.

Myers et al. (2018) examined whether behavioral compensation for exercise-induced energy deficit could be through EI, non-exercise physical activity, or sedentary behavior (Myers et al. 2018). They solely examined women who completed 12 weeks of supervised exercise (5 × 500 kcal per week). Exercise increased hunger and EI which only partially compensated for the increase in EE. There was no evidence for a compensatory reduction in non-exercise physical activity or an increase in sedentary behavior.

When EI has been assessed during long-term exercise training (12 weeks to 18 months), studies typically report no change in EI (Donnelly et al. 2014). Yet again, EI is typically measured using self-report. The modest reductions in body weight seen with long-term exercise are suggestive of some form of compensation in response to prolonged energy deficit (via changes in EI or other pathways such as RMR or non-exercise physical activity as highlighted by Blundell and colleagues (2012)). At present there are few well-controlled studies to confirm this.

Exercise Versus Diet for Weight Loss

A weight loss of 5% has been shown to be clinically meaningful which has substantial health benefits (Magkos et al. 2016). Weight loss as a result of PA or exercise is often less than what would be expected since predictive equations do not consider changes such as reductions in RMR or increases in fat-free mass. Also, the widely accepted idea that 1 kg of body mass is equivalent to 7700 kcal which consists 70% fat and 30% fat-free mass was determined from short-term, low-calorie diets. These are not directly applicable to changes in body composition that occur as a result of exercise since the percentage of fat would decrease with a subsequent increase in fat-free mass (Thomas et al. 2013).

The effects of aerobic exercise training distinct from PA as part of daily living in the absence of dietary restriction on weight loss have been extensively reviewed (Washburn et al. 2014). Modest reductions (1.5–3.0 kg) are typically reported over 3–18 months. Weight loss is greater in well-controlled, supervised conditions such as in a laboratory when the exercise energy expenditure is greater than 2000 kcal per week or when exercise is combined with dietary restriction.

Research highlights that if the energy deficit created by exercise or diet is the same, then the weight loss is the same (Washburn et al. 2014). However, it is acknowledged that whether it is easier to run 3 miles or refrain from eating crisps, cookies, and a chocolate bar is not clear. However, losing weight using dietary restriction alone is unlikely to yield the desired results. Humans have a complex system to control food intake, and following weight loss our appetite tends to promote overeating and weight regain (Sumithran and Proietto 2013).

There is a commonly held belief that exercise is less effective for weight loss in women than men. While on average women have a lower fat-free mass, they can lose body mass if undertaking a program of regular aerobic exercise (Caudwell et al. 2013). It is true that women will expend less energy for a given duration and intensity of exercise, compared with men if their body mass is lower, but a recent review supports the continued promotion of exercise as a strategy for inducing short-term energy deficits irrespective of adiposity and sex, as well as the ability of exercise to positively influence energy balance over the longer term (Dorling et al. 2018).

While weight loss is the commonly reported outcome of successful weight management interventions, inclusion of PA and exercise leads to other independent health benefits. These include maintaining skeletal muscle mass, reductions in blood pressure, an improved blood lipid profile, and improved insulin sensitivity. Also, regardless of body mass, people with higher aerobic fitness are at lower risk of all-cause mortality than those with lower fitness (Blair et al. 1995). Recent evidence highlights that low fitness is associated with abdominal adiposity and low-grade inflammation independent of body mass index (Wedell-Neergaard et al. 2018). While losing weight is important, improving people's fitness should be the priority.

Exercise for Weight Maintenance and the Prevention of Weight Regain: The Magic Pill

Most individuals who lose weight will regain it in less than a year. PA and exercise have consistently been reported as being essential for prevention of weight regain. Jakicic et al. (2008) recruited women with overweight and obesity to a 24-month behavioral weight loss intervention that recommended reducing EI to 1200–1500 kcal per day and to increase PA to achieve an EE of 1000 or 2000 kcal per week using either moderate or vigorous intensity, giving rise to four different groups. Weight loss did not differ between the randomized groups at 6 months (approximately 8–10% weight loss) or 24 months (approximately 5% weight loss). However, further analysis showed that individuals maintaining $\geq$10% weight loss at 24 months reported the highest PA which was 1835 kcal or 275 min of physical activity per week (Jakicic et al. 2008).

Conclusion

Exercise and diet are inextricably linked, both for optimal performance and for the prevention and treatment of noncommunicable diseases. Athletes appear to have a fairly tight coupling between EE and EI but may need observation to ensure their energy availability to meet the demands of training is adequate. This will ensure that adequate nutrients are present to support the desired training stimulus. There are certain aspects that athletes can specifically benefit from, such as increasing protein intake during periods of intense training and ergogenic aids to improve performance or training adaptation. Conversely, compensatory changes in appetite and EI are potential reasons why exercise often produces weight loss that is less than expected in people with overweight or obesity, so the benefits of exercise for weight management have been questioned. Based on current evidence and the authors' combined experiences, it is our belief that PA and exercise combined with a calorie-controlled diet are the best strategies for weight loss. The evidence for the health effects of exercise regardless of weight loss is overwhelming, and an optimal combination of exercise and diet will lead to improved overall health, specifically reductions in blood pressure, visceral adipose tissue, and inflammatory markers and maintenance or increase skeletal muscle mass. A final point of consideration is that most individuals who lose weight will regain it within a year; thus increasing PA and reducing sedentary time during weight maintenance is crucial for long-term weight maintenance success.

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Obesity and Socioeconomic Status

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Gregory Pavela, Tara Harman, Michelle I. Cardel, and Alex Lee

Contents

Abstract

This chapter discusses the association between socioeconomic status (SES) and obesity, with a focus on explanations for the inverse association between SES and obesity in high-income countries. In addition to a review of the most common explanations, including that the relationship is spurious, due to underlying differences in human capital and/or due to SES group differences in the consumption of energy dense foods, we review the hypothesis and evidence thereof that the association is due, in part, to the direct effects of perceived scarcity on weight-related behaviors.

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Introduction

Socioeconomic status (SES), usually measured by indicators of education, income, or occupation, is associated with obesity (Sobal and Stunkard 1989; McLaren 2007; Cohen et al. 2013; Wu et al. 2015). In higher income countries, SES is negatively associated with obesity and, in a seminal review of the association between SES and obesity (McLaren 2007), low levels of education was the SES indicator most consistently associated with increased weight, a finding subsequently supported by a focused review of the education and obesity relationship (Cohen et al. 2013). Regarding educational differences in the prevalence of obesity, between 2013 and 2016, the estimated age-adjusted US adult prevalence of obesity among women with less than a college degree was 47.3%; among women with a college degree, the prevalence was 29.3%. Among men, the SES gradient was less stark and statistically insignificant: 36.2% of men with less than a high school degree had obesity versus 30.0% among college graduates (Hales et al. 2018). Nuances in the relationship between SES and obesity are important to recognize at the outset of any discussion purporting to explain the association. In contrast to the negative association found in higher income countries, SES is positively associated with obesity in lower income countries (Pampel et al. 2012). The shift in direction is more pronounced for women, as is the relationship between SES and obesity more generally (McLaren 2007; Dinsa et al. 2012).

Keeping the contextual nuances of the relationship between SES and obesity in mind, the focus of this chapter is on the association in higher income countries, where a sedentary lifestyle is normative and food is abundant (Evenson et al. 2015). Proposed explanations for between-country differences in the association between obesity and SES – though outside the scope of this chapter – include variations in the availability of food, levels of physical activity, and cultural values vis-à-vis body shapes (Monteiro et al. 2004). While many of the explanations for the association between obesity and SES are applicable in the context of either high- or low-income countries, most evidence review here comes from higher-income countries. Specifically, this chapter reviews several explanations for the association between obesity and SES, including the relationship between energy density, food cost, and obesity, given the Handbook's broader focus on eating and drinking. As we'll see, this explanation focuses on the higher financial costs of nutrient-rich, low energy density foods, making them less accessible to lower socioeconomic status individuals.

We also consider alternative explanations, including that the relationship is (1) spurious; (2) due to the differences in underlying knowledge, skills, and resources of individuals at varying socioeconomic strata; (3) differential exposure by SES to sociocultural values regarding weight and weight-related behaviors; and (4) direct effects of perceived scarcity on weight-related behaviors, an explanation receiving much recent attention. Each of these explanations is reviewed in turn, beginning with the role of nutrient-poor, high energy density foods. It's important to note that none are mutually exclusive from the others; indeed, it's likely that each of these factors contribute to the socioeconomic gradient in obesity.

The Role of Nutrient-Poor, High Energy Density Foods

The observation that lower SES individuals have poorer health due to diet is not new, though the health outcome of interest presumably affected by poor diet has shifted from nutritional deficiencies (now rare in higher-income countries) to cardiovascular risk factors (James et al. 1997). If micronutrient composition was responsible for past SES differences in nutritional deficiencies, what dietary characteristic explains why obesity is more prevalent in lower SES groups? While innumerable dietary constituents have been the focal point of health claims (and vociferous debates), including the relationship between sugar consumption and obesity (Bray and Popkin 2014), these claims are generally framed as explaining recent trends in cardio-metabolic health and obesity prevalence more generally rather than explaining variation in obesity by SES. However, one dietary characteristic of research interest for its potential to explain variation in obesity by SES is *energy density*.

Energy density is the amount of metabolizable energy available in food per a given unit of weight. Foods with a high ratio of calories per gram (kcal/g) are said to be energy dense. The least energy dense foods contain 0 kcal/g, while the densest foods contain 9 kcal/g – the amount of energy per gram of fat. As water contains zero calories, the primary drivers of energy density are moisture and fat content, with low moisture, high fat foods such as butter, chocolate, and cheese, being the most dense (Rolls 2009). Indeed, whether energy density of meals and diets is calculated with or without beverages is an important methodologic decision, as the inclusion of beverages can significantly reduce the calculated energy density of meals (e.g., Hall et al. (2019) included a beverage with a dissolved fiber supplement in their calculation of the energy density of an "ultra-processed" diet presented to subjects, reducing the calculated energy density of ultra-processed meals, ordinarily energy dense, such that their density was similar to that of unprocessed meals. When beverages were excluded from the calculation, the energy density of the ultra-processed meals was 54% higher than the unprocessed meals).

One basic outline of the argument for the role of energy density in the socioeconomic gradient in health is as follows. First, research suggests that energy dense foods promote increased energy intake, especially in short-term, laboratory settings (Stubbs et al. 2000). Second, energy dense foods may be more affordable and convenient, making them more attractive to individuals with less financial resources and time to devote to food and its preparation (Darmon and Drewnowski 2015). Thus, lower SES individuals may be more likely to choose and consume energy dense foods, predisposing them to weight gain due to uncompensated increased energy intake. The two basic premises of this argument are reviewed below, beginning with the claim that higher energy density leads to greater energy intake.

Energy dense foods may promote increased intake due to their relatively high palatability (Drewnowski and Greenwood 1983) and reduced satiating effects, with palatability defined as, "the momentary subjective orosensory pleasantness of food" (Stubbs and Whybrow 2004). If the consumption of energy dense foods promotes increased long-term energy intake without a corresponding compensation in energy expenditure, one would expect an association between energy density and body weight, with those consuming more energy dense diets weighing more, on average, than those consuming less energy dense diets (Rolls 2009). Consistent with the hypothesis that higher energy density is associated with increased dietary intake and body weight, Ledikwe et al. (2006) found that free-living US adults who self-reported consuming a low energy density diet had a lower prevalence of obesity relative to those consuming an energy dense diet.

However, the association between energy density and body weight is inconsistent. de Castro (2004) found that free-living adults who self-reported consuming energy dense diets reported greater energy intake but did not find a corresponding association with body weight or BMI. Indeed, this result was noted as surprising, “given the rather salient apparent effect of dietary energy density on meal and daily intake,” suggesting that individuals may compensate for acute increases in energy intake associated with energy dense meals and that dietary energy density does not affect body size in the natural environment (de Castro 2004). A 2016 meta-analysis of observational studies on the association between dietary energy density (calculated from self-reported measured of food intake) and weight found a complex mix of associations: dietary energy density was not significantly associated with the risk of elevated BMI or abdominal obesity; however, higher energy density was significantly associated with excess adiposity and weight gain over time (Rouhani et al. 2016).

Taken together, evidence consistently suggests that consuming foods with a high energy density is associated with acute increases in energy intake, while evidence that energy density is associated with long-term increases in energy intake and risk of obesity is less consistent (Karl and Roberts 2014). Herein lies the relevance of the premise that energy dense foods are more affordable and convenient, making them more attractive to lower SES individuals. If the long-term effects of the energy density of food intake on weight are, on average, de minimis due to compensatory behaviors (i.e., reduced energy consumption following acute energy density associated increases in energy intake), financial factors which discourage compensation for increased energy intake – such as an inability to afford or prepare less energy dense foods and other means by which individuals might reduce their energy intake – may induce an association between energy density and obesity among lower SES individuals. It’s thus important to consider the association between food cost and energy density and whether variations in the availability of energy dense foods are associated with obesity (Darmon and Drewnowski 2015). Indeed, energy density is inversely associated with the cost of food such that energy-dense foods cost less, on average, than less energy-dense foods (Drewnowski 2010). High energy density foods such as oil, margarine, and sugar have a per-energy unit cost much less than that of low energy density foods such as lettuce, strawberries, and frozen fish (Drewnowski and Specter 2004). Individuals facing economic constraints may thus preferentially select lower-cost, higher energy density foods in order to meet their energy needs. Economic modeling suggests that the introduction of a progressively stronger cost constraint pushes rational consumers to meet a higher proportion of their energy needs from energy-dense sweets and added fats and less from fruits and vegetables, recapitulating a dietary pattern commonly found in lower SES groups likely facing similar constraints in their selection of foods (Darmon et al. 2002).

Another analysis comparing the cost of a "healthy" diet versus an "unhealthy" diet using data from the UK Women's cohort study found, on average, that women consuming the healthiest diet spent $1,285 (2018 USD) more per year on food than those consuming the least healthy diet (Cade et al. 1999). Further, those consuming the healthiest diet spent approximately $4.45/day on foods with low energy density, such as fruits and vegetables, which was three times the money spent on such items by women consuming the least healthy diet (remarkably, the same study found that women consuming the healthiest diets also self-reported consuming about 1,000 kcal more per day than those consuming the least healthy diets while also maintaining the lowest BMI, etc.). Finally, a 2015 systematic review on the effects of food costs on diet quality concluded that studies of dietary costs in multiple countries were "unanimous" that "the global hierarchy of food prices is such that energy-dense foods composed of refined grains, added sugars, or fats are cheaper per calorie than are the recommended nutrient-dense foods" (Darmon and Drewnowski 2015).

The increased cost of low energy density diets may encourage individuals to preferentially select energy-dense foods, potentially counteracting compensatory behaviors that would ordinarily prevent long-term changes in energy balance. The financial resources individuals have at their disposal to spend on food vary substantially, and cumulative differences in financial resources by education level are especially striking: median lifetime earnings of an individual in the United States with less than a high school education is $973,000 (in 2009 dollars), compared to the estimated $2,268,000 lifetime earnings of a college graduate (Carnevale et al. 2011). Higher wages are associated with a decreased risk of obesity (Kim and Leigh 2010), as is living in a neighborhood with a higher percentage of adults with incomes over $75,000 and home valuations in the upper quartile (Grafova et al. 2008). Of course, differences in individual financial resources are not the only SES-related factor affecting diet. Indeed, differential access to healthful foods has been argued to be a causal factor in the rapid increase in obesity prevalence in the United States (Drewnowski et al. 2012). Neighborhoods in the United States have grown increasingly segregated by SES, and individuals with greater educational attainment increasingly live in more isolated and affluent neighborhoods (Massey et al. 2009; Robert and Reither 2004). As individuals reside in increasingly economically segregated neighborhoods, the characteristics of the food environments they are exposed to will continue to diverge, with lower income neighborhoods having food environments believed to promote unhealthy eating (Hilmers et al. 2012; Larson et al. 2009).

Given the above discussion of energy density, obesity, and socioeconomic status, one might expect that exogenous increase in income would reduce obesity, presumably because individuals would have more money to devote to (more costly, less energy dense) foods. Yet some studies suggest the opposite – that the provision of short-term financial resources may, in fact, exacerbate trends in obesity prevalence. For example, results from *Programa de Apoyo Alimentario* (PAL), a program implemented by Mexico to improve the health and nutritional status of families, found that families receiving a monthly cash transfer for 23 months had a 53% increase in weight gain relative to a control group not receiving a monthly cash transfer (Leroy et al. 2013). One explanation for this finding and others like it (Forde et al. 2012), as described elsewhere (Maner et al. 2017), is that "increased energy intake and other behaviors that promote adipose accretion may result from physiological and psychological responses to uncertainty about the future availability of food" (Pavela et al. 2019) as a means to build energy reserves to "buffer" against future food scarcity (Kaiser et al. 2012). Short-term exogenous cash infusions may thus be sufficient to improve access to food but insufficient to reduce perceptions of food scarcity, an explanation revisited shortly. Longer-term studies of the effect of direct financial aid on obesity and other weight-related behaviors are needed, as newfound financial support might be expected to lead to an acute increase in spending on food, leading to weight gain, before settling into a longer-term dietary pattern. Similarly, in the United States, participation in the Food Stamp Program is associated with higher adult BMI; however, participation in the program is associated with a lower BMI *among those participating 6 months or more* (Webb et al. 2008).

Obesity and Socioeconomic Status: Additional Explanations

As indicated at the outset, in addition to the role of energy density and food costs in the association of SES and obesity, additional explanations include the possibility that the relationship is spurious, due to the differences in human capital (Mirowsky and Ross 1998), differential exposure by SES to social norms regarding dietary intake, physical activity, and body size (Sobal and Stunkard 1989) and possible direct effects of perceived scarcity and social inequality on weight and weight-related behaviors. These explanations are briefly reviewed herein, with a focus on the relationship between education and obesity, as education is commonly used as an indicator of SES, along with income (Pavela et al. 2016).

First, the association between SES and weight may be spurious – that is, due to factors other than a causal effect of SES on weight, including reverse causation and omitted variables affecting both education and weight (Devaux et al. 2011; Boardman et al. 2015; Haas 2006). For example, obesity is associated with lower academic performance (Caird et al. 2013), with some evidence to suggest teacher and peer prejudice contribute to lower grades (MacCann and Roberts 2013). Students with obesity are more likely to report school absences, school problems, and low engagement (Carey et al. 2015). Obesity is also associated with a wage penalty, such that among white males, a 1 kg increase in body fat is associated with a 1.8% decrease in wages and, among white females, a 1 kg increase body fat is associated with a 1.9% decrease in wages (Wada and Tekin 2007). Other studies have found a similar wage penalty for both sexes and multiple racial ethnic groups in the United States, with white women with obesity earning 11.9% less than their peers with normal weight, African-Americans with obesity earning 6% less than peers with normal weight, and Hispanic females with obesity earning 8% less than peers with normal weight. The possibility that obesity affects educational attainment and income raises the general problem of reverse causation, especially in cross-sectional studies. If individuals who are obese are selected into a lower SES, it suggests that at least part of the association between obesity and SES is not due to the causal effects of SES on weight.

Second, the association between SES and obesity may be due to differences in human capital. Human capital is the embodiment of knowledge and skills in humans (Becker 1994). Originally developed by economists conceptualizing human capital as a form of investment in the self in the pursuit of increased productivity, the concept of human capital has since been applied to the analysis of health outcomes (Mirowsky and Ross 1998; Grossman 1972). From this perspective, greater educational attainment and resulting increases in human capital improve the productive and allocative efficiencies of individuals who demand good health, with productive efficiencies being those which directly improve returns on investments in health, such as an improved ability to understand the advice of a medical doctor, and allocative efficiencies being those that improve the selection of health inputs for a desired health goal, implying that greater educational attainment increases the likelihood that individuals will select effective health-producing behaviors (Grossman 2008).

When a particular weight is the desired health outcome, the human capital perspective posits that a more highly educated individual will, on average, select activities better suited to achieve weight goals and derive greater benefit from those activities given their greater skills and knowledge. Evidence of a causal relation between education and weight are consistent with the human capital perspective (as well as sociocultural explanations – see below). In the absence of randomized controlled trials to test the causal effects of education on weight, multiple non-RCT Extended Association Tests (EATs) have been used (Richardson et al. 2017). These methods go beyond what have been called "Ordinary Association Tests," (OATS) for "which the sole or primary means of controlling for potential confounding factors is inclusion of measures of some potential confounding factors as covariates in statistical models (or stratifying by measures of such factors)" (Richardson et al. 2017). Although not all EATS find a causal relation (e.g., Petter 2008; Kenkel et al. 2006; Clark and Royer 2010), many have found causal evidence utilizing changes in mandatory school laws (Kemptner et al. 2011; Grabner 2009; Brunello et al. 2013), sibling fixed-effects (Fletcher and Frisvold 2012), and timing of school entry (Zhang and Zhang 2011). For example, Grabner (2009) utilized US state-level variation in compulsory schooling requirements, finding that an additional year of education is associated with a 2–4 percentage point reduction in the probability of being obese, an effect that is stronger in females. This analysis and others like it which utilize variation in *compulsory* school attendance requirements are valuable as they substantially reduce the risk that the association between education and obesity is due to selection (i.e., individuals *choosing* to stay in school longer). Sibling fixed-effects models utilize variation in educational attainment (or other independent variable of interest) *within* sibling pairs in an effort to reduce the risk of confounding in the relationship between education and obesity due to unobserved family characteristics or genetics (when using identical twins). Research using variation in education among Australian twins found that education was inversely associated with the probability of being obese among men but not women (Webbink et al. 2010).

Third, and in contrast to the human capital perspective, a sociocultural perspective emphasizes the role of education as a socializing institution that reinforces weight-related norms and influences individual attitudes toward body shape (Neighbors and Sobal 2007). In their original review, Sobal and Stunkard (1989) recognized the likely role of societal attitudes toward obesity as an explanation for the consistent relationship observed between SES and obesity among females, a relationship less consistently observed among males. Indeed, evidence suggests that beginning in the 1960s, the ideal feminine body became thinner (Garner et al. 1980). The pressure to stay thin begins early in life, with some evidence indicating that girls as young as 3 years old have internalized the thin ideal (Harriger et al. 2010). Educational institutions may thus act to reinforce social values, including the value of thinness. Among college students, women believe that men have a thinner feminine ideal than men actually report liking, potentially leading to greater body image dissatisfaction and weight control behaviors among women (Fallon and Rozin 1985). Certain educational environments may also more strongly reinforce the thin ideal; compared to freshman at all female colleges, female freshman at mixed colleges may be more likely to endorse thinner ideals once they become seniors (Spencer et al. 2013).

Finally, in addition to the explanatory roles of financial resources and human capital, a more recent line of research examines the hypothesis, sometimes called the Insurance Hypothesis (Nettle et al. 2017), that *perceptions* of food scarcity directly promote weight-related behaviors that encourage a positive energy balance, perhaps as a means to buffer against future food scarcity (Kaiser et al. 2012). Thus, insofar as low socioeconomic status begets perceptions of food scarcity, the association between SES and obesity may be due, in part, to the effects of perceived food scarcity. Emblematic of this line of research is (Cardel et al. 2016), which experimentally manipulated social status to observe its effects on energy intake, finding that participants randomized to a lower social status position consumed a significantly higher proportion of their daily calorie needs compared to participants randomized to the higher social status position. However, not all studies in this vein have found a significant effect of social status on energy intake (e.g., Pavela et al. 2017).

Perceptions of food scarcity may also promote adipose accretion via reductions in energy expenditure rather than increases in energy intake. Energy expenditure can be broken into three primary categories: resting metabolic rate, thermic effect of food, and physical activity energy expenditure. Lee and Cardel (2018) expanded on the Insurance Hypothesis to include energy expenditure, theorizing that individuals in subordinate positions (e.g., of lower social status) may have lower resting metabolic rates and lower physical activity energy expenditure as a means to preserve energy during times of insecurity or scarcity (Lee and Cardel 2018; Dhurandhar 2016). This protective mechanism could lead toward a state of energy imbalance that promotes excess adiposity and obesity development due to both the immediate effects of reduced energy expenditure as well as the potential effects on the regulation of energy intake. Hill et al. (2012) hypothesize that “human physiology developed under circumstances that conferred [an] advantage for achieving energy balance at a relatively high (compared to resting metabolic rate) level of energy expenditure – a high energy throughput – or high energy flux,” which suggests that humans today are better able to match energy intake and expenditure (achieve energy balance) at higher levels of energy expenditure; thus factors which tend to reduce energy expenditure, including perceptions of food scarcity, may make it more difficult to achieve energy balance and promote weight gain.

Current evidence for the hypothesis that perceptions of food scarcity are associated with reduced energy expenditure primarily exist in animal models. For example, mice in a subordinate position have significantly lower total energy expenditure compared to mice in dominant positions after experiences of psychosocial stress (Moles et al. 2006; Sanghez et al. 2013). Though experimental studies in humans exist to study social status and energy intake, there has yet to be experimental work focused on social status and energy expenditure. Thus, in humans there is minimal experimental evidence available to assess the strength of this hypothesis. Observational studies of the association between socioeconomic status and physical activity (a contributor to energy expenditure) are at least consistent with the Insurance Hypothesis, as physical activity (PA) is inversely associated with SES in higher income countries. In the United States, the proportion of adults meeting physical activity guidelines significantly increases as education level increases and adults on private insurance (a common proxy for higher income level) were 93.1% more likely to meet guidelines than those with public insurance (U.S. Department of Health and Human Services 2019). An umbrella review of systematic reviews also found convincing evidence that SES is significantly associated with overall PA, occupational-based PA, and leisure-based PA in adults (O’Donoghue et al. 2018). Infrastructure accessibility and quality can differ between high- and low-SES neighborhoods. Access to sidewalks, paths, parks, and recreational facilities have all been found to facilitate physical activity, but may not be present in lower SES neighborhoods (Salvo et al. 2018; Smith et al. 2017). When such facilitators of physical activity are present, perceived access and safety concerns can impact use and behavior. A study between high- and low-income neighborhoods in Australia found that, even though the number of recreational facilities in neighborhoods were equitable, low-SES residents perceived that they did not have access to recreational facilities (Giles-Corti and Donovan 2002). Individuals in high crime areas have 28% reduced odds of achieving sufficient levels of PA; however, perceived safety can increase the odds of achieving higher activity levels by 27% (Rees-Punia et al. 2018).

Though minimally studied, similar relationships are observed between objectively measured socioeconomic status and PA as when assessed using subjective measures of social rank or subjective social status (SSS). In adolescents, a study conducted in Finland found that low SSS was positively correlated with moderate to vigorous PA and negatively correlated with sedentary time (Rajala et al. 2019).

In adults, an analysis of data collected from China, Taiwan, South Korea, and Japan found that SSS was significantly associated with odds of weekly or daily PA except in South Korean and Japanese females (Frerichs et al. 2014). There is a need to replicate these findings in countries with different income and education classes, as well as diversity of racial ethnic identities, as these factors could affect the perception of social status in countries of greater inequality.

Research on the relationship between perceptions of food scarcity and weight-related behaviors may also add insight into the perhaps counterintuitive association between food insecurity and obesity. Food insecurity occurs when there is a lack of reliable access to safe and nutritious foods to support an active and healthy lifestyle. Individuals that have low food security experience reduced diet quality or variety due to inadequate resources and are at subsequent risk of poor nutrition and health outcomes. In more severe instances of very-low food security, individuals also experience disrupted eating patterns and an overall reduction in food intake due to their inability to consistently access food in a safe, socially appropriate manner. Those living with very-low food security are known to experience the sensation of hunger without the means of relieving this physical discomfort (USDA 2018). Though not causal, the prevalence of food insecurity in the United States is closely related to poverty rates. Food insecurity is three times more likely among households below the federal poverty line, yet households above this federal poverty line may experience food insecurity due to nonmonetary causes, such as instances of family illness, emergency, or other unforeseen life circumstances (Holben and Marshall 2017; Coleman-Jensen et al. 2019).

Access to nutritious foods is essential in the promotion of healthy food choices, eating patterns, and positive health outcomes (ODPHP 2019). Limited access to healthy foods has been shown to contribute to either extreme of malnutrition – both undernutrition, a by-product of food insecurity, and obesity (SOFI 2019; World Health Organization 2019). The United Nations' Food and Agriculture Organization estimates that 10.9% of the global population experiences undernutrition, and 13.2% of adults have obesity (SOFI 2019). Estimates exclusive to the United States are even graver: 12.5% of Americans experience food insecurity and 39.8% of adults have obesity, and these statistics are not mutually exclusive (What Is Food Insecurity in America? 2019; Centers for Disease Control and Prevention 2019). The prevalence of obesity is greater among lower SES women in affluent countries such as the United States, yet there is no known association among men (McLaren 2007; Nettle et al. 2017). Food insecure, lower SES women are at a 50% greater risk of obesity than food secure women (Nettle et al. 2017).

The association between food insecurity and obesity may occur for a multitude of reasons. For instance, the limited availability of financial and other resources among food insecure individuals makes selecting healthy food choices even more challenging for this population. Food insecure individuals are also prone to consuming calorically heavy food items, given the inverse relationship between calorie density and cost of foods (Dhurandhar 2016; Seligman et al. 2007). As a means of coping with their circumstance, food insecure individuals may seek calorically dense food for the sensation of satiety (Holben and Marshall 2017). Understandably, these choices often occur without consideration for nutritional adequacies to support an active, healthy lifestyle or for potential long-term health outcomes. Each of these actions may exacerbate the risk of obesity by contributing to limited fresh fruit and vegetable intake or consumption of dietary variety, and, when ample food is available, promote overeating (Dhurandhar 2016; SOFI 2019). Given that low SES households are more likely to experience food insecurity, *taste* differences by class may serve to reinforce (or counteract) tendencies to devote limited financial resources to energy dense foods. As the authors have noted elsewhere, "*taste* may be embodied in the working class through their attention to the strength of the male body while the professions prefer non-fattening options due to their greater focus on body shape," an observation stemming from the sociologist Pierre Bourdieu (Pavela et al. 2017), whose concept of cultural capital is increasingly applied to differences in health and health behaviors by SES, including SES differences in food preferences (Kamphuis et al. 2015). Promoting healthy food choices among food insecure adults could help to prevent against and reduce the prevalence and severity of obesity in this population (Rees-Punia et al. 2018). Supporting the intake of nutritionally adequate foods among those who are food insecure should be addressed through holistic methods such as innovative community-based initiatives that incorporate nutrition education (ODPHP 2019). More emphasis is needed on training for community-based initiatives and programming that is based upon research and consistent program evaluation (Holben and Marshall 2017).

Conclusions

Socioeconomic status is associated with obesity, an association that is context-specific and varies in strength by sex, food insecurity, and race-ethnicity. This chapter has reviewed several of the standard explanations for the inverse association between SES and obesity in higher-income countries, as well as a more recent explanation – the Insurance Hypothesis – which posits that social-psychological mechanisms in response to perceived food scarcity may promote weight gain. However, there are other important social-psychological factors that influence food intake and may, ultimately, increase the risk of obesity. Thus, rather than close with a brief summary of the chapter, a few especially important determinants of food intake not necessarily linked to SES, including modeling, social facilitation, and impression management, are reviewed here (see ▶ Chap. 14, "Social Influences on Eating" by Higgs in this volume for additional detail). These factors may operate synergetically with some of the factors contributing to the excess risk of obesity in lower SES individuals, for example, the social modeling of the consumption of energy dense foods.

Research on the effects of social modeling on food intake stems from the external/internal food cues distinction developed by Schachter (1971). Social cues are just one type of external cue among many, including sensory inputs that indicate the palatability of food. Although Schachter (1971) originally believed that obese individuals were more sensitive to external cues than nonobese individuals, including social cues, Nisbett and Storms (1974) found little evidence that an individual's weight moderated the relationship between social modeling and food intake behavior among males, a finding supported by later research using both male and female subjects (Conger et al. 1980). A recent systematic review of research on the effects of social modeling on food intake and selection found that the majority of research found a statistically significant effect of social modeling (Cruwys et al. 2015). While most research on modeling effects has used palatable, energy dense foods, some research has found a modeling effect for nutrient-dense foods such as vegetables among college-age females and adolescents (Hermans et al. 2009; Salvy et al. 2008), and the effect appears to be less pronounced with nutrient-dense foods than with energy dense foods (Cruwys et al. 2015).

A second important influence on energy intake is social facilitation. de Castro, who has done much of the research on social facilitation, has called it "the most important and all-pervasive influence on eating yet identified" (de Castro et al. 1990). Indeed, a large amount of research indicates that people eat more in groups than they eat alone and that meal size appears to increase as the number of people increase – each additional person at a meal is associated with an increase in meal size, likely due to increasing length of the meal (Bell and Pliner 2003; Pliner et al. 2006; Feunekes et al. 1995).

Finally, impression management may influence the type and amount of foods consumed, as the kinds of food we eat convey to others (and ourselves) information about the kind of person we are. Insofar as we associate different foods with different traits that an individual might possess, such as high social status, masculinity, femininity, or healthfulness, individuals may select certain foods to manipulate the perceptions of others (and their self-perceptions) – a process of impression management (Leary 1995). Several studies have suggested that types of food and amount eaten are associated with gender. Rozin et al. (2012) found that subjects were quicker to make the association between "meat" and "male" than other associations (suggesting the two concepts are linked in thought), and, among college students, males expressed a greater preference for meat than females (along with beef and orange juice), while females expressed a greater preference for salad and vegetables.

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Part VIII

Business, Marketing, and Economic Sciences

Wine's Gradual Globalization

40

Kym Anderson

Contents

Abstract

Until the 1970s, wine was a product produced and consumed almost exclusively in the Mediterranean region and the nearby Levant. Today it is enjoyed in a much broader range of countries. Yet notwithstanding the dramatic recent globalization of this product, the total volume consumed is very similar today to what it was in the 1960s. This chapter explains the apparent inconsistency between these two facts. It points to the rapid growth in New World wine production, to the gradual move by consumers from other alcohols to wine in previously beer- or spirits-consuming cultures, to wine's near disappearance in North Africa in the 1960s once the region became independent from France, to the huge decline in wine consumption in the most wine-focused countries, and to the dramatic rise of East Asia as a wine-importing region. Also characterizing these changes has been a steady rise in the *quality* of wine being consumed around the world – even though the overall quantity has not grown. This premiumization has occurred despite fears by wine tragics that the accompanying emergence of multinational

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wine brands would lead to the homogenization of wine styles. The bottom line is that most wine consumers have never had it so good. The exceptions are those addicted to rare iconic wines, particularly from Bordeaux and Burgundy, whose prices have risen to stratospheric levels – to the immense financial benefit of owners of the best wine assets in, and finest wines from, those iconic regions.

Introduction

The cultivation of *Vitis vinifera* grapes (by far the most suitable for winemaking) began around 6000 BC in or near the Caucasus region. It spread west to the Eastern Mediterranean from 2500 BC and spread north into much of Europe by 400 AD. It then took another 1100 years before spreading to Latin America from the 1520s, South Africa by 1655, Australia by 1788, and California and New Zealand by 1820 (Unwin 1991). But this gradual spreading involved mostly the transfer of vine cuttings and grape and wine production knowhow and only to temperate climate regions in the 30° to 50° latitude band north and south of the equator. Long-distance international trade in anything but the most expensive wine was rare: ordinary wine deteriorated quickly prior to the use of standardized corked bottles and sulphur as a preservative, which only began to be used from the 1700s (Johnson 1989, pp. 195–198). Even in those New World countries with the potential to grow wine grapes, production expansion was slow until very late in the twentieth century.

In 1860 the top five countries accounted for four-fifths of the global wine market, and the next three also were European. That is, the rest of the world – which included numerous nearby countries of Northern Europe – consumed less than one-eighth of the world's wine (Anderson and Pinilla 2017, 2018). A century later the situation was much the same, despite the huge reduction in trade costs. The share of global wine production that was exported was no higher at the end of the first globalization wave (1913) than it was in 1860, at just 5%. Even more remarkably, nor was it any higher in the 1960s: wine still was predominantly produced and consumed in just a few European countries.

In contrast with that stability, the growth of new wine markets in the past three decades has been spectacular. Production has expanded rapidly in a handful of New World countries, wine imports have grown in many countries whose alcohol consumption was previously beer- or spirits-focused, and most recently there has been a dramatic rise of East Asia as a wine-importing region. However, coinciding with these developments has been a near-halving of wine consumption per capita in the key traditional wine-producing countries.

Together these trends mean that (a) the volume of wine consumed globally is very similar today to what it was in the 1960s and (b) the share of global wine production that is traded internationally has grown from 5% to 15% during 1960–1990 and then to 40% by 2012. That is, in less than half a century, wine has switched from being one of the world's least-traded agricultural products to one of the most traded.

Simultaneously, and largely because of increased competition from the New World, there have been huge improvements in the quality and diversity of wines available to consumers. This premiumization has occurred despite fears by wine tragics that the accompanying emergence of multinational wine brands, and the convergence of wine grape varieties to a few key "international" ones, would lead to the homogenization of wine styles (McWine).

Thus this recent globalization of wine has been an unprecedented boom for almost all consumers in an ever-expanding number of countries, at very affordable prices. The only consumers who may be worse off are the less prosperous of those who consume the most iconic of wines, particularly from Bordeaux and Burgundy, the prices of which have risen to stratospheric levels. Those price rises of course are a great financial benefit to owners of the best wine assets in, and finest wines from, those iconic regions. Indeed those who store the finest wines as an investment have found that not only do they tend to enjoy capital gains as the wine matures in bottle, but also those values tend to move counter to the business cycle, making such wine a convenient alternative store of wealth (Sokolin 2008; Masset and Henderson 2010).

This paper seeks to shed light on the forces behind these developments. It begins by elaborating on and explaining the above facts to do with the quantity of wine and then looks at factors contributing to the rise in wine quality. The paper concludes by speculating on how wine production, consumption, and trade might develop in the foreseeable future, bearing in mind the premiumization of other beverage markets, notably the craft beer and craft spirits revolutions that began late last century.

The Belated but Sudden Globalization of Wine

The first globalization wave (roughly 1860–1913) seemed to affect global wine markets very little – except for the transfer of the tiny phylloxera insect from the United States to Europe. That insect devastated the majority of Europe's vineyards, starting in France in the mid-1860s (Campbell 2004). It led to French vignerons initially importing raw material from other European countries to supplement their diminishing supplies, while they invested hugely in nearby North Africa. The latter led to Algeria's share of global wine production rising from 0.1% in 1870 to 8% by 1910, by which time it accounted for more than 40% of the world's exports. However, almost all Algerian exports went to France, so if colonial Algeria is thought of as part of France (as the French Government did), then global wine exports averaged no more than 5% of the volume of global wine production before the 1960s, apart from the 1880s when phylloxera caused France to temporarily import from its neighbors (Fig. 1).

Global wine output in total during the interwar period was about 50% higher than during 1860–1899. That total volume then doubled in the four decades to the mid-1980s, before returning to the level of the 1960s. In per capita terms, global wine availability had decadal averages that fluctuated between 7.5 and 9 l per year between 1860 and 1939. It then began its decline, falling back to 7.5 during 1950–1979, 6.5 in the 1980s, 4.5 during 1990–2009, and 3.8 l in 2010–2015

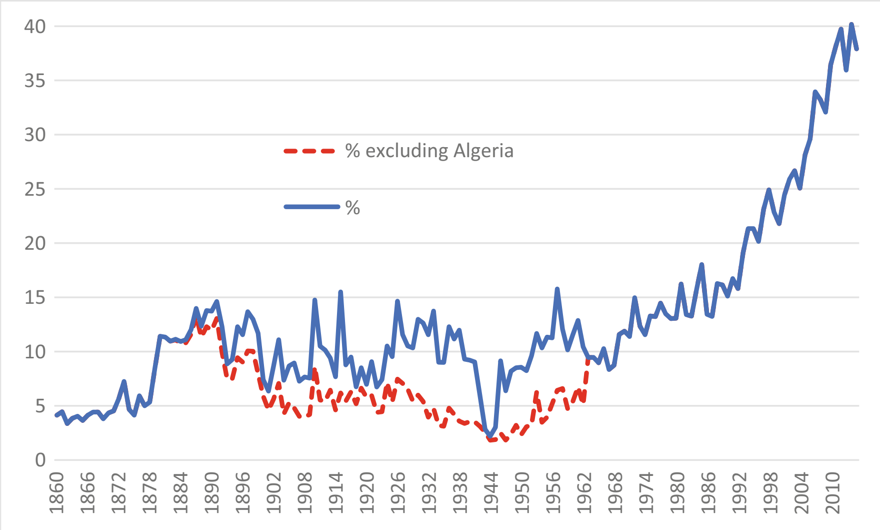


Fig.1 Share of volume of global wine production exported, 1860–2015 (%). (The dashed line assumes Algeria is part of France so that its exports are excluded from the world total. Source: Anderson and Pinilla (2018, Chap. 2))

(Fig. 2). That is, the industry has not been growing globally in total volume terms and has been shrinking since the mid-1980s in terms of global volume per capita.

Notwithstanding wine's output per capita decline in the current globalization wave, the numbers of countries producing and exporting the world's wine have been increasing. Through the first globalization wave, both the top two producers and the top ten producing countries retained their combined shares of world wine production: the top two (France and Italy) accounted for almost 60% and the next highest eight countries accounted for a further 30% of global wine output. There was very little diversification in wine grape growing beyond the traditional European base during those five decades to World War I. By the early 1960s, the share of the top four countries had fallen from three-quarters to two-thirds, but the top ten's share was no different than during the first globalization wave at almost 90%. It is only in the most recent decades that significant production shares have been accounted for by additional countries (Fig. 3a).

Similarly, global wine exports were almost fully accounted for by the top ten exporters (all European) at both the start and end of the first globalization wave, and their share was still 92% by the early 1960s; but it has declined since then, especially since the late 1980s (Fig. 4). Even so, the volume of exports of at least Italy and especially Spain have continued to grow on a per capita basis, albeit not as fast as for New World countries (Fig. 5).

Values of wine exports expanded at different rates to volumes in these various countries because of quality differences. That matters because values are used in generating indicators of international competitiveness in product markets. If wine's

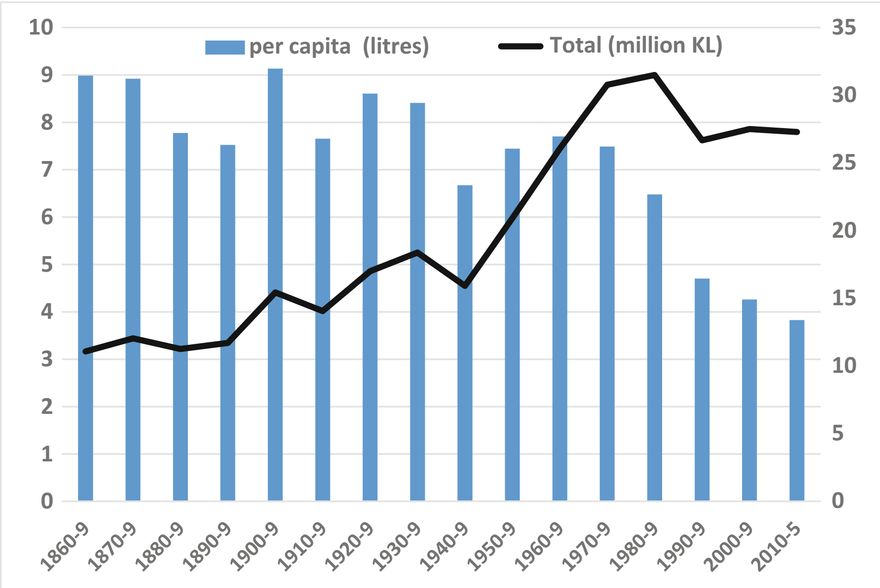


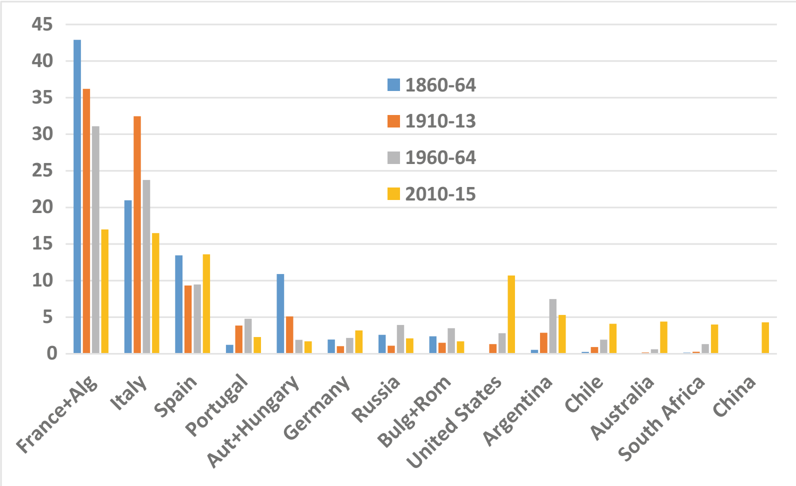
Fig. 2 Total and per capita wine production in the world, 1860–2015 (liters on left axis, million KL on right axis). (Source: Anderson and Pinilla (2018, Chap. 2))

export value alters at a different rate to the value of a country's other exports, it could indicate a change in that economy's comparative advantage in wine – depending on how that ratio alters in the rest of the world. One way to capture this is to estimate an index of comparative advantage, defined as the share of wine in national merchandise exports divided by wine's share of global exports. Those indexes, shown in Fig. 6, reveal that France, Italy, and Spain have been able to retain their strong comparative advantage in wine despite the dramatic strengthening of comparative advantage in key wine-exporting countries of the Southern Hemisphere. However, New Zealand and Chile have surpassed them by this measure, as did Australia in the 2000s.

The emergence of strong comparative advantages in wine in New World countries during the current globalization wave begs the question as to why they did not emerge in the first globalization wave. Part of the answer has to do with trade costs: in all those settler economies, only two products (both primary) accounted for the vast majority of their exports prior to 1914, both having high value-to-weight ratios sufficient to make them tradable (Anderson and Pinilla 2018, Fig. 2.17). For example, they were hides and grain for Argentina, gold and wool for Australia, copper and salt for Chile, and cotton and wheat for the United States. Evidently the perceived quality of those countries' wines was not high enough pre-1990s for them to attract prices that could cover production plus trade costs.

To get a sense of the importance of the wine industry in the overall economy of each country at any point in time, it is helpful to consider wine production per

(a) Production



(b) Consumption

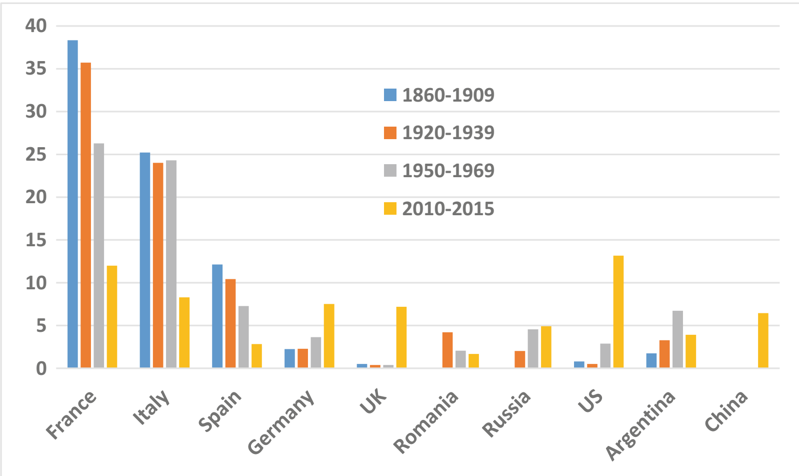


Fig. 3 National shares of global wine production and consumption volumes, 1860–2015 (%). (Source: Compiled from data in Anderson and Pinilla (2017))

dollar of real GDP. During the first globalization wave, at least six countries produced more than 10 l of wine per real US$ ‘000 of GDP: Spain, Portugal, Italy, France, Algeria, and Greece (Table 1). Those same five exceeded 25 l in the interwar years, when four others produced between 12 and 24 l: Chile, Romania, Argentina, and Bulgaria. Hungary was next with 8.5 l; and Moldova and Georgia probably would have been above 10 l had they been separate countries. During 1960–1979 there were still no other countries in those ranges. Then by 2000–2015, when real GDPs of all countries were much higher, the range had shrunk to no more than 5 l except for Moldova at 11 l. But note that those same 13 countries

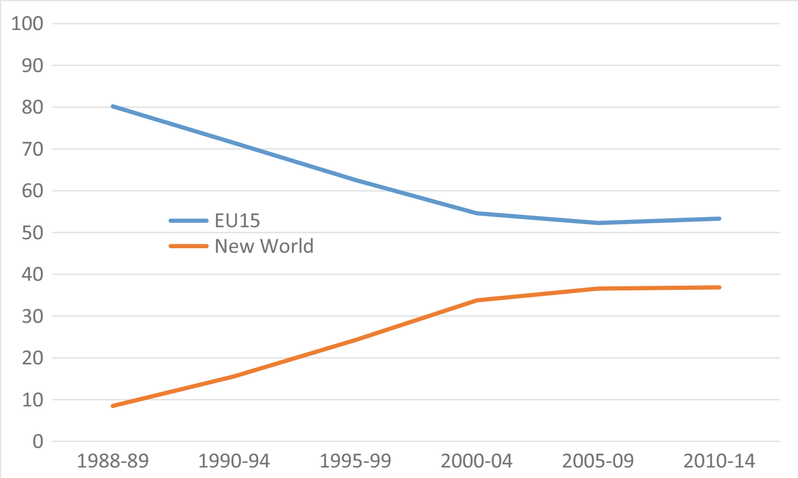


Fig. 4 Shares of European Union 15 and New World in value of global (excluding intra-EU15) wine exports, 1988–2014 (%). (The "New World" is defined here as Argentina, Australia, Canada, Chile, New Zealand, South Africa, the United States, and Uruguay. Source: Compiled from data in Anderson et al. (2017))

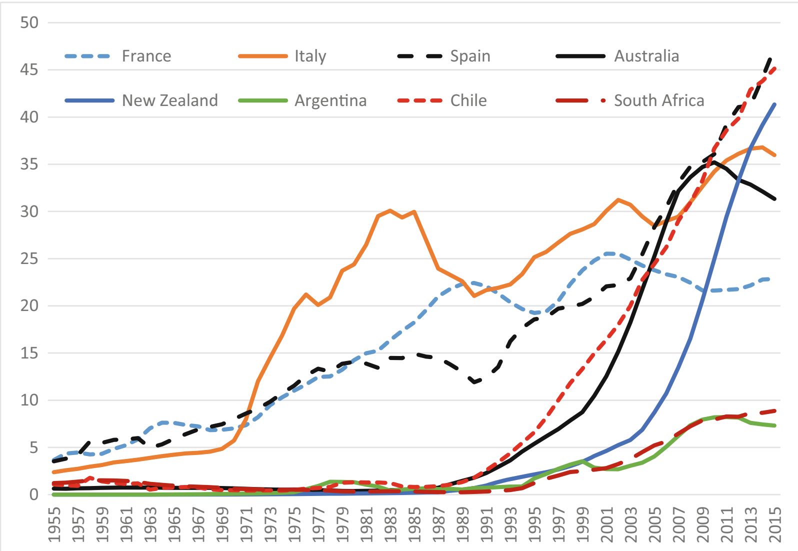


Fig. 5 Volume of wine exports per capita, key Old World and New World countries, 1955–2015 (liters, 5-year averages to the year shown). (Source: Compiled from data in Anderson and Pinilla (2017))

mentioned are still the highest ranked in 2000–2015, together with South Africa and Uruguay, covering the relatively narrow range of 2.4–5.2 l per real US$ '000 of GDP.

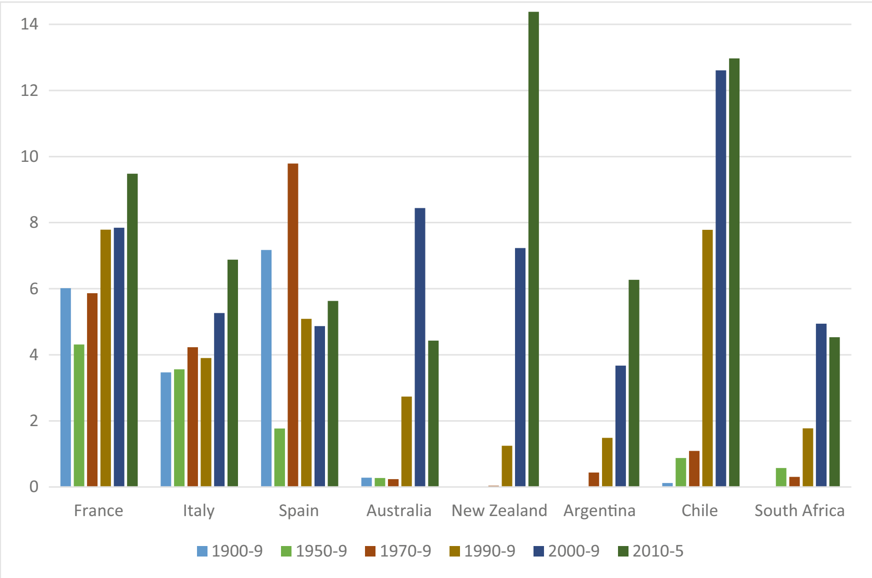


Fig. 6 Index of “revealed” comparative advantage (RCA) in wine, eight countries, 1900–2015. (The RCA is the share of wine in national merchandise exports divided by share in global exports. Countries with higher RCAs than those shown are Moldova and Georgia, whose RCAs in 2000–2015 averaged 64 and 28, respectively. Source: Compiled from data in Anderson and Pinilla (2017))

The extent of national exports per capita rose moderately for two decades after the 1960s, before rising very rapidly over the subsequent 25 years (Fig. 5). The moderate rise in exports during the 1970s and 1980s was mainly a by-product of a faster decline in wine consumption than in production in the traditional wine-consuming countries of France, Italy, and Spain: their combined annual consumption fell by 4 billion liters (from a little over 12 billion) over those two decades, while their annual exports rose by 2 billion liters (from a little over 1 billion).

The acceleration since the 1980s in the volume of wine that crosses national borders is due to the emergence of New World wine exporters. That surge began in Australia from the late 1980s, helped by a very low value of the country’s currency at that time (Anderson 2018). Similarly, New Zealand’s currency was very depressed in the early 2000s, while a large real devaluation in late 2001 triggered the export takeoff of Argentina, aided by declining domestic consumption just as in Spain (Anderson and Pinilla 2018, Chaps. 11 and 12). Australian wineries’ international competitiveness over the past decade declined because of the real exchange rate appreciation associated with Australia’s massive mining investment boom (Anderson 2017a, 2018). That appreciation relative to the currencies of other wine-exporting countries enabled the latter to expand their sales in third countries at Australia’s expense (Anderson and Wittwer 2013). This is a clear example of how, in a globalized world, temporary misfortune to the industry in one country –

Table 1 Wine production volume per dollar of real GDP, various countries, 1860–2015 (liters per US$'000 of GDP at 1990 prices)

	1860–1909	1920–1939	1960–1979	1980–1999	2000–2015
Spain	71.5	39.7	14.6	7.4	5.2
Portugal	61.1	62.6	24.5	8.1	4.3
Italy	54.4	36.8	14.0	7.6	4.2
France	50.9	35.3	12.1	6.4	3.5
Greece	26.5	25.1	8.3	4.2	2.4
Switzerland	7.0	1.9	1.0	0.9	0.6
Austria	6.9	3.6	3.0	2.1	1.2
Germany	1.8	0.9	0.9	0.8	0.5
Moldova				10.6	11.4
Romania		16.5	11.2	8.9	4.7
Bulgaria		12.4	10.6	6.7	2.6
Hungary		8.5	8.6	6.7	3.8
Georgia				4.0	3.6
Croatia				3.6	2.2
Australia	1.2	1.7	1.6	1.7	2.3
New Zealand	0.0	0.1	0.6	1.0	2.1
United States	0.3	0.2	0.3	0.3	0.3
Chile	6.8	16.7	10.9	4.7	3.9
Argentina	5.4	14.5	13.0	7.7	3.9
Uruguay	1.3	6.3	5.6	4.0	2.4
South Africa	4.9	4.8	5.4	5.9	4.3
Algeria	>50	>50	34.5	1.4	0.5
Morocco			7.2	0.7	0.3

Source: Compiled from data in Anderson and Pinilla (2017)

including from economic forces outside the industry – can be a boon to the industry in other countries.

The top seven wine-consuming countries, which accounted for 80% of global wine consumption in 1909–1913, still accounted for 77% a half-century later. France, Italy, and Spain plus Argentina still accounted for nearly two-thirds of global wine consumption during 1950–1969. The share of France alone was 36%, helped by the fact that from 1931 the French government explicitly campaigned on behalf of its wine industry to encourage greater wine consumption in France (Phillips 2014, pp. 286–289) – despite the fact France already had at that time the highest per capita wine consumption in the world, at more than 150 l per year. However in the half-century to 2010–2015, the top seven countries' combined share fell to just 61%. France, Italy, and Spain saw the largest falls, but the shares of Argentina and Romania also fell. Meanwhile, those of Germany, the United Kingdom, the United States, and East Asia (especially China) rose (Fig. 3b). Bear in mind that while Britain was important for centuries as a consumer of fine wines from Bordeaux, accounting for a substantial share of the value of global wine imports, it accounted for well under 1% of the volume of global wine consumption prior to the early 1970s

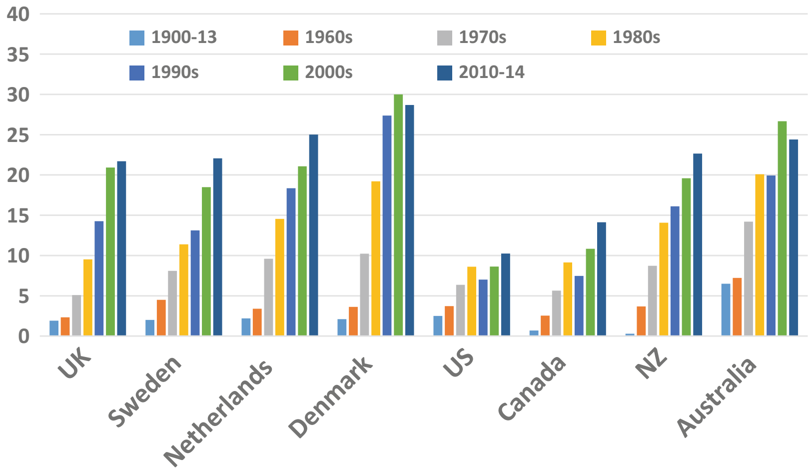


Fig. 7 Wine consumption per capita, New World countries and European wine-importing countries, 1900–2014 (liters per year). (Source: Compiled from data in Anderson and Pinilla (2017))

(Anderson et al. 2017, Table 137). Also, per capita wine consumption grew rapidly in a number of smaller countries that had previously focused on beer or spirits (Fig. 7). That is, beverage consumption mixes have been converging across countries, with wine markets emerging in countries where beer or spirits previously dominated – and vice versa (Table 2). As part of that, East Asia's share of global wine imports has grown from 2% in the mid-1980s to around 12% since 2012.

To put the growing extent of international wine trade in perspective, it is instructive to compare it with that for other products. Having been never more than 15% before 1990, and no more than 5% before the phylloxera outbreak in the final quarter of the nineteenth century, the share of global production exported for wine was much lower than the share for other farm products, the average of which has been estimated to be 10–15% during 1900–1938 and 15–30% during 1950–1990 (Aparicio et al. 2009, p. 57). The fivefold increase in wine's share since the late 1960s to around 40% (Fig. 1) now puts it at the higher end of the spectrum – as it should be for a heterogeneous, highly differentiated product group whose primary ingredient (wine grapes) can be grown profitably in a very small share of the world's cropping land (currently less than 0.5%; see Anderson et al. 2017).

Of course wine is not the only beverage that is becoming more globalized. Beer traditionally was produced and sold only locally. However, with technological advances and exploitation of economies of scale through mergers and acquisitions of what have become multinational companies, beer brands are becoming nearly as global and concentrated as carbonated soft drinks (Swinnen 2011; Caravaglia and Swinnen 2017; Swinnen and Briski 2017). As part of that, beer is increasingly being traded across national borders: in 1960 only 1.5% of the world's recorded beer production was exported, but by 2015 that share had increased fivefold to 7.5% (Anderson and Pinilla 2017). Most of the world's spirits too are produced by a small

Table 2 Alcohol per capita consumption and shares of beer, wine, and spirits in alcohol consumption volume and expenditure, seven regions and the world, 1961–1964 and 2010–2014 (LAL and %)

	Total alcohol consumption (LAL/capita)[a]		Share of alc. volume, 1961–1964 (%)[b]			Share of alc. volume, 2010–2014 (%)[b]			Share of alc. expenditure, 2010–2014 (%)			Alcohol's share of all expend. (%)
	1961–1964	2010–2014	Wine	Beer	Spirits	Wine	Beer	Spirits	Wine	Beer	Spirits	
Western Europe	12.3	8.4	**55**	29	16	**42**	38	20	34	40	26	3.9
Eastern Europe	1.9	7.2	22	22	**56**	14	42	**44**	20	46	34	5.9
North America	5.4	7.0	8	49	43	18	**49**	33	21	48	30	1.9
Latin America	6.5	5.1	**48**	34	18	11	**60**	29	10	64	26	4.2
Australia and NZ	6.5	7.1	10	**76**	14	39	**46**	15	28	53	19	3.5
Asia (incl. Pacific)	1.9	3.2	1	12	**87**	4	34	**62**	15	35	50	4.3
Africa and M East	1.0	1.7	27	**38**	35	14	**67**	19	15	60	25	2.5
World	**2.5**	**2.7**	**34**	**29**	**37**	**15**	**43**	**42**	**21**	**44**	**35**	**3.5**

Sources: Anderson and Pinilla (2018, Chap. 2)

[a]These data are volume-based in liters of alcohol (LAL) per year, 5-year averages

[b]The bold numbers indicate which beverage has the highest share in total alcohol consumption volume in the period shown

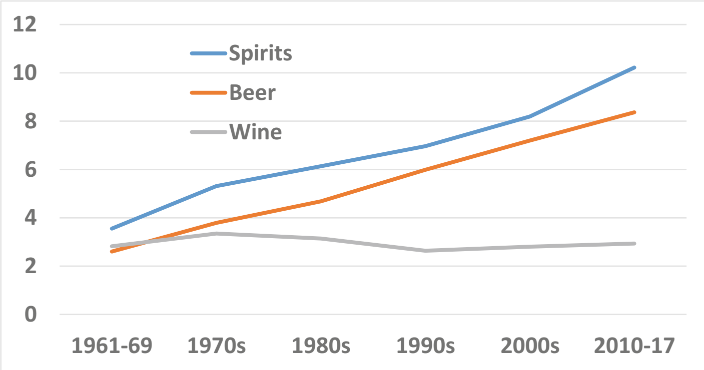


Fig. 8 Global consumption of wine, beer, and spirits (liters of alcohol), 1961–2017 (billions of liters of alcohol). (Source: Compiled from a revision and update of data in Anderson and Pinilla (2017))

number of multinational firms and are now very highly traded globally: the value of that annual trade has grown from less than US$2 billion in the mid-1970s to more than $30 billion by 2013 – very closely matching that of wine, which grew from $2.2 billion in the 1970s to $32.4 billion in 2010–2016.

In the 1960s, all three beverages had a similar share of the global recorded alcohol market (measured in liters of alcohol or LAL). In the subsequent three decades, the share of wine in that overall market halved and is now just one-third of the shares of beer and spirits which are each a little over 40%. Total alcohol consumption per capita in the world has traced a flat trend since 1960 (at around three LAL per year), but annual wine consumption has fallen from 0.9 LAL in 1960 to 0.4 LAL in 2015, while beer has risen from 0.7 to 1.2 LAL and spirits consumption per capita has grown from 1.1 to 1.6 LAL. In total terms, wine consumption has changed little, while beer and spirits have nearly trebled, at least as recorded by governments (Fig. 8). This overstates the situation somewhat for beer and spirits though, because some of that growth in their consumption is to replace what was previously produced illicitly and so not recorded, especially in developing countries (Holmes and Anderson 2017).

Premiumization: The Demise of Non-premium Wine and Emergence of Commercial Premium Wine

The lack of growth in the volume of wine consumed globally hides the net effect of the decline in consumption in traditional wine countries coinciding with rapid rises in wine consumption in traditionally beer- or spirits-drinking countries. But it also hides the fact that the quality of wine consumed since the late twentieth century covers a far wider spectrum than previously and their average quality is very substantially above that of the past.

Earlier, the majority of wine consumed in wine-producing countries of Europe was sold in bulk, was unbranded, and was simple in style and meant for immediate local consumption rather than for cellaring or branded export marketing. The rapidly expanding exports from New World countries did not replace such non-premium wines. Instead the New World effectively created a new category of branded, varietal-labelled bottled wines in large volumes that newly licenced supermarkets in Britain and elsewhere could advertise nationally as being approachable, consistent, without obvious faults, and yet affordable for those on an average income. Many of those brands have since added a super premium range to their commercial premium range by separating out their best as the quality improved with experience. Hence there is now a far broader spectrum of branded wines available to consumers over a wide range of prices, instead of the simple caricature of just two qualities: cheap commodity wine (most of which was not exported) or expensive fine wine.

Meanwhile, with the wealthy of China (including Hong Kong) having become major players in the ultra-premium and iconic fine wine buying segment over the past 15 years, the UK-based Liv-Ex index of prices of the top 100 wines has risen more than 350% (Phillips 2018). So while most of the world's wine consumers have never had it so good, the exceptions are those addicted to rare iconic wines, particularly reds from Bordeaux and Burgundy: their prices have risen to stratospheric levels, to the immense financial benefit of owners of the best wine assets in, and finest wines from, those iconic regions.

Looking Forward

The dramatic changes in national and global wine production, consumption, and trade over the past 150+ years, and particularly in the drinking of wine versus other alcohols during the current globalization wave, raise lots of questions as to how the situation might change in coming decades.

In terms of wine production potential, it is instructive to look at national vine bearing areas as a share of total area under crop. Figure 9 reveals this share to be above 4% in the main wine-exporting countries of Europe and 2–4% in numerous other European countries. Among the new exporters, by contrast, it is only Chile whose cropping has a high share under vines. In Argentina, Australia, and China, barely 0.5% of cropped land is under vine, in the United States only 0.25%, and that share is even smaller in emerging cool climate areas such as Canada, Southern England, elsewhere in Northwest Europe, and Tasmania. Should the world's climate continue to warm up, those cooler areas with still-low vine intensities of cropping may develop a stronger comparative advantage in wine production in the decades ahead (Anderson 2017b). The dramatic rise in the New World's shares of global wine production and exports over the past three decades, at the expense of Europe's shares, may have plateaued (Fig. 4), with limits on irrigation water possibly being a more binding constraint in the future thanks to climate changes. It seems unlikely the Islamic countries of North Africa or the Middle East will play a more significant role in global wine markets, but it is less clear whether some former East European

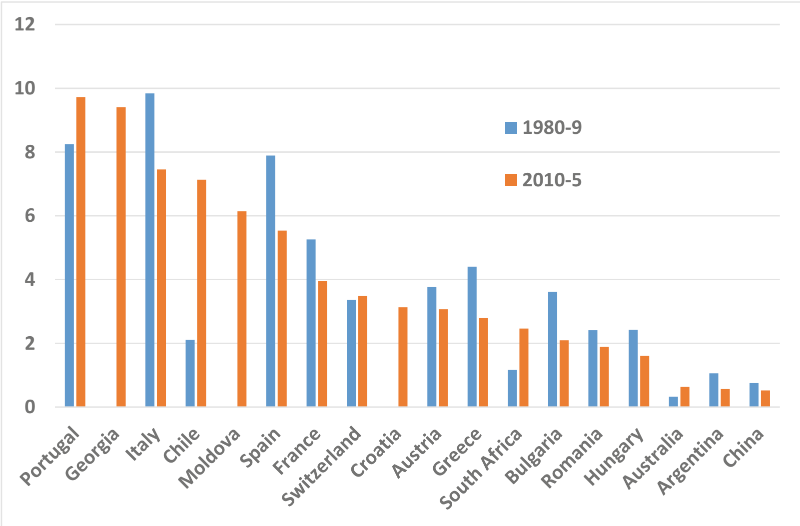


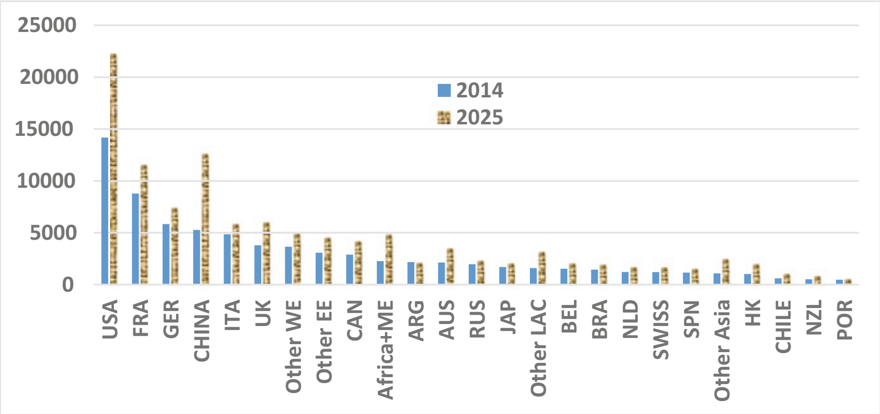
Fig. 9 Vine bearing area as % of total crop area, various countries, 1980–2015. (Source: Compiled from data in Anderson and Pinilla (2017))

socialist economies might re-emerge as wine exporters. East Asia, on the other hand, may well continue to become more significant in terms of value of wine imports as its economies continue to grow and its consumers embrace more western habits (Anderson and Wittwer 2015).

Whether total global consumption of wine or wine's share in global recorded alcohol consumption will continue to fall is unclear, but there is still plenty of scope for further convergence across countries in wine consumption per capita and as a share of national alcohol consumption. In particular, recorded alcohol consumption is still low per capita in Asia and sub-Saharan Africa where incomes are growing fastest and wine's share of that is extremely low in Asia (Table 2). Contributing factors will include various developments in institutions and policies affecting consumption (Anderson et al. 2018): Will health lobbies succeed in their lobbying for higher taxes and other curbs on alcohol consumption? Will there be further deregulation of retailing liquor laws and supermarketing or online sales of wine at all hours? Will consumers continue indefinitely to upgrade the quality of the wine they consume at the expense of quantity as their incomes grow? Will governments of wine-exporting countries lower barriers to imports so their consumers get access to a wider range of wines? Bilateral and regional trading agreements – or their undoing in the case of Brexit – also will continue occasionally to impact on both production and consumption of affected nations and thereby on bilateral and global wine trade flows (Anderson and Wittwer 2018).

Formally projecting into the future is always risky, since myriad assumptions need to be made. The final chapter of Anderson and Pinilla (2018) nonetheless draws on a model of global wine markets to project how those markets might change over

(a) Value of wine consumption (2014 US$ million)



(b) Projected change in volume of wine consumption, 2014 to 2025 (ML)

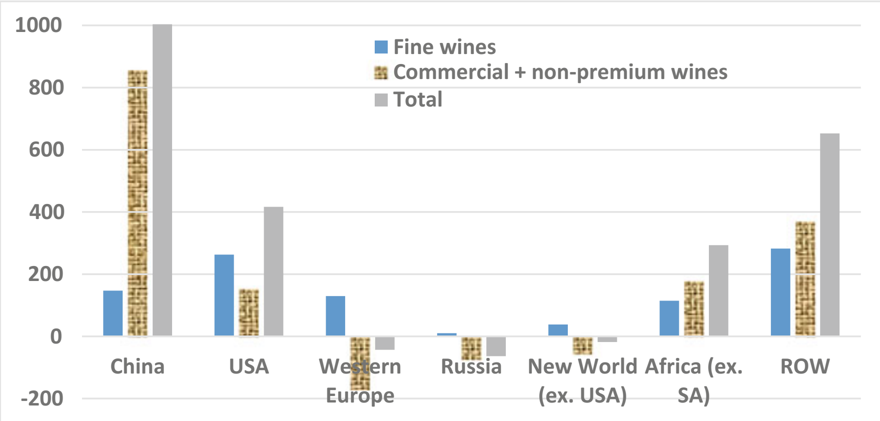


Fig. 10 Real value of wine consumption in key countries, 2014 and projected 2025, and projected change in volume of wine consumption, 2014–2025. Note: "ROW" in Fig. 10b refers to the rest of the world. (Source: Anderson and Pinilla (2018, Chap. 18))

the decade to 2025. In their baseline scenario, the real value of wine consumption is projected to rise slightly for most key countries (Fig. 10a). However, the composition is projected to continue the move to higher-quality wine. In Western Europe, Russia, and Southern Hemisphere New World countries, for example, the volume of commercial wine consumed is projected to fall more than the volume of fine wine consumption rises, whereas in Asia and Africa the former is expected to rise more than the latter (Fig. 10b). Overall, the volume of consumption of both fine wines and commercial premium wines is projected to be about one-sixth higher and the volume of non-premium wine to be 6% lower, in 2025 than in 2014. That is, according to that modelling, premiumization of wine drinking in the world is to continue for some time to come, and Asia – especially China – will increasingly become a major importer of wine. Further into the future, one could expect sub-Saharan Africa to add to Asia's import demand.

Conclusion

A final point not made explicit in the modelling just described is the assumption that policies toward marijuana (and other stimulants) do not change. But governments on both sides of the North Atlantic are gradually liberalizing their stances first on medicinal and then on recreational use of marijuana. How that will disrupt consumption of wine and other beverages has been the subject of much speculation in recent years, with wildly differing perspectives being put forward. No serious empirical analysis has yet been undertaken on this issue to date, other than to make guesses as to the possible value of national sales of marijuana in a few years' time. Only time will tell whose guesses came closest to what eventuates – which itself will depend heavily on the extent of consumer taxation of the various forms in which the drug will be allowed to be marketed.

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Predicting Purchase and Consumption of New Products

41

David M. H. Thomson

Contents

Abstract

People are often very enthused by the idea of innovation and new product development. This is quite understandable. After all, the prospect of creating something new, taking it from inception all the way through the supermarket shelf and then

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hearing that satisfying "beep" as the barcode flashes past the laser scanner to register a sale at the checkout, would surely warm the coldest heart. Unfortunately, the reality of new product development is rather different from this.

Dispelling the NPD Myth

People are often very enthused by the idea of innovation and new product development. This is quite understandable. After all, the prospect of creating something new, taking it from inception all the way through the supermarket shelf and then hearing that satisfying "beep" as the barcode flashes past the laser scanner to register a sale at the checkout, would surely warm the coldest heart.

Unfortunately, the reality of new product development is rather different from this. In the world of consumer packaged goods (CPG), most new products and almost all new brands fail to deliver the anticipated return on investment in the required timeframe and are withdrawn as commercial failures (O'Reilly 2014; Nielsen 2014a, b, 2019). While our supermarket shelves may be revitalized constantly by a seemingly never-ending stream of new brands and products, most are just "passing through" en route to ignominious commercial failure. The shear amount of money, physical resource, time, energy, and human endeavor squandered on launching products that never, from the moment of their inception, had a ghost of a chance of success is incalculable. What should be an exciting and enriching enterprise usually ends up being anything but.

Working on the assumption that the development of most new products will normally have been informed by consumer guidance research and also that prior to launch, the finished product may have been submitted to sales volume prediction, perhaps this chapter should be retitled "Failure to Predict Purchase and Consumption of New Products." Something is obviously amiss!

Any outsider looking into the world of new product development might wonder why it is that reputable companies, managed by sane, intelligent people, repeatedly launch new products that fail, and were destined to do so, from the moment of their inception. This just doesn't make sense. The answer is simple, a heady mixture of misplaced optimism and necessity. Misplaced optimism is part of the human condition. It allows us to "carry on regardless," in spite of the travails and setbacks of life. Necessity derives from the requirement that most publicly and privately owned companies should deliver year-on-year profit growth. Bringing new products to market can form an important part of this strategy. In some product categories such as automotive or consumer electronics, technical and aesthetic innovations produce a near constant stream of new models that deliver real benefits over their predecessors. In both of these categories, products obviously have limited life expectancy and therefore must be replaced at some stage. When doing so, who wouldn't want a better car or a smarter phone?

However, with consumer packaged goods, it's a different story altogether because technical innovations rarely deliver radically improved functionality and aesthetic improvements are often a matter of opinion and much less motivating than generally imagined. While there have been notable successes over the years, including Red Bull, Pepsi Max, Coke Zero, Fever-Tree Tonic, Belvita (breakfast biscuit), Nespresso (a rare example in the food and beverage category of a technical innovation delivering both functional and sensory improvements), and TRESemmé (hair care), these have been remarkably few. Indeed, it transpires that most large CPG companies have a poor record of delivering profit growth through bringing new products to market. As witnessed in more recent times, the principal routes to profit growth have been through merging with or acquiring other companies (e.g., Mondelez, Kraft Heinz, etc.), thereby bringing efficiencies of scale and cost savings through rationalization, or by gobbling up young, entrepreneurial companies that have already brought new products to market successfully (e.g., Coca Cola's acquisition of Innocent). Aside from failing to deliver profits, another insidious consequence of failed innovation is that it inserts underperforming new products into already crowded product portfolios, where they often reside for far too long, soaking up management time and otherwise deflecting resource from other more profitable enterprises. This realization has persuaded the CEOs of many consumer packaged goods companies to rationalize their product portfolios, slash their innovation budgets, and look to other strategies that will deliver a better return on investment. Who could blame them?!

Why Is It So Difficult to Create New Products That Succeed?

To address this question, it's important to understand what is meant by "success." In strictly commercial terms, it means that the new product will deliver a predefined return on investment within a specified time period. This usually means several multiples of the money the company has invested in developing the new product, bringing it to market and maintaining it in-market during its "establishment phase." According to Nielsen, a "breakthrough innovation winners" (Nielsen's term for a really well-developed product) should generate $50–300 million in new revenue for a brand (Nielsen 2016). Unfortunately, "breakthrough innovation winners" are few and far between; just 0.5% of launches according to Nielsen (2019). To justify the risk, most companies would expect the new product to be cash and profit generative for many years post-launch. The absolute amount of cash that the new product should generate and the timeframe will depend on the product category and the fiscal policy of the company. In reality, most new products fail to satisfy these fiscal criteria, and, consequently, the cost and effort involved in maintaining them in-market cannot be justified. However, there's a fine line to be drawn between the time, investment, and commitment needed to give the new product a fighting chance to become successful, which could take several years, versus the requirement for immediate, short-term profitability that so bedevils most public companies.

The arithmetic of success is very straightforward: A large enough number of people must buy the product frequently enough and in sufficient volumes over a long enough period of time, at a commercially viable price. It's relatively easy to encourage people to try a new product for the first time by making the branding,

Fig. 1 Repertoire purchasing – the key to in-market success for new products

the packaging, and the product aesthetically pleasing, by promising a lot through carefully crafted marketing communications, by advertising it heavily to create awareness and familiarity, by incentivizing retailers to stock it and display it prominently instore, and by discounting the retail price using special offers. However, intensive advertising, retailer incentivization, and discounting are all very expensive and, consequently, only sustainable in the short-term. Once this support is reduced to a sustainable level, it's essential that the new product should continue to sell in viable volumes. At some point, most of those people who are aware of the new product and inclined to try it will have done so. This means that after the initial launch phase, ongoing sales must derive largely from customers who are motivated to buy the product repeatedly at the non-discounted selling price (known as "repeating"), and they should keep doing so, frequently enough and in sufficiently large volumes, in the longer term. Such people are known as repertoire buyers. To create profitable sales volumes, the new product must attract trialists, convert them into repeat purchasers, and thereafter transform a sufficiently large number of repeat purchasers into repertoire buyers (Fig. 1). Failing to draw a clear distinction between repeat purchasing and longer-term repertoire purchasing is a common oversight when forecasting longer-term sales volumes.

Why Is It So Difficult to Convert Trialists into Repertoire Buyers?

Converting trialists into repertoire buyers is difficult for two fundamental reasons: Firstly, in the developed world, the repertoires of most consumers are already saturated with products. Through trial and error, each of us will have narrowed our choices down to a sometimes surprisingly small selection of products that deliver what we seem to want. When we shop in-store or online, we automatically home in on our repertoire products (as if on autopilot) and place them in our shopping trolleys without much deliberation. Why no deliberation? There's no need! We've learned through experience that these products will satisfy our needs and desires, even although we may not know what our needs and desires are, what it is about our repertoire products that satisfy us, or even that our needs and desires are actually being satisfied. This form of mental activity is known as System 1 (or more correctly, Type 1) thinking. According to evolutionary psychologists, we developed this facility to avoid thinking things through every time when we're already familiar with the likely outcome, even if we don't realize it (Evans and Stanovich 2013). This frees up the mind to concentrate on things that do require our attention via System 2 (Type 2) thinking.

In societies where consumers have unrestricted choice, to become a repertoire purchase, a new food or beverage will almost always need to displace one or possibly several repertoire incumbents, to some extent at least, because there's a limit to how much any one person can consume. However, even in other product categories, where there are no such limitations, it seems that we're still very reluctant to displace our repertoire products without good reason. This is because they have proven themselves over time and we trust them to deliver whatever it is we require of them without the need to think about it. Trustworthiness is a hugely important concept in product choice because it provides certainty in terms of the functional and emotional outcomes we seek from the products we buy and use.

Functional outcomes in the context of foods and beverages include things like "give me energy," "thirst quenching," "fill me up," "nutritious," "non-fattening," "easy to prepare," "safe," "hygienic," etc., to mention but a few. The concept of trustworthiness suggests that the product will deliver and won't let you down in delivering the required functionality. However, the emotional outcomes associated with the concept of trustworthiness are much more difficult to imagine and capture because, apart from obvious emotions such as happiness, sadness, anger, etc., we're often unaware of the emotions that drive our behavior (Feldman-Barrett 2016, 2017).

Products become repertoire incumbents because they consistently satisfy several of our needs and desires and will probably have done so for a considerable length of time. Consequently, for a new product to become a repertoire product, it must satisfy some of our needs and desires to a greater extent than one or more of our repertoire incumbents. Alternatively, it must satisfy our needs and desires to a broadly similar extent as an incumbent, but do so differently, thereby providing variety and novelty, or it must do so more cheaply. In each case it must continue doing so over a long enough period of time to prove itself and become established. This is no mean feat! Even if a new product is aesthetically very appealing (looks, feels, smells, and tastes great) and seems to deliver the required functionality as well as or better than an incumbent, it must also deliver the required emotional outcomes without compromise.

These days, with all the recent advancements in manufacturing technology and product optimization processes, it's relatively easy to create a new product that delivers functionally and aesthetically. However, it's much more difficult to create a new product that delivers the required emotional outcomes and does so better than repertoire incumbents. Moreover, any new product is inevitably at an immediate disadvantage in this regard by virtue of the fact that it's new and therefore unlikely to engender the trustworthiness of repertoire incumbents. While some novelty-triggered emotional outcomes may be positive for some people (neophiles), these are likely to dissipate when the novelty wears off, potentially leaving an emotional vacuum. Other novelty-triggered emotional outcomes may be negative for some people (neophobes), caused perhaps by the absence of trustworthiness. (Neophiles are people who characteristically seek out new things. Neophobes tend to avoid things that are new and different.) This leads to the idea of repertoire products delivering a certain threshold of emotional positivity and the need for new products to exceed this threshold in order to displace them. One of the greatest impediments to new product success has been the failure of brand, product, and packaging developers to appreciate the need for new products to deliver specific emotional outcomes and how these should factor up to deliver a suprathreshold level of emotional positivity that's sufficient to displace repertoire incumbents (refer to section "New Key Performance Indicators (KPIs)"). Allied to this, capturing and measuring emotional outcomes and estimating emotional positivity has, until very recently, been almost impossible because the emotional outcomes that drive our behavior are not always apparent. Consequently, the direct questioning methods often used by researchers to capture emotions may be of limited effectiveness. All of this leads to the inescapable conclusion that predicting future purchasing and consumption of new products is currently based on inappropriate criteria.

Key Metrics: Why They Fail to Predict Longer-Term Repertoire Purchasing Behavior

To recap, new products will only deliver the required return on investment if a sufficiently large number of trialists and repeaters convert into longer-term repertoire buyers (Fig. 1). The two key metrics typically used to evaluate the potential of new products are liking (or overall opinion) ratings and purchase intent ratings (Fig. 2). While very few experienced practitioners would suggest that, other than by exception, either of these metrics is likely to be a reliable predictor of longer-term repertoire purchasing behavior, both are commonly used as key performance

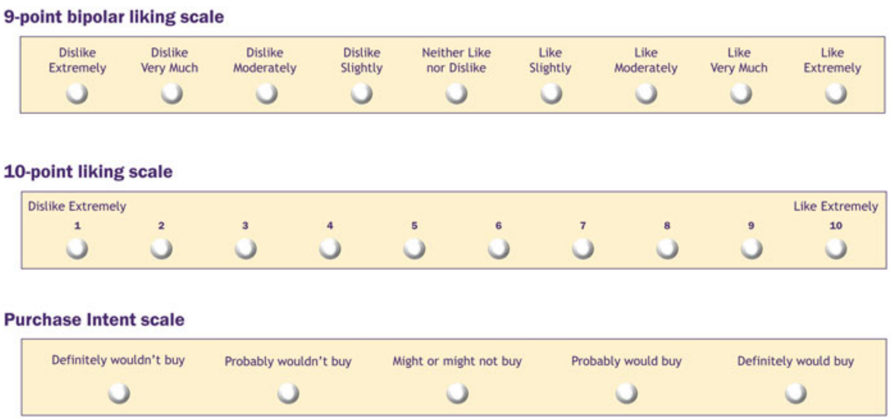

Fig. 2 Example of scales used to capture liking and purchase intent; the two most common metrics used to evaluate the potential of new products

indicators for determining whether or not a product (or brand) should proceed to the next stage of development and possibly even to launch. These metrics are also used as key inputs to volumetric models (e.g., Nielsen's BASES®) that supposedly predict post-launch sales volumes. This raises three very obvious questions: Why don't liking ratings predict longer-term repertoire purchasing potential? What do liking ratings actually measure? Why are liking ratings used so widely in brand and product development? Let's address the last question first.

Why Are Liking Ratings Used So Much?

There are several reasons why liking ratings are collected routinely in almost all branded and unbranded product research, but principal among these is the simple fact that respondents know exactly what is meant when asked how much they like something. The response (in the form of a thought) comes to mind instantaneously and effortlessly, and lay people find it incredibly easy to transpose the magnitude of this thought onto a position on a liking scale. Because there's absolutely no misunderstanding about what is meant, the resulting data is both reliable and repeatable. Knowing this gives the researcher and the product developer great confidence in their findings. Too much, perhaps! Moreover, the data is also highly amenable to analysis using a variety of statistical tools. These range from simple means with associated standard deviations all the way through to complex multivariate modeling and mapping processes which allow researchers to interpret and present their data in interesting ways that are easily visualized and readily understood. Further reassurance comes from the observation that liking data seems to have predictive validity insofar as it's possible to build coherent models that relate the sensory characteristics of products to liking ratings. When these models are used to predict how changes in the sensory profile of a product might impact on liking, the predictions are usually confirmed when the reformulated products are evaluated in subsequent product tests. This level of apparent precision is quite amazing when dealing with subjective data, and it only goes to prove the point that subjective data can be precise.

So, where's the catch?

While making positive adjustments to the sensory aesthetics of brand, product, and form of packaging may increase liking ratings and generate increased trial and even repeating, only exceptionally will improvements to sensory aesthetics alone be potent enough to translate into increased repertoire purchasing. Indeed, there are some circumstances where aesthetic improvements may even have a negative impact on repertoire purchasing by detracting from the brand or product in other less obvious ways. Counterintuitive as this may seem, both of these phenomena are becoming more widely acknowledged among new product development practitioners.

The apparent precision of liking data and its amenability to statistical analyses has led successive generations of researchers and product developers to become over-reliant upon it as a key performance indicator in brand and product research, without giving due consideration to what it's actually measuring and what it's really telling them about products.

What Liking Ratings Actually Measure and Why They Fail to Predict Repertoire Purchasing?

In trying to understand "liking," it's important to draw a distinction between dispositional liking (positive or negative disposition toward something) and the instantaneous liking (or disliking) experience triggered by "real-time" sensory stimulation (referred to as sensory liking, hereafter). Although somewhat interdependent (we tend to be well disposed toward things that taste nice), sensory liking and dispositional liking are discrete psychological phenomena that influence our choices and behavior in different ways (Thomson 2016). The fact that both phenomena are labeled with the word "liking" is an unfortunate foible of idiomatic English that merely adds to the confusion.

Sensory liking/disliking (as defined above) is an instantaneous affective experience which causes us to be attracted toward things that are potentially beneficial and to reject things that are potentially harmful. The key words to consider here are "affect," "experience," and "instantaneous." In this particular context, affect and pleasure may be used interchangeably as they are essentially the same phenomenon. Affect has both valence (it can be positive or negative) and magnitude (it can be large or small). Positive affect (pleasure) is positively rewarding. Negative affect (displeasure) is negatively rewarding. Consequently, the greater the valence of positive affect, the greater the reward, the greater the attraction. The greater the valence of negative affect, the greater the inclination to reject. Some of the associations between benefit and positive affect (or harm and negative affect) will be heritable traits, while others will be learned and reinforced via feedback mechanisms (Cabanac 2009). Crucially, this type of affect is experienced instantaneously which means that it may exert an immediate influence on behavior, especially when the magnitude of affect is extreme. For example, the human orgasm is a potent, instantaneous, positive experience which motivates sexual intercourse and, consequently, procreation. Conversely, feeling pain (negative affect) causes instantaneous withdrawal from the apparent source of the pain, thereby avoiding tissue damage. The benefits, from an evolutionary perspective, are obvious.

It's important to recognize in this context that it's positive affect (i.e., pleasure) that's the principal instantaneous attractant rather than any subsequent benefits associated with the stimulating object, although these benefits may well reinforce the association via feedback mechanisms. The simple upshot of all of this is that we tend to like (both sensory and dispositional liking) things that are pleasant and tend to dislike things that are unpleasant.

From a nutritional perspective, we're strongly attracted by positive affect to the perception of sweetness, umami, saltiness, and fattiness, when experienced within certain bandwidths of magnitude. Sweetness correlates with carbohydrate content, umami with protein, saltiness with salt, and fattiness with fat content, all of which are vital sources of essential nutrients (de Graaf 2018). Back in the mists of time, those who evolved the capacity to detect these sensory characteristics and coincidentally to link them to positive affect would be more likely to select these essential nutrients, thereby enhancing the probability of surviving to reach sexual maturity and procreating. Conversely, experiencing negative affect inclines us to reject things that are very bitter or sour. Coincidentally, some of the most potent, naturally occurring toxins taste bitter, and bacterial degradation of foods often produces acid. Again, those who evolved an enhanced capability to perceive bitterness and sourness and link them to negative affect would be more likely to survive and procreate successfully. This type of sensory liking is autonomous insofar as it comes to mind automatically, and it cannot be attenuated or nullified via cognitive intervention.

Dispositional liking also comes to mind automatically when we think about a specific object (e.g., a particular food) or when our attention is otherwise directed toward it. It derives from aspects of the individual's accumulated conceptual and affective knowledge of the object, some of which may have been experienced knowingly but much of which might not. For example, someone might think that they like chocolate because it "tastes nice" or because it tastes sweet, creamy, and chocolatey, but, unbeknown to them, their dispositional liking could also be driven by the unnoticed psychological consequences of theobromine (a vasodilator, diuretic, and heart stimulant found in chocolate) or because of the not so obvious emotional outcomes that occur via chocolate's associations with concepts such as treating and being made to feel special and love, for example. Whatever the underlying causality, dispositional liking is a thought that comes to mind very readily with or without the object being physically present, and people have no difficulty in relating this notion to others or in quantifying it verbally or more formally using a liking scale.

In practice, when presented with various samples of chocolate to evaluate in a typical product testing scenario, consumers' liking ratings are likely to be based on two influences: the individual's dispositional liking for chocolate and the extent of sensory liking (instantaneous affective experience) triggered when tasting each of the test chocolates. It's envisaged that the former sets the "baseline" which is modified by the latter, depending on whether sensory liking for the specific chocolate is better or worse than expected. Assuming this to be the case, consumers' liking ratings will derive from the combination of dispositional liking and sensory liking, integrated via some complex algorithm lodged deep within the recesses of the individual's mind. Assuming that all experimental biases are controlled, the dispositional liking baseline should remain constant. If so, any differences in the mean liking ratings among the chocolates should derive from differences in sensory liking alone (i.e., the instantaneous affective experience). Further assuming that the participants are regular consumers of milk chocolate, and the chocolates evaluated are of typical retail quality, mean liking ratings would normally fall within the range of ~7.0 ± 0.5 for UK consumers (MMR Research Worldwide 2019). If an equivalent product test was repeated with tea among UK tea consumers, the equivalent range would normally be ~5.5 ± 0.5 (MMR Research Worldwide 2019), which is obviously much lower than chocolate. This happens because the integral of dispositional liking and sensory liking for tea is lower for tea drinkers than milk chocolate is for chocolate consumers. Paradoxically, or so it might seem at first, the UK consumes many more servings of tea than chocolate. This serves to illustrate the point that neither dispositional liking nor sensory liking, or whatever combination thereof is captured by consumer-derived liking ratings, is likely to be a credible predictor of longer-term consumption behavior.

The implications of this are very clear: Optimizing the aesthetics of branding, pack, and product may stimulate trial but, other than by exception, this alone should not be expected to contribute hugely to the conversion of trialists into repertoire buyers. Consequently, we should anticipate that metrics derived from liking ratings may misrepresent true product potential.

Prediction of Sales Volumes Using Purchase Intent Ratings

Purchase intent ratings are used almost universally in brand and product research, either to make direct predictions of future purchasing of new products or as inputs to simulated test market models, such as Nielsen's BASES®, which attempt to make more refined forecasts of new product sales volumes (section "A Brief Introduction to BASES®"). The most common 5-point version of the purchase intent scale is shown in Fig. 2, although there are other less commonly used versions such as the Juster 11-point scale (Juster 1966). Irrespective of whichever purchase intent scale is adopted, numerous studies have shown that individual consumer's self-reported intentions to purchase do not reliably predict their subsequent purchasing behavior (Morwitz 2001). Moreover, averaging purchase intent ratings across consumers does nothing to improve the accuracy of the predictions, which suggests that purchase intent ratings are afflicted by systematic biases (rather than random error), which usually results in overprediction.

In an attempt to improve the accuracy of prediction, Nielsen related actual purchasing by individuals back to their purchase intention ratings and recalculated purchase probability accordingly, as shown in Table 1 (Risen and Risen 2008). In essence this implies that 75% of the people who endorse "Definitely would buy" will actually buy, 25% of those who endorse "Probably would buy" will actually buy, etc. When the proportion of people in the survey who endorse each of the five response categories is multiplied by the corresponding predicted purchase probability, this yields a weighted estimate of the proportion of the survey population that is

Table 1 Translation of 5-point intention scale into purchase probability (Risen and Risen 2008)

Scale	Description	Intent probability	AC Nielsen BASES® predicted purchase probability
5	Definitely would buy/use product	0.99	0.75
4	Probably would buy/use product	0.75	0.25
3	Might/might not buy/use product	0.5	0.1
2	Probably would'nt buy/use product	0.25	0.05
1	Definitely would'nt buy/use product	0.01	0.02

predicted to buy. In practice, most marketers only consider the top two response categories ("boxes"). Thus, for example, if 40% endorsed "Definitely would buy" and 20% endorsed "Probably would buy" the proportion of buyers/users would be estimated as 35% (i.e., $40\% \times 0.75 + 20\% \times 0.25 = 35\%$).

If only life were so simple! Unfortunately, there are two major flaws in this reasoning. First of all, what is meant by "use" or "buy?" Buying to try? Buying several times? Buying as a repertoire purchase in the longer-term? At best this metric will perhaps estimate trialists; a few of whom may go on to make repeat purchases and possibly even adopt the product longer term. However, it's highly likely that this simple purchase metric will exaggerate product potential. There seems to be an astonishing lack of clarity on this matter. The second problem is rather more insidious. In the foregoing, the correction factors are obtained by relating purchase intent ratings of the surveyed individuals to their subsequent purchasing of the product. This makes the implicit assumption that the same relationship would hold for non-surveyed individuals. However, it is entirely possible that measuring purchase intention could self-generate some of the association between the intentions and the behavior of a particular individual, thereby artificially inflating the probability of future purchasing (Feldman and Lynch Jr. 1988). Chandon et al. (2005) have identified this as a likely cause of exaggerated product potential and, consequent upon this, permitting the launch of products that were always destined to fail.

When liking and purchase intent ratings are obtained for the same product, these are invariably correlated ($r > 0.9$ is common; MMR Research Worldwide 2019). This suggests that both responses probably derive from the same mental activity. Although the question, *How likely would you be to buy Product X in the future?,* may allude to purchase intent, it seems that in trying to answer this question, consumers unwittingly default to answering a much simpler question *How much do you like Product X?* This is known as heuristic thinking and, specifically in this case, an "affect heuristic" (Kahneman 2011). It's not that these people are deliberately lying or otherwise being deceitful, it's just that unbeknown to them, they have limited awareness of what ultimately influences their purchasing and consumption behavior. Because of this, they are fundamentally incapable of forming the sort of overview that would allow them to predict, with any great certainty, whether or not they'd include a particular new product in their long-term purchase repertoire, so they unwittingly default to thinking about liking.

To summarize thus far, other than by exception, liking and purchase intent ratings are poor predictors of whether or not new products will eventually become repertoire purchases. While it may seem reasonable to assume that liking something should be a prerequisite of purchase, it transpires that there are many factors, other than how much something is liked, that finally determine repertoire purchasing behavior. Many flawed product launch decisions have been made, and continue to be made, on the basis of this misunderstanding. Naïve misinterpretation of target consumers' declared purchase intentions is another principal reason why so many new products and brands that should never have been launched in the first place make it onto the market only to fail spectacularly. Bearing in mind that making the transition from merely liking a product to it becoming a repertoire purchase is germane to commercial success, it's time to start thinking differently about how the potential of new products and brands should be assessed during development (section "New Key Performance Indicators (KPIs)").

Volumetric Sales Prediction Using Test Markets

Test markets usually provide the most accurate means for predicting future sales volumes. In a typical test market scenario, a highly refined version of the new product is launched in various stores across three or four representative cities nationwide, with the test product left in-store for up to 12 months and sometimes even longer. To be effective and valid, the product, packaging, branding, advertising, marketing, and merchandising all need to be fully developed, as if for a full-blown product launch. At the end of the test market, local sales figures are factored up to predict national sales.

Aside from accuracy of prediction, there are five other principal benefits associated with test marketing a new product:

(1) Allows various different advertising, marketing, pricing, and merchandising strategies to be evaluated, compared, and optimized.
(2) Depending on the nature of the product, the duration of the test market would normally be gauged to permit trial among early and late adopters, several cycles of repeat purchasing, and potential adoption as a repertoire product, thereby allowing sales figures to stabilize at a realistic level.
(3) Provides opportunities to garner feedback from purchasers via in-store intercepts or online feedback.
(4) It's cheaper than a full nationwide or international launch.
(5) Reputational damage is localized and minimized should the new product fail.

The downside of test marketing is time, cost, and loss of the commercial advantage associated with surprise and being first to market. In the time that elapses between beginning and completing the test market, a determined and agile competitor could easily have copied the idea and launched their own version nationwide.

In the modern era, where speed-to-market is crucial, test markets are largely a relic of the past. Innovation directors now find themselves under tremendous pressure to bring new products to market in 6 months or less and at a fraction of the cost that would be incurred in conducting a test market. To facilitate this, they need rapid and reliable forecasts at various stages of the new product development process, in order to determine whether or not further investment in the development program is warranted.

Prelaunch Volumetric Sales Prediction Using Simulated Test Markets (STMs)

During the 1970s, the growing need for faster, cheaper, and earlier volumetric predictions heralded the dawn of the simulated test market (STM), where predicted sales, rather than liking or purchase intent ratings, is the principal decision-informing metric. The assumption was, perhaps, that greater apparent face validity should confer greater predictive validity.

Innovation directors are often overwhelmed with new product ideas. Consequently, their main challenge is to quickly screen out and cull the weak ideas as early as possible, so that resource can be concentrated on innovations that seem to have the potential to succeed. In early-stage STMs (also known as concept STMs), the new product idea is presented as a concept, typically comprising a graphic of the branding and sometimes a sketch of the packaging, along with a description of the nature of the product, the needs it purports to address, and the other benefits it promises to deliver (or some combination thereof). Occasionally, the concept will include the proposed selling price, although marketers often prefer to hedge their bets at this early stage of development by alluding to an "affordable price."

For those new product ideas that make it all the way through the development process to the point where branding, packing, product functionality, product aesthetics, and marketing communications are all highly refined and the retail selling price is set, a further stage of volumetric sales prediction is often undertaken to determine whether or not the cost (and risk) of launching the new product and maintaining it in-market can be justified. These late-stage STMs (also known as concept-product STMs) usually involve concept evaluation (as above but with a highly refined concept) followed by product evaluation. Concept evaluation normally occurs online using target consumers recruited via a panel provider, followed by placement and evaluation of the product in-home, typically using concept acceptors (and/or non-rejectors). Feedback is normally gathered online. If the new product requires specialized preparation or it needs to be dispensed from an expensive prototype container, product evaluation will take place in a central location, although this adds greatly to cost, and participants inevitably self-select on the basis of availability and proximity to the venue.

Two fundamentally different processes are used to evaluate new products:

The most common approach asks a series of direct questions about the new product, principal among which is purchase intent. The data is adjusted to attenuate overclaim and then integrated with strategic marketing information, based on a number of "what if" scenarios, in order to arrive at volumetric predictions. Historically, STMs based on purchase intent ratings included BASES® (Nielsen), Micro-Test (Research International – now part of Kantar), and ForeSight, InSight, RePurchase (TNS – also part of Kantar).

The second process, based on share of preference, was pioneered by Alvin Silk and Glen Urban (1978), then working out of the prestigious Sloan School of Management at Massachusetts Institute of Technology. Over the years there have been many different implementations, but most modern approaches involve choice-based conjoint (CBC) analysis where the new product idea is embedded within its likely competitive set (all represented similarly as concepts) and consumers are required to assign chips (or counters) to the various brands within the set according to the strength of their preferences.

Assuming, for example, ten chips are available for allocation and further assuming that a particular individual is singularly loyal to one of the established brands in the set with no inclination to change, then all ten chips should be allocated to that brand. However, another individual might allocate four chips to each of the two brands they use most often and assign the remaining two chips to the new product, should it interest them. (Some implementations of the method specifically draw the participant's attention to the new product, while others do not.) By aggregating the number of chips assigned to each product, share of market for the new product can be estimated. If the actual share of market of the competitors is known, this can be used to "correct" the model and, consequently, the estimated share of market of the new product. Since this process is conducted online, it's fast and relatively inexpensive. This allows various "what if scenarios" to be explored and modeled, such as different price points for the new product, different emphasis or different combinations of the various needs and desires addressed by the new product, different branding, different graphical executions, etc. Competitor product parameters can also be adjusted experimentally, such as various price discounting scenarios that might be implemented to thwart the competitive threat posed by the new product. Assuming that all the variables are adjusted systematically according to a carefully considered design, conjoint analysis can be used to identify the optimal combination of parameters to deliver the greatest predicted share of market for the new product. There is much to commend this highly intuitive choice-based process. The principal criticism leveled at share of preference models is that, in reality, repertoire buyers of a product generally make their purchases on "autopilot" (System 1 thinking) and give little or no consideration to the competitive set, even when displayed prominently in store, adjacent to their habitual purchase. It's argued by some that presenting all of the competitive set on a level playing field might encourage respondents to give undue consideration to competitor brands (and allocate chips to them), than would otherwise be the case. For a comprehensive description of share of preference volumetric estimation, the reader is encouraged to consult *The CBC System for Choice-Based Conjoint Analysis* published online by Sawtooth Software Inc. (2017).

Historically, STMs based on share of preference have included Assessor® (M/A/R/C®), Designor® (Ipsos), and Market Simulator (Vantis – now part of Ipsos). More recent implementations of STMs sometimes incorporate both purchase intent and share of preference data.

A Brief Introduction to BASES®

BASES® (Booz-Allen Sales Estimating System) was originally developed in 1977 by Lynn Y.S. Lin at Burke Marketing Research. Nielsen subsequently acquired BASES® in 1998. Since then, it has become the global, industry-standard STM. Although up-to-date figures are not available in the public domain, it's variously estimated that at its zenith, BASES® had >50% share of the global STM market and possibly even more than this in the USA (Wherry 2006).

Across many of the large, global CPG manufacturers, its company policy is to launch only those new products that "pass" BASES®. Indeed, the bonuses of some marketers, innovators, and product developers actually depend on whether or not their new products satisfy this criterion. (This must surely lead to some rather bad-tempered project debriefs.) Whether or not this is the best approach is something of a moot point because, it will inevitably lead to new products that are designed to pass BASES®. As discussed shortly, this definitely doesn't guarantee that the new product will become a longer-term repertoire purchase for enough people to deliver commercial success. Under other circumstances, development budgets may not stretch to the cost of BASES®, in which case manufacturers will often base their development decisions on liking and/or purchase intent ratings, underpinned with a heady mixture of intuition, blind faith, and wishful thinking. Unfortunately, new product failure statistics speak volumes about both of these strategies!

BASES® uses consumer response data gleaned either from concepts alone (early-stage BASES® I) or from concept and product (late-stage BASES® II) as inputs to its volumetric model. The data is adjusted for overclaim and integrated with manufacturers' marketing plans to create predictions of sales volumes. Initial predictions are compared to Nielsen's substantial database of previous product launches in the same category, along with in-market sales data obtained from Nielsen's Consumer Panels∗, to produce adjusted estimates of sales volumes post-launch. (∗Nielsen panelists take an inventory of products purchased using mobile scanners in-home.)

With BASES® seven different questions are typically posed to consumers using rating scales (Nielsen 2009):

Purchase intent – "Which statement best describes how you feel about buying this product?" (5 – category purchase intent scale similar to Fig. 2).

Liking – "How much do you (think you would) like this product?"

Price/Value – "Considering the price of this product, how do you feel about the value for money of this new product?"

Believability – "How do you feel about the believability of the statements made about the product?"

New & Different – "How do you rate this product in being new and different from other products?"

Claimed Units – "How many units of the new product, if any, would you buy the first time you buy the new product?"

Claimed Frequency – "How often, if ever, would you buy this product if it was available where you shop?"

Consumers' ratings of liking, price/value, believability, and new and different, assuming they're answered wholeheartedly, can perhaps be taken at face value because they're simply reactions that automatically come to mind with little or no thought (System 1). We instantly know how much we like or dislike something, whether it seems good or poor value, etc. However, predictions of likely purchase intent, claimed units of purchase, and claimed frequency of purchase are probably well beyond the capacity of most people to compute accurately, simply because they cannot take the required overview that would confer validity on such ratings. Although Nielsen apparently adjusts these metrics for overclaim, predictive validity is always going to be a problem when the very essence of the input data is open to doubt.

It's variously suggested that 90% of the new products submitted to BASES® fail to make the grade. Again, this figure is not verifiable from up-to-date data held in the public domain, but it's certainly the opinion of some industry professionals that BASES® sets the bar too high, making it nigh on impossible (or so some might suggest) for a new product to "pass." The clear inference being that many products with assumed market potential are screened out. Conversely, others argue that BASES® "passes" too many products that should have been culled. Either way, it's difficult to reconcile the ubiquity of BASES® combined with various accuracy claims (e.g., 9% accuracy in predicting Year 1 sales – Nielsen 2019; Wherry 2006) versus the continuing, very high levels of in-market new product failure.

According to Wherry (2006) the claimed accuracy of BASES® is:

+/– 25% of actual sales 95% of the time.

+/– 20% of actual sales 91% of the time.

+/– 15% of actual sales 80% of the time.

+/– 10% of actual sales 62% of the time.

+/– 5% of actual sales 37% of the time.

While it has not been possible to update Wherry's estimate of 2006, taken at face value, +/– 25% of actual sales, 95% of the time, is a wide confidence interval that would surely render volumetric prediction rather questionable from a commercial perspective. A confidence interval of +/– 5% of actual sales, 37% of the time, would be much more realistic for financial planning purposes, but this means that 63% of sales predictions would fall outside this bandwidth of accuracy. Even Nielsen's claim of 9% accuracy in predicting Year 1 sales (Nielsen 2019) is questionable, not in terms of absolute accuracy, but more because one year probably isn't long enough to flush out the distorting influence of sales associated with once-only trialists and short-lived repeaters. Remember, the ultimate fate of a new product depends on convincing enough people to adopt it into their repertoires in the longer term. One is left to wonder about the accuracy of Year 2 and Year 3 sales estimates, as these are less likely to be influenced by transient purchasers and more likely arise from the purchasing patterns of long-term adopters. Moreover, in asserting that "less than 0.5% of all new products that launch achieve enduring breakthrough performance" (Nielsen 2019), one is left wondering what proportion of the remaining 99.5% might have been submitted to BASES® and "passed."

In recent times, most major, mass market CPG brands are facing pressure on multiple fronts from various challenger brands, designed to deliver maximum appeal to relatively small subsets of people with particular needs and desires. These challenger brands are often developed by small and nimble competitors or entrepreneurial businesses. Although often highly profitable, few of these challenger brands would satisfy the financial criteria imposed on mass market products, and, consequently, it's likely that correspondingly few would deliver convincing BASES® sales projections. Again, one is left wondering how many such gems are discarded among the new products that "fail" BASES®.

BASES® has recently been accredited by the Marketing Accountability Standards Board (MASB) marketing metric audit protocol, claiming to be the first and only forecasting model in the industry to meet this accountability standard (Nielsen

2016). While this is laudable, final proof of accuracy can only be achieved if Nielsen was to submit its claims to a credible, peer-reviewed scientific journal. For further comment on BASES®, the reader is directed to Jacobs (2016).

Looking to the Future

Although the appalling failure rates in CPG new product development may be exacerbated by inappropriate evaluative criteria and/or inaccurate predictions of sales volumes, the underlying problem probably lies with the fundamental inadequacy of most new products. Whether such fundamental product inadequacy is a matter of design or a matter of implementation (the normal scape goat) is a moot point, but either way, it's self-evident that too many products are launched that don't meet or surpass the expectations of enough people, at a price they're willing to pay. In other words, they're just not good enough to become repertoire purchases.

Simplistically, the obvious solution would be to "design out" negative product features and "design in" more positively motivating features. However, this is easier said than done when some of the features that deliver satisfaction may not be apparent, even to loyal brand and category users. Moreover, it may not be evident, even to these people, when, how, or if their needs and desires are being satisfied. Indeed, the only thing that might be apparent to them could be a vague urge to mindlessly seek out and buy the product again (and hopefully, again and again and again). Although this may be mindless behavior, it's not moronic behavior! Repeated, mindless selection is actually the hallmark of a truly successful product, where many of the positively motivating influences are subsumed into the unconscious and processed autonomously via System 1 thinking (Kahneman 2011; Evans and Stanovich 2013). Consequently, even the most articulate and astute consumers will often be quite unable to describe some (and possibly even any) of the factors that actually motivate them to buy, because they simply don't know! This leaves product innovators with the vexing problem of having to design and optimize products without knowing very much, if anything, about the nature of these hidden influences. The problem is further exacerbated by consumers genuinely experiencing the feeling that they really like the product, wholeheartedly describing why and enthusiastically declaring that they'd definitely buy it again when, unbeknown to them, it's not delivering anything like the full extent of subliminal satisfaction necessary to motivate repertoire purchasing. Worse still, their declared reasons for liking are often misconceived. This is the seemingly intractable problem facing all new product developers, although not all of them appreciate the fact.

Exploring Hidden Influences

Think of the color yellow. Now think of the color purple. Which of these is the *happiest* color? This question has been posed (by the author) to thousands of people in many different countries over the last few years and the answer is invariably “yellow.” Which is the most *powerful* color? Invariably, the answer is “purple” (Thomson and Coates 2018). *Happy* and *powerful* are concepts that have come to be associated with the colors yellow and purple, respectively. Through experience, observation, and what we glean from others, we’ve learned to associate yellowness with happiness, purple with powerful people, and vice versa. Why? There are lots of reasons, but it won’t have escaped your attention that the sun appears to be yellow. We only see the sun when the sky is blue and clear of those dark, foreboding rain clouds. Being bathed in sunshine is usually a pleasurable experience, whereas being soaked with rain is invariably rather unpleasant. Daffodils are yellow. For those of us living in northern climes, their appearance in our gardens and public places signals the end of the cold, dark Winter months and the prospect of long, warm Summer days. Most people (not just people with seasonal affective disorder) generally feel happier in the Summer.

Happiness is an emotion that almost everybody must surely have experienced. Being happy is an outcome (a state of being) caused by the emotion of happiness. Consequently, being happy may be described as an emotional outcome. Being happy is also an aspirational goal for most people (if not everybody). Assuaging our *aspirational goals* is positively rewarding, so we seek out those things, people, activities, etc. that make us happy. Conversely, avoiding unhappiness (emotional outcome) is also a goal (for which the expression *avoidance goal* has been coined by the author). Consequently, we avoid those things, people, and activities that make us unhappy, thereby ameliorating this particular avoidance goal (unhappiness) and minimizing the risk of negative reward. However, it goes without saying that most of the time we simply don’t realize it. This fairly straightforward relationship, which is generalizable, is shown in Fig. 3.

Figure 4 shows the concepts that are most and least associated with the colors yellow and purple (Thomson and Coates 2018). These are the conceptual profiles of yellow and purple, derived using a process known as best-worst scaling (Crocker and Thomson 2014; Thomson and Crocker 2014). The qualitative and quantitative differences in the conceptual profiles of these two colors are readily apparent. These differences are the reason why yellow and purple affect us differently, why we might choose yellow décor for one room and purple for another, and why we might choose to wear a yellow item of clothing for one occasion whereas we might otherwise feel more comfortable wearing purple. Needless to say, we don’t systematically think about and rationalize the conceptual profiles of both colors when selecting a t-shirt or

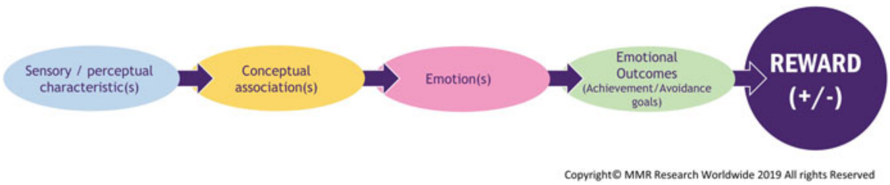

Fig. 3 A mechanism through which sensory characteristics may deliver behavior-motivating reward

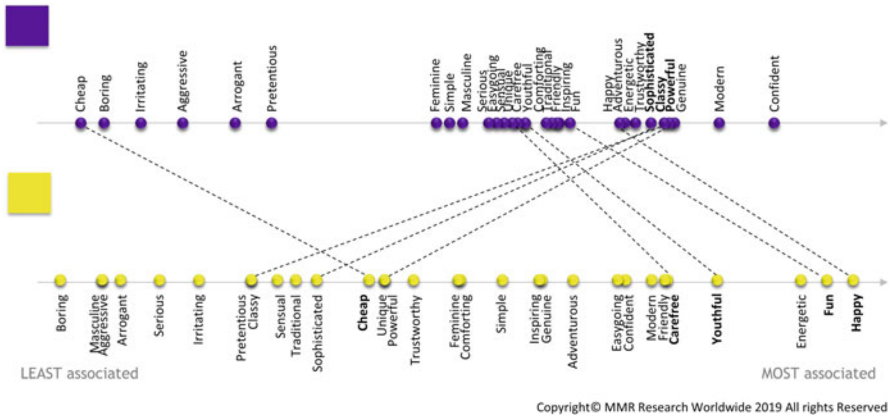

Fig. 4 Generic conceptual profiles of the colors yellow and purple

jumper from the drawer; it's just something that happens automatically. Although we may struggle to describe these conceptual associations, they can be accessed and revealed if we're stimulated appropriately using various qualitative research tools or quantitative techniques such as best-worst scaling.

Sigmund Freud described those thoughts held in the subconscious but potentially accessible upon reflection, as being preconscious (or existing in the preconscious – Stafford-Clark 1965). This fits quite well with modern theories of System 1 and System 2 mental processing (Evans and Stanovich 2013), which hold that much of what influences our behavior isn't thought about at the time (System 1), but it is potentially accessible upon reflection (System 2). However, whether what's actually recovered as a consequence of System 2 deliberation is a true reflection of what really does determine our behavior, is quite another matter. It seems plausible that the concepts that we associate with all objects, people, places, events, etc. will exist predominantly in the potentially accessible subconscious. However, the possibility that our behavior is influenced by utterly inaccessible, nonconscious concepts cannot be disregarded.

Although sensory characteristics are usually thought of as conscious experiences because they're readily apparent to us, it's plausible that some may not be experienced consciously, in the same way that some conceptualizations may not be experienced consciously. By way of example, imagine you're tasting a particular food item for the very first time. You instantly recognize the standout sensory characteristics such as sweet, sour, firm, oily, etc., but there's an indefinable flavor note that eludes you until someone mentions "cinnamon." Suddenly, all is crystal clear. Prior to that moment, the cinnamon character was subsumed within your preconscious, but mere mention of the word brought the cinnamon character into sharp and conscious relief, leaving you to wonder, perhaps, how you could possibly have failed to identify it in the first place.

It's also possible that some people might never consciously experience the abovementioned cinnamon note and no amount of description or cajoling could ever bring it to their attention. Does this mean that they don't have all of the necessary physiological apparatus to sense the various chemical compounds responsible for cinnamon character? Alternatively, does it mean that they don't have the psychological capability to transform the sensory inputs triggered by the various chemicals in cinnamon into a consciously experienced perception? If it's the latter, do the consequences of cinnamon stimulation trigger nonconscious psychological activity, and does this influence our reaction to the novel food without us ever realizing it?

As explained in the foregoing, Freud classified mental activity as conscious (accessible and apparent), preconscious (potentially accessible), and deeply unconscious (fundamentally inaccessible). While Freud's ideas about consciousness are certainly not without detractors, they have found support in more recent times by way of various modern theories that allude to System 1 (or more correctly, Type 1) and System 2 (Type 2) mental processing.

Although we're only immediately aware of conscious mental activity, it's entirely possible that our feelings and our behavior could be influenced by mental activity occurring simultaneously across all three levels (conscious, preconscious, and subconscious). This applies to emotions and emotional outcomes, as well as conceptual associations. While we're all aware, presumably, of what it feels like to be happy, sad, frightened, angry, disgusted, surprised, etc., these are probably just our most obvious emotions, and beyond these, we construct many hundreds (possibly even thousands) of subtle, multifarious emotions that we may only occasionally experience consciously (Feldman-Barrett 2017). The mere fact that there are many hundreds of emotion words within almost all languages is surely indicative of the diversity and complexity of our emotion landscape.

It's impossible to judge what proportions of each of our sensory, conceptual, and emotional mental activity are likely to be conscious, preconscious, and unconscious. However, it's proposed that we would have evolved the capacity to experience much of our sensory-related mental activity consciously because of the crucial role played by sensory characteristics in alerting us to potential sources of benefit and harm. Conversely, interpreting the many and multifarious emotions that we construct simultaneously, integrating these, translating them into feelings, and otherwise using them as a rationale to determine our behavior are likely to be beyond the conscious mental processing capacity of even the most intelligent individual. Moreover, it would completely overwhelm the limited and finite capacity of the working memory, leaving little or no spare capacity for other thoughtful processes. For this reason, it is proposed that, unlike sensory-related mental activity, much (possibly most) of the consequences of emotion-related mental activity are likely to occur and remain below the level of conscious awareness. If, as previously mentioned, much (possibly most) of reward derives from the emotional outcomes that allow us to satisfy our achievement goals and ameliorate our avoidance goals (Fig. 3), it surely follows that much of what influences our feelings and our behavior is fundamentally inaccessible, leaving psychologists, consumer researchers, marketers, and product developers alike, with the seemingly intractable problem of accessing and understanding what really influences consumption behavior.

Prediction of Emotional Outcomes and Reward

One possible way forward might be to predict what can't be accessed and measured, using what can. As discussed previously, conceptual associations may be conscious but, most probably, largely preconscious and therefore potentially accessible and measurable. Arguably, emotions, and the emotional outcomes that they trigger, are also largely unconscious occurrences (Feldman-Barrett 2017). The model shown in Fig. 3 proposes a causal relationship between conceptual associations and emotions/ emotional outcomes. If a means of associating concepts to emotions could be found, it would be possible to use knowledge of the conceptual profile of a triggering object, person, or event to predict the consequent emotional outcomes.

Building such a predictive model has been a huge undertaking. In practice, it meant taking all of the conceptual landscape and all of the emotion landscape and linking the former to the latter. An abridged version of the four-stage research protocol is shown in Fig. 5 and is described briefly below (Thomson and Coates 2018).

Stage 1: The topographies of the conceptual and emotional landscapes were captured using words (British and US idioms of the English language). This is based on the premise that language evolved as a means of communicating thoughts (Chomsky 1967), and therefore it's highly likely that words would have evolved to describe those concepts and emotions that are important in defining and otherwise giving meaning to the objects we interact with and feelings we experience in everyday life.

Existing conceptual and emotion vocabularies, British and US English dictionaries and lists of synonyms and antonyms were scanned to create our initial word lists. This yielded two vast lexicons of ~1000 terms in each case. Via successive iterations of qualitative research conducted in the UK and the USA, the conceptual and emotion lexicons were honed down to 558 conceptual and 515 emotion terms,

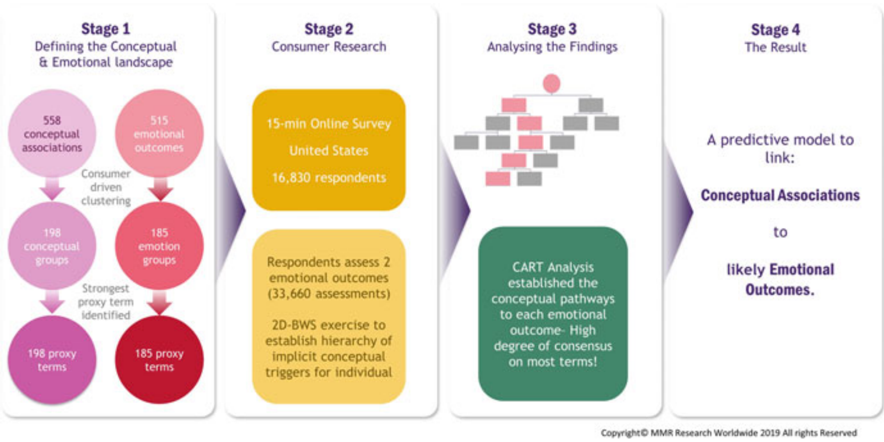

Fig. 5 Four-stage research protocol used to relate conceptual associations to emotional outcomes

respectively. Within each lexicon, terms were grouped, where possible, on the basis of conceptual equivalence. This yielded 198 conceptual and 185 emotion clusters, respectively. Finally, participants selected proxy words to label each cluster.

Before proceeding further, it's important to acknowledge that there may be aspects of both conceptual and emotional mental activity that influence our behavior, but they've never been experienced (i.e., they've never come to conscious awareness). If this were the case, words would obviously not have evolved to label these mental phenomena. While this possibility can never be discounted, the size and the qualitative diversity of our conceptual and emotion lexicons suggest that both are probably comprehensive enough to describe almost all (if not all) of what matters.

Stage 2: 17,000 online respondents recruited in the USA used best-worst scaling (BWS) to associate single conceptual terms to 5 sets of 5 emotion words (Thomson and Crocker 2014). Each respondent participated in two BWS exercises. Approximately equal proportions of males and females were recruited, but otherwise there were no further selection criteria.

Stage 3: Bayesian hierarchical modeling (Allenby et al. 2005) was used to supplement the data matrix. Classification and Regression Tree (CART) Analysis (Breiman et al. 1993) modeled the conceptual pathways leading to each of the 185 emotional outcomes.

Figure 6 shows an example of the CART decision tree for "soothed" (emotional outcome). Being "easygoing" (conceptualization) has primacy in delivering "soothed," followed by *not* being "exciting" (as opposed to being unexciting), *not* being "uncaring" (as opposed to being "caring" – the subtlety of the double negative is important), and *not* being "cutting edge" (as opposed to being "cutting edge"). Similar decision trees have been prepared for each of the other 184 emotional outcomes (not presented here).

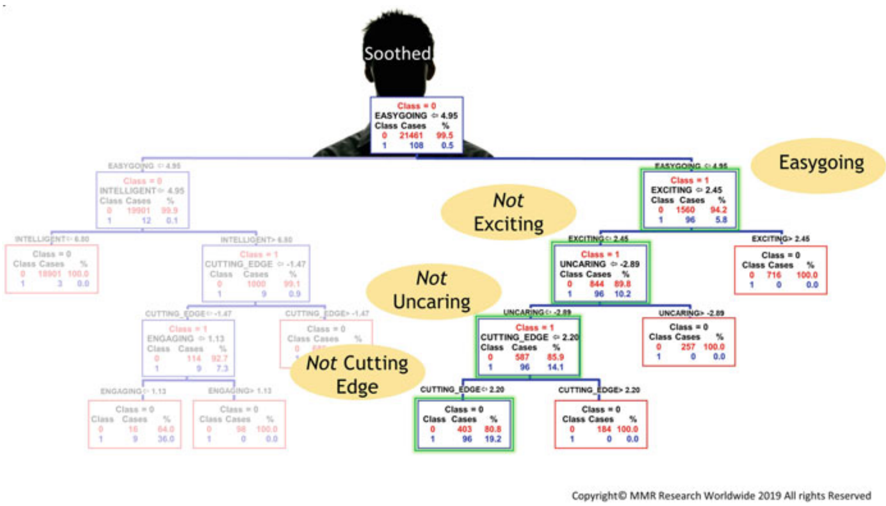

Fig. 6 Example of the CART decision tree for "soothed" (emotional outcome) and the associated conceptualizations that drive

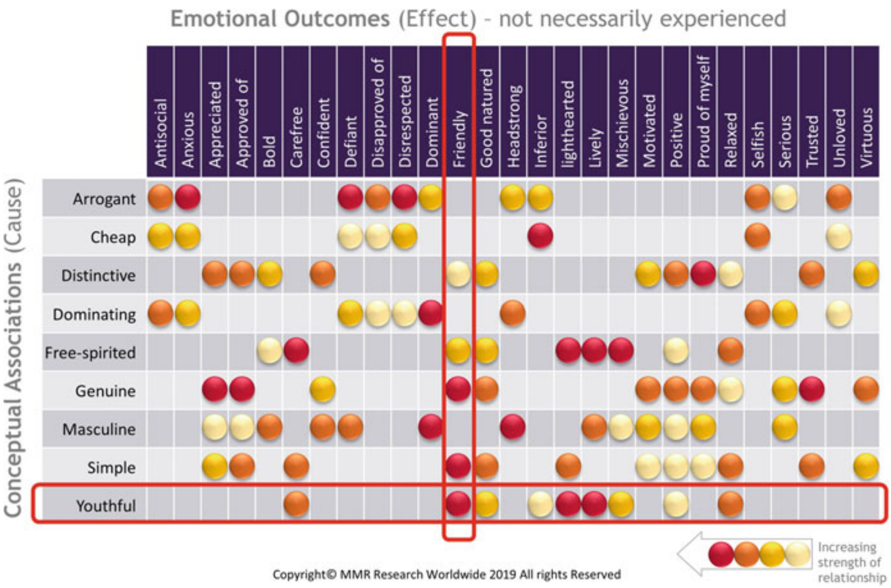

Fig. 7 Excerpt from the prediction matrix relating conceptual associations (cause) to emotional outcomes (effect)

Stage 4: All of the foregoing data has been condensed into a prediction matrix that links all of the conceptual associations to all of the emotional outcomes. Figure 7 is a simplified excerpt from an earlier version of this matrix. By way of example, if something is conceptualized as *youthful*, it's likely to engender *friendliness*, *light-heartedness*, and *liveliness* as emotional outcomes. Conversely, *friendliness* as an emotional outcome can be achieved by designing *genuineness, simplicity, youthfulness*, etc. into the product.

The value of this prediction matrix is that it holds a vast body of empirical data linking conceptual associations to emotional outcomes. This makes it possible to use the readily accessible conceptualizations associated with a brand, a product, a pack, or any combination thereof, to predict the often inaccessible emotional outcomes that they trigger. This is the fundamental basis of the emotional positivity index (EPI) described in section "Emotional Positivity Index (EPI)".

New Key Performance Indicators (KPIs)

The criteria currently used to evaluate new products and predict the likelihood of longer-term repertoire purchasing are failing innovators, marketers, and new product developers, alike. The fact that the CPG industry has rumbled on for decades using the same tired old procedures and the same tired old evaluative criteria, in spite of the appalling NPD failure rates, is surprising to say the very least. It's definitely time to think differently.

In this next section, two new KPIs are proposed, based on the rationale presented in Fig. 3. The first of these is the brand-product-pack Conceptual Consonance Index (CCI). The second is the emotional positivity index (EPI). Neither of these indices predict likely sales volumes but the associated metrics indicate whether or not the new product has the wherewithal to deliver reward via emotional outcome, something that we believe to be fundamental to longer-term repertoire adoption.

Brand-Product-Pack Conceptual Consonance Index (CCI)

The conceptualizations we associate with the various objects, people, places, events, etc. that we encounter cause us to construct emotions. These, in turn, deliver emotional outcomes that allow us to satisfy our achievement goals and/or ameliorate our avoidance goals, thereby delivering the positive reward and/or minimizing the negative reward that motivates our immediate and subsequent behaviors. To achieve this end to maximum effect, new products need to satisfy two criteria: Firstly, the conceptualizations associated with the branded product as a whole must be fundamentally capable of triggering rewarding emotional outcomes. This aspect is addressed via the EPI (see section "Emotional Positivity Index (EPI)"). Secondly, the conceptual profiles of the three primary elements of any branded product, the branding, the form of the packaging, and the product per se, should be aligned as far as possible. When there's alignment, this is known as conceptual consonance. Conceptual dissonance occurs when the conceptual profiles of the three elements are different and therefore contradictory. Dissonance diminishes the capacity of the branded product as a whole to deliver emotional outcomes single-mindedly, thereby diluting reward and attenuating the inclination to buy the product repeatedly in the longer term.

As branding promises what the product must deliver, the conceptual profile of the brand normally has primacy with the onus falling on product and packaging developers to align the conceptual profiles of these elements with that of the brand. The practical procedures involved in conceptual profiling and associated analysis tools are described in detail elsewhere (Thomson and Crocker 2014; Crocker and Thomson 2014). Suffice to say, the process for conceptual profiling of branding, product, and pack form is relatively straightforward and very well established. In the first place, a lexicon of conceptual descriptors is generated to cover the category of interest. After this, a process known as best-worst scaling is used to elicit the conscious and preconscious conceptualizations associated with the brand, product, or pack and to quantify their strength of association.

By way of example, the conceptual profile of the Baileys Irish Cream® brand, a long-established and highly successful product on the global drinks market, is shown in Fig. 8 (MMR 2019). The top portion shows the conceptual profile of the branding obtained in the absence of product, and the bottom portion is the conceptual profile of the liquid (served with ice) in the absence of branding. (The conceptual profile of the bottle was not included in this study.) The similarities in the conceptual profiles

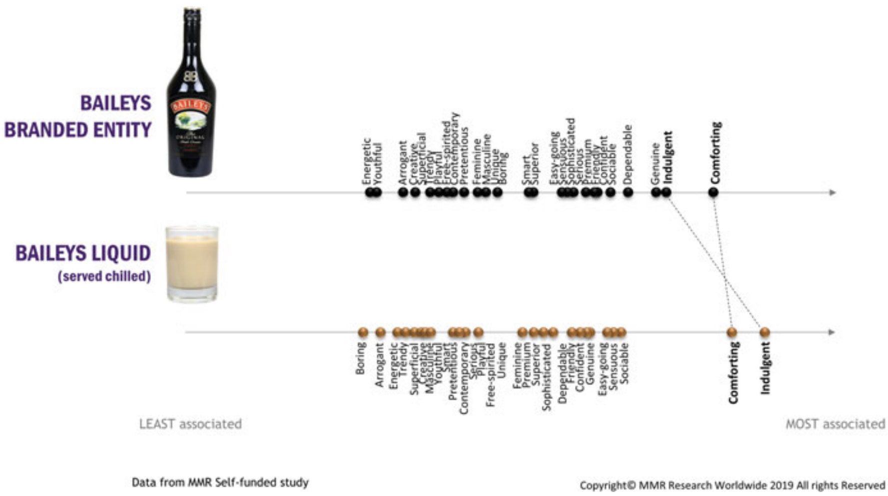

Fig. 8 Conceptual profiles of Baileys Irish Cream® branding and the corresponding product presented unbranded (served with ice). The Conceptual Consonance Index (CCI) for Baileys is 85 (r = 0.85)

are readily apparent particularly regarding comforting and indulgent, two concepts strongly associated with both the branding and the product. The CCI is obtained by calculating the degree of correlation between the two conceptual profiles (r = 0.85 or 85/100). Based on normative data obtained by MMR Research Worldwide over many different studies and product categories, it has been established that successful brands (i.e., brands that have become repertoire purchases for a large number of people) will usually have a CCI of 85 or greater (Fig. 9). If the branded product has a CCI that's markedly less than 85, it may be seriously compromised and potentially vulnerable.

Bearing in mind that most new products will normally need to displace established products in consumers' repertoires (section "Why Is It So Difficult to Convert Trialists into Repertoire Buyers?"), they need to pack a huge punch of reward. To do this, the conceptual profile of the entire branded entity must, at the very least, be very single-minded (CCI ≥85). Most new products don't even come close. This is likely to be a contributing factor in their failure.

Gordon's Pink Gin, launched in 2017, is a notable exception. The conceptual profile of the branding (without product) is shown at the top of Fig. 10 with the corresponding product profile (without branding) shown in the bottom portion. As with Baileys, the degree of conceptual consonance is extremely high (CCI = 90); one of the highest we've ever seen for a new product. Gordon's Pink has been a huge commercial success for Diageo. In the UK, it was voted "Product of the Year" for the alcohol category, in a Kantar TNS survey of 10,637 people. It also received The Grocer's "Top Launch of the Year" in the Alcohol: Spirits category.

However, a high CCI alone is no guarantee of success because, as mentioned previously, it's essential that the conceptual associations should also deliver

Fig. 9 Representation of the Conceptual Consonance Index (CCI) model showing thresholds

compelling emotional outcomes. This is where EPI, the second of the new KPIs, comes into play.

Emotional Positivity Index (EPI)

The prediction matrix used to associate conceptual associations (largely accessible) to emotional outcomes (mostly inaccessible) is described in section "Prediction of Emotional Outcomes and Reward" (Figs. 6 and 7).

In practice, the conceptual profile of the object in question (i.e., brand, product, pack, or anything at all, for that matter) is input to the matrix. Predicted emotional outcomes are obtained as outputs. By making a subjective valence judgment (i.e., positive, negative, or neutral) with respect to each of the emotional outcomes, it's possible to estimate the extent of emotional positivity delivered by the object in question. This is the EPI.

Again, by way of example, consider Gordon's Pink Gin. The predicted emotional outcomes for brand and product are not presented here in deference to Diageo's entitlement to commercial confidentiality (even although this was an MMR Research Worldwide self-funded study). The EPIs are estimated at 66% and 65% for the brand and the unbranded liquid, respectively (Fig. 11). A normative database is currently under construction but, suffice to say at this stage, that most established brands have an EPI that exceeds 50% among regular brand users, although it does differ by category. By any standard, an EPI of 65% is very high for a new product (the highest for any new product in the alcoholic drinks category obtained thus far), but it's

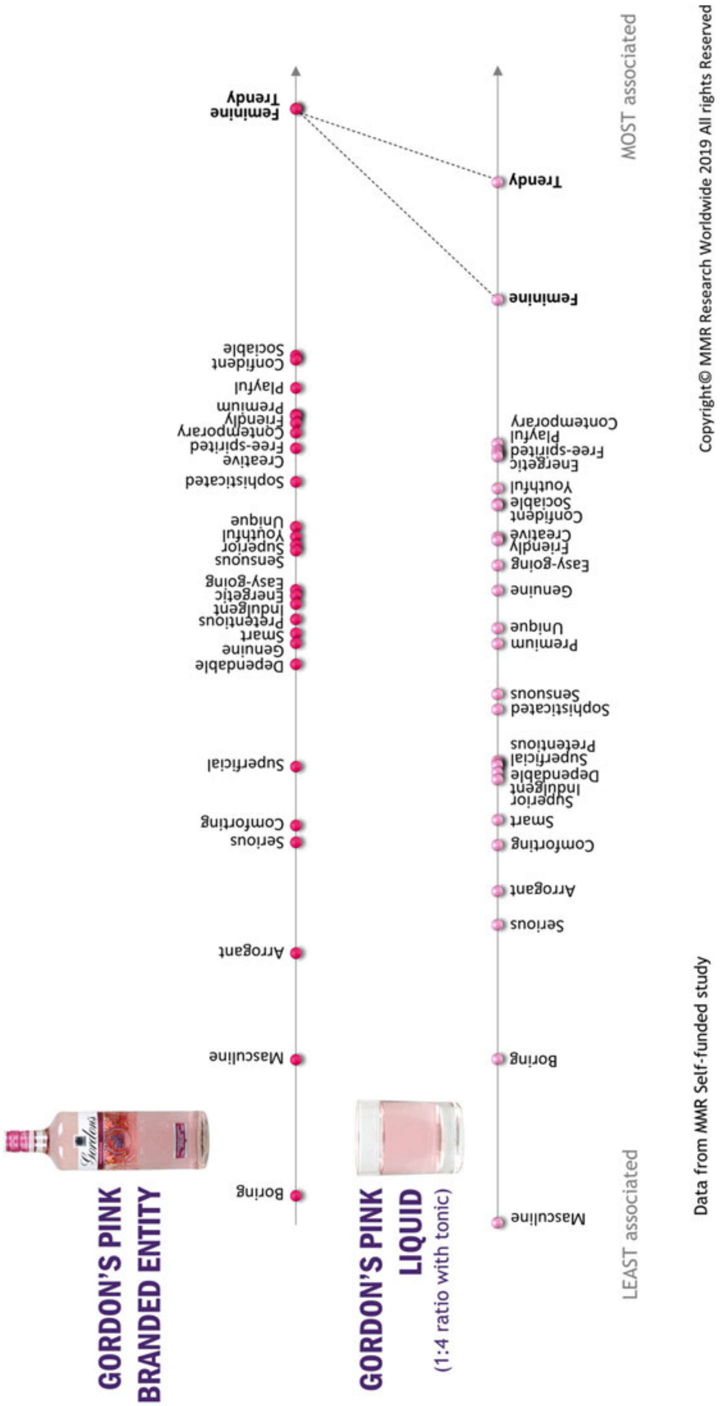

Fig. 10 Conceptual profiles of Gordon's Pink Gin® branding and the corresponding product presented unbranded (served with tonic and ice). The Conceptual Consonance Index (CCI) for Gordon's Pink Gin® is 90 (r = 0.90)

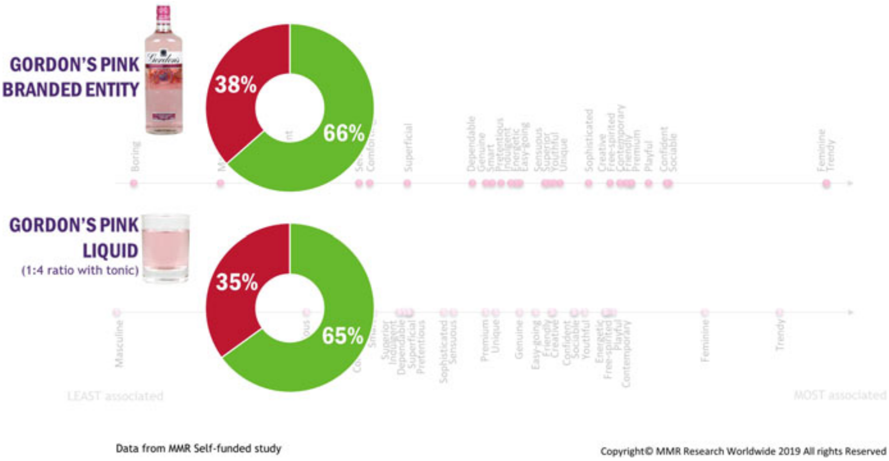

Fig. 11 Emotional Positivity Index (EPI) for Gordon's Pink Gin®

probably indicative of just how high the bar is set for new products to succeed in market by becoming longer-term repertoire purchases.

Summary

Most new products and almost all new brands are commercial failures. This situation has prevailed for the past 40 years and more, in spite of countless innovations in marketing, product development, and consumer research. There are two underlying reasons for new product failure: Firstly, most lack the potency required to convert those people persuaded to try it once, or even several times, into long-term repertoire purchasers. In the final economic analysis, motivating a large enough number of people to adopt the new product as a repertoire purchase and convincing them to buy it at a commercially sustainable selling price is the only thing that matters. Secondly, the criteria used to evaluate new products (usually liking and purchase intent), from ideation through the development process to launch, are fundamentally incapable of predicting whether or not trialists will convert to longer-term repertoire purchasers. Simulated test market methods (STMs) also fail to isolate and predict sales associated with trial and repeat from longer-term repertoire purchasing.

However, the most fundamental problem of all is a general failure to appreciate what really does motivate repertoire purchasing. For too long, it has been assumed that functionality and aesthetics matter most of all. In all probability these are merely the supporting act to the hidden emotional influences that drive behavior-motivating reward. These are the stars of the show. The problem, and it's a profound one, is that hidden influences are by definition "hidden!" Because they exert their influence below the level of conscious awareness, people can't bring them to mind and, consequently, can't relate them to others. This creates an intractable problem for product developers and marketers.

A new idea advanced in this chapter uses what's measurable (conceptual associations) to predict what's largely unmeasurable (emotions and the emotional outcomes that they deliver). Two new key performance indicators (KPIs) have been developed on this basis: the Conceptual Consonance Index (CCI) and the emotional positivity index (EPI). Examples of both indices are presented using one established and one newly launched alcoholic beverage.

Agility and speed to market are the words that seem to be on every innovation director's lips these days. If this merely amounts to taking a few risky shortcuts to deliver the same old thinking faster and with less rigor, then NPD will be in an even sorrier state in the months and years to come. Alternatively, if it translates into "stand back," "think differently," "think scientifically about what really motivates people to repertoire purchase," "adapt," and "out with the old and in with the new," then maybe, just maybe, NPD will finally deliver new products that really do enrich people's lives!

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Organic Food Perceptions of Indian Millennials, and the Growth of the Indian Organic Food Industry

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Abstract

This research seeks to understand the perceptions and motivations of Indian millennial organic food consumers, a huge segment that is driving the growth in organic food consumption in India. This chapter begins by reviewing the nascent but fast-growing Indian organics food market, which may be representative of organic consumers in emerging markets generally and for which there is less research than for Western markets. Focus groups were used to identify the needs/benefit attributes Indian millennial organic consumers consider when purchasing organic products finding that the participants tend to perceive organic products more holistically than their US counterparts, feel a spiritual connection to organics, and focus more readily on the augmented product including the societal benefits of a cleaner environment, better treatment of animals, and the improved health of farmers. The Indian focus groups reveal themselves to be traditionalists who see the organics movement as taking them back to the agricultural roots of their culture and away from unhealthy Western influences. Whereas US focus groups view the US diet as unhealthy and look to organics not as a way back but as a means to a healthier future, the Indian low-involvement focus groups view organic foods favorably but largely remain aspirational organic consumers only, due to issues of availability and price. With the aid of an Indian marketing research firm, 115 Indian millennials who regularly buy and use organic foods were then asked to specify which one of the ten aforementioned motivators were primary to their organics purchases. We find distinct perceptual profiles suggesting that Indian millennial organic consumers are a segmented market. Theoretical and managerial implications are discussed.

Keywords

Organic food · Indian millennials · Indian food culture · Organic food motivation

The Organic Food Perceptions and Motivations of Indian Millennials

The organics movement has gained a lot of momentum in the last two decades and currently underlies a huge global market. Global Market Intelligence (2012–2021, 2017) mentions that the global organic foods and beverages market in 2016 was worth more than $80 billion, and the global organic food market is projected to register a compounded annual growth rate of over 16% from 2015 to 2020 (Global Organic Food Market Forecast and Opportunities, 2020 2017). The current global trend of increased consumption of organic food and products originated in North America and Europe and has expanded to emerging economies like India and China.

Although Europe and North America are the largest consumers of organic food, in developing countries, the demand for organic foods is increasing (Chakrabarti 2010). The organic food market in Asia is likely to account for the highest growth rate over the next 5 years (Global Organic Food Market Forecast and Opportunities, 2020 2017). The number of retailers is growing, providing greater availability, and many desire to buy organic food as healthy food for their children. But, demand is moderated by a lack of infrastructure and high prices (Iqbal 2015). Thus, organic foods are a small percentage of the total food market at 2.5% (Khare and Pandey 2017).

Hand-in-hand with the growth in consumption of organic food around the world, academic research on organics has also made great strides. However, there seems to be a dearth of studies focusing on organic food consumption in developing or emerging economies (Hughner et al. 2007). Emerging economies have undergone a significant shift in their patterns and behaviors of food buying and consumption due to higher disposable incomes, greater global interaction, and changes in lifestyle, among other things (Jabir et al. 2010). To capture the growing opportunities in these markets, companies are investing significant resources and designing appropriate marketing programs to target them. However, without a proper understanding of how organic products are perceived in emerging economies, it seems likely that companies are apt to be in the dark when it comes to effectively marketing organic food and products in these high-growth markets. Specifically, it becomes important to understand and identify consumer perceptions and behavior surrounding organics in emerging markets vis-à-vis developed economies.

India has been identified as one of the top five countries in the organic foods and beverages market (MarketWatch.com 2018) in terms of sales and one of the most lucrative markets for organic food among emerging economies worldwide (Paul and Rana 2012). It may be assumed that the Indian food industry is at a different stage of technological development than their counterparts in the West, and hence there are likely to be several variances in the general perception of food and food consumption there. Dubé et al. (2016), for instance, found different effects of food processing levels on perceptions of healthiness and taste in India, as opposed to the USA. Mukherjea et al. studied Indian immigrants to the USA and showed that the two cultures identify different specific foods and cooking methods as “good” or “bad.” According to Rozin (2005), American food culture values abundance, quantity, and convenience, whereas Indians traditionally like to have fresh home-cooked meals (Goyal and Singh 2007).

Considering the substantial cultural differences between the USA and India, and, by extension, between developed and emerging economies generally, along with the buzz surrounding the organic movement, and the growth of the organic food industry globally, there is a real need for more research in this area. This study focuses on India. Also, since individuals currently 22–37 years old (i.e., millennials) are a huge consumer segment in India, and thought to be the drivers of organic food consumption India, this research focuses on this age-based segment. Specifically, we compare the perceptions of Indian and US millennials – those who are 22–37 years old – who are the biggest consumer segment by population in both the Indian and US markets. We further break our comparison across high- and low-involvement organic food consumers in each country, acknowledging the important role that involvement also plays in belief formation (Tarkiainen and Sundqvist 2005) along with culture.

Though much has been written about what motivates consumers who buy organic products, there is little to no examination of whether these consumers can be segmented according to their primary motivations, and this has been called for (Bhatia and Panwar 2016). That is the purpose here. Specifically, we examine the perceptual profiles of Indian millennial organic consumers – those who are the future of organics in a large, emerging economy whose interest in organic products is nascent but growing and who are important producers of organics themselves. Prior research has collectively identified ten motivators for buying organic products, whose importance to Indian millennial organic users was confirmed in a series of focus groups.

In the following, we review the Indian organic food market and report the results of a series of studies that seek to understand the perceptions and motivations of Indian millennial organic food consumers, a huge segment – 400 million, a third of India's population – that is driving the growth in organic food consumption in India.

The Organic Food Industry in India

Upon its independence in 1947, India faced food shortages due to a growing population. The Green Revolution was an effort at that time to increase crop resources in the early 1960s. Its aim was to achieve self-sufficiency in good grains by the introduction of high-yielding seeds, irrigation, fertilizers, and the consolidation of scattered land holdings. Over the next 50 years, cereal crop yields tripled with only a 30% increase in land use, while population doubled. Though this program brought prosperity, the increased use of chemicals and pesticides damaged the land and water, affected the health of many villagers, and, in turn, once again reduced productivity (Kumar 2019). As a cure, the government and NGOs are now recommending a move to organic farming (Misra and Singh 2016).

According to the Indian Organic Foods Production Act of 1990, organic foods are those that are produced using conventional pesticides (Bhatia and Panwar 2016), referring to an ecologically balanced and natural farming technique that does not make use of chemical fertilizers and pesticides (Singhal 2017; Sondhi 2013).

Despite international standards and trade regulations covering organics, substantial confusion exists in the minds of consumers worldwide regarding the term "organic" (Hughner et al. 2007). Although many consumers are likely aware of some of the central tenets of organic food (viz., chemical free), a meta-analysis finds that Western consumers, despite being in an established organic market, tend to be lacking in knowledge when it comes to actual organic practices and standards (Hughner et al. 2007).

Academia also has conceptualized organic food in different ways. Schleenbecker and Hamm (2013) have used the Armstrong and Kotler (2009) core/actual/augmented product paradigm in their model and associate organic food with the categories of nutrition, health, and sensory properties as the basic core and actual benefits and ethical properties as the augmented product. The tangible sensory properties (comprised of shape, color, taste, smell, and texture) describe important quality criteria in organic foods (Beck et al. 2012). Sensory characteristics are also sometimes classified as hedonic characteristics, alongside aspects of nutrition and health (Brunsø et al. 2002). Ethical properties are referred to as the intangible, extended value of organic products (Böckenhoff and Hamm 1983) and can be understood as the "image impact" of the product to consumers.

India offers great potential for the growth of organic food (Kumar et al. 2014). Projected to grow to \$1.5 billion from \$360 million in 2014 (Kumar et al. 2014), India is among the countries with the largest area under organic management, along with Argentina, Brazil, China, and Uruguay, at 1.03 million hectares. Categories of farmers who grow organically are (1) farmers who cannot afford chemicals and depend upon natural fertilizers; (2) farmers who have adopted organic farming in response to awareness of the damage to lands due to excessive use of chemicals and pesticides; and (3) big farmers who are exploiting organic farming to capture the urban market and the high prices that that segment is willing to pay (Misra and Singh 2016).

India is the seventh largest producer of organic foods with 1.5 million hectares devoted to organic farming, but 85% of it is exported (Progressive Grocer 2018). The Indian organic food market is in its nascent stages. One third of food processing and packaging is organized, and 10% of the market is branded. Local markets have taken off in many cities in the southern and eastern parts of India, generally known as the Golden Crescent (Chakrabarti 2010). Ninety-five percent of Indian organic market are in urban areas, though smaller cities are catching up (Progressive Grocer 2018), and the Indian market as of 2010 was to grow by 17% in the next 2 years to \$1.36 billion (Chakrabarti 2010). This surge in interest in natural/organic/better-for-you foods, particularly among Indian millennials, is a major opportunity for private label and store-brand products (Petrak 2015).

Organic Food Consumption in India

Different parts of the world have different reasons for their affinity for organic foods (Kumar et al. 2014), which makes it problematic that research on Indian consumer behavior toward organic food has been scant (Khare and Pandey 2017).

Indian lifestyle has changed and evolved continuously in the 63 years since independence, including food and taste habits. Indian consumers are moving toward healthier foods, including organics (Progressive Grocer 2018). Health and safety are motivators (Misra and Singh 2016). The middle class in urban India are projected to account for three quarters of urban spending by 2025 and increase their spending on higher-end items in terms of both variety and quality.

India saw a significant economic shift toward deregulation in the 1990s. Market-led development has led to accelerated economic growth and the expansion of the middle class, which has in turn led many Indians to now view many consumer goods they heretofore considered inaccessible to now be affordable and available to them

(Kumar 2019). In terms of food consumption, Indians have already begun to choose food they perceive to be higher quality and are more cognizant of attributes such as nutrition, health, and safety. Many factors have induced consumers to be drawn toward organic products, including perceived damage to the environment as a threat to health and safety (Bhatia and Panwar 2016; Chakrabarti 2010).

The progressive increase in environmental concerns due to the damage caused by the overuse of chemical fertilizers and pesticides has now moved into the mainstream Indian consciousness, resulting in more stringent legislation, further resulting in consumers taking greater responsibility for ecological damage, in part by adopting less harmful foods, including organic foods (Paul and Rana 2012). In particular, the growing awareness about environmental problems and its related health implications have brought changes in consumption patterns, such that, for example, organic fruits and vegetables are becoming popular because they are associated with health and wellness (Kumar 2018). Consumers are altering their diets; eating healthier; eating more local products, fruits, and vegetables; balancing calorie intake with calorie usage; eating fewer refined grains and salt; and paying more attention to label information and about environmental claims including third-person certifications (Kumar 2019).

Thus, Indians are now among the top ten global buyers of foods with health supplements and are eager to buy organic foods for their children (Sakthirama and Venkatram 2013). Urban India accounts for 1/3 of food consumption in India. Growing incomes, falling poverty, changing lifestyles and preferences, and competition for new customers are factors underlying predictions that the Indian food marketing will change dramatically in coming years, with the total growth in consumption of food and beverages expected to 4.5% per annum for the next 20 years. While the rate of spending is projected to grow twice as fast in urban areas, at a rate of 6.3% per annum, making it one of the fastest growing food markets, total food consumption will be much greater in rural India due to a huge and disproportionate rural population (Kathuria and Gill 2013).

These changes include the Americanization of taste habits, including eating out, fast food, and snacking, all culminating in the increasing importance of convenience as a food attribute (Anand 2011) – consumers are drawn to innovation in packaged goods and interested in trying new food products they encounter in the grocery store (Kumar 2018). Additionally, packaged goods are perceived to be hygienic and high quality, causing rapid growth in branded and packaged goods.

In spite of this growth in food consumption, and the growth in the consumption of organic foods, organic foods currently are still consumed by a very small subset (Majundar and Swain 2018). Price and availability continue to hold back organic food consumption (Laheri 2017) and reinforce the perception that organic food is seen as the province of the rich and famous, found in specialty stores (Progressive Grocer 2018). Additionally, there remains a felt skepticism concerning the organic claims of organic food producers. Therefore, certification is important for acceptance (Chakrabarti 2010). Nonetheless, in spite of these barriers, the surge in interest in natural/organic/better-for-you foods, particularly among Indian millennials, is a major opportunity for private label and store-brand products (Petrak 2015).

The Indian Millennial

There are two billion millennials worldwide. They are those who are 22–37 years old and just now coming of age and growing into an important economic segment. Emerging and developing countries are home to 85% of them, of which 410 million are Indian, whose spending power is $330 billion. This latter group is huge, larger than the entire population of the USA. By comparison, the USA is home to a comparatively paltry 73 million millennials (Gapper 2018).

Asian millennials share many attributes of those in the West, but not their insecurity. They are aspirational consumers, confident of living better lives than their parents (Gapper 2018). Younger millennials are not yet financially independent, and as consumers remain influenced by their parents. They are extremely independent and desire authenticity. They are not brand conscious, nor are they particularly loyal to brands. They have little time and demand convenience. They are enthusiastic about a green lifestyle but not motivated to acquire one (Agarwal and Sinha 2018).

Nonetheless, Indian millennials do share, or perhaps are at this point driving, all of India's general growing consciousness about the environment. With more use of pesticides, food safety is a growing concern for Indian youth, who want to eat healthier and perceive organic foods to be healthy. However, as with all of India in general, the high prices of organic foods in India – four times those of premium mainstream foods – serve as a barrier to penetration, which remains low (Tyagi 2017).

Having reviewed the Indian organic food market and its consumers with emphasis on Indian millennials, the latter a huge market that may drive the organic food market there, this chapter presents the results of two studies examining the perceptions and motivations of Indian organic food consumers.

The Food Culture of India

East Asians tend to be holistic and interdependent in their way of thinking. Holistic thinking involves focusing on the object in relation to its context (i.e., the background) (Nisbett et al. 2001). The interdependent self-concept is prevalent in Eastern culture (Markus and Kitayama 1991). Individuals possessing interdependent self-concepts are holistic, connected, and relation-oriented; they are driven by other-serving motives and are motivated to discover their interdependence with others (Bagozzi et al. 2000).

Emerging markets, like India, are characterized as being highly localized and governed by faith-based sociopolitical institutions, in which public policy takes on greater importance (Engardio 2007; Sheth 2008; Sheth and Sisodia 2006). India favors more traditional food, considering more processed foods to be less tasty (Dubé et al. 2016). There are religious perceptions and uses of food in India. Specifically, in terms of religion, the Indian holy text, the Bhagavad Gita, describes different categories of food as having either positive or negative connotations, leading to different cultural values for specific foods that differ from mainstream evaluations of food found in the USA or the West (Sen and Dharma 2017). For example, large portions of the Indian population are vegetarian, largely for spiritual reasons, and fasting is common. There are also different ideas about the role and meaning of home cooking in the two cultures, with fresh-cooked meals being preferred in India. These differences may indicate that organic food may also be perceived differently across the two countries.

The Role of Involvement

Based on past research, the importance of involvement is acknowledged here as well, by looking at two different groups in each of the two cultures – consumers with low involvement and consumers with high involvement in organics. Despite consumers having positive attitudes toward organic food, they usually buy it with low frequency (Tarkiainen and Sundqvist 2005). Hence, buying behaviors cannot be effectively predicted. Tarkiainen and Sundqvist (2005) show that attitude-based models are likely to become better predictors when certain other variables, like involvement, are introduced. Zanoli and Naspetti (2002) investigated the impact of involvement on the relationship between attitude toward sustainable behavior and behavioral intention to purchase sustainable food products. They found that more sustainable and ethical food consumption can be stimulated through raising involvement with the issue, as well as by increasing perceived availability.

Indian Focus Groups: To address the role of perception, two focus groups were conducted in India. The script used to guide the focus groups is shown in the Appendix. The topics addressed and the questions asked that formed the script were derived from the prior research reviewed in the above background sections and reflect their findings. The topics covered included what organics meant to the focus group participants, what information sources their knowledge of organics came from, what benefits they believe organics offer, what the shopping experience for organics is like, what attributes they associate with organics, and what appearance they associate with organics including its packaging, whether they feel there are issues of trust with products labeled organic, and their personal feelings about organics.

Each focus group consisted of 8–12 students, divided into high- versus low-involvement organic consumers. Purposive sampling was used to recruit respondents with high and low levels of involvement with organics. A standard 10-item, 7-point involvement scale (Zaichkowsky 1985) was used to assign participants to focus groups according to their level of involvement with organic products. Those with a mean involvement-with-organic-products score of five or higher on a 7-point scale were placed in the high-involvement focus group for their respective country, and those with a mean score of less than 5 were placed in that country's low-involvement focus group.

The same moderator conducted all four focus groups using the same script based on the research questions. Focus groups were video recorded and then transcribed by graduate students. The researchers observed the focus groups and read the transcripts, and then using a template based on the research questions, analyzed each focus group for themes. Comparisons were made across researchers to ensure inter-rater reliability. And, finally, these themes were compared across cultures and levels of involvement.

Findings Based on Culture: Our focus group discussions suggest that Indian consumers have strong symbolic associations with the term "organic." They see organic products as healthy, expensive status symbols that require more effort on the part of consumers. There is also some confusion about what organic actually means and concern over potential misuse of the term.

There is little known about how organics are perceived and used in India. We are told by the focus groups that associations with organics are rooted in tradition and taste, going back to their roots. They see the beginnings of the unhealthy Western food culture in India and are not very approving of it, even with their tendency to copy the West. One of our main findings is that Indian focus group participants tend to perceive organic products holistically, focusing more readily on the augmented product, including the collective societal benefits of a cleaner environment, better treatment of animals, and improved health of farmers, as Nisbett et al. (2001) would predict. Even when looking at benefits to the individual consumer, the focus of the focus groups is more on feeling lighter and closer to the earth.

The focus group participants also acknowledged a spiritual connection to organics, noting that those wanting to be purer or engage in a religious practice such as yoga might be aided by eating organic food. No such association seems to exist in the USA and has not been found in any research on Western organic consumers.

The focus groups report little awareness and availability of packaged, marketed organic products in India. This is especially true in the smaller cities. Focus group participants associate packaged organic food with consumers who have health problems and/or are older and are therefore very conscious of their diets or also with city people living more Western lifestyles who need to make up for unhealthy behaviors.

In smaller towns and cities in India, it is said that people trust homemakers to cook good-quality food that will not harm the family's health, and home-cooked meals are assumed to be healthy. Interestingly, home-cooked meals prepared and consumed by families are also assumed to be organic, due to their being fresh from the farm and freshly prepared. The family and the female homemaker in particular are seen as the main sources of information about organic products by those Indian respondents with some experience with organics, rather than marketer-originated sources. In fact, commercially packaged foods are seen as less organic by Indians, especially if they are convenient fast or snack foods. Also, organic products from India or sourced locally are trusted more.

The focus groups see organic foods as fitting very well with the values of their culture, more so than is usual with US organic consumers, for example. Indian participants indicate the importance of tradition to them – they think of the organic movement as going back to the agricultural roots of their culture, before things go too far in the unhealthy Westernized direction.

Effects of Involvement Level: Differences exist between the high- and low-involvement participants with respect to their frequency of use of (or experience) organic products and with their level of information acquisition and knowledge (or expertise). Those with more organic experience buy into the idea of organics more and tend to think anything labeled organic is better – tastes better, makes you feel better, and has long-term health benefits. There seems to be a sort of halo effect. The high-involvement participants are generally more optimistic about organic products and their benefits. They see the organic lifestyle as healthier, happier, and more informed.

The low-involvement Indian focus group favors organic foods because they are at the center of a favorable, spiritual lifestyle to which they themselves belong. Interestingly, this sense of belonging exists on the part of low-involvement Indians in spite of their low consumption, but not due to disinterest but for reasons of affordability and availability. This renders them an aspirational consumption group distinct from the low-involvement US group, who choose not to consume because they disfavor organics.

The focus group interviews yielded more and deeper insights to our participants' perception and behavior with respect to organic foods beyond those reported as specific to our research questions. We report those here, affording a more complete profile. We begin by discussing the highly involved organic foods consumers, followed by the less involved group.

High-Involvement Indian Consumers: This group had more experience with organic products and said they learned a lot from their mothers regarding this topic. They had stronger, more confident perceptions of what "organic" means. They see organic food as tastier and lighter than normal food, healthier, naturally grown, green, visibly fresh, and pricey. They said that organic vegetables are smaller, good and nutritious, and light on stomach and make you feel healthier. They defined organic as nonchemical and unadulterated, but there was some confusion between what is natural, herbal, and/or organic, saying the anything created naturally will have an organic output. They also linked organic products with water conservation and environmental friendliness and said that more knowledge about organics leads people to use them more.

This group viewed people who consume organic products as health conscious, much healthier and happier, feeling lighter and closer to nature, and more sophisticated, since they are more aware of the benefits of organic and thus put in the extra effort that is required. They thought that the new generations are more health conscious and that people aged 25–40 who put effort into making themselves healthy are the main segment for organic. However, they also said that older retired folks (55+) who have more free time along with health needs are likely organic consumers, along with those suffering from diabetes or any other lifestyle disorder who may switch to healthy eating because of a prescription from a doctor. People might try to balance their junk food consumption by eating organic. They felt that a more disciplined, hygienic lifestyle is part of going organic, with consumers being diet conscious and particular about what and when they eat.

The high-involvement Indian participants thought the main psychological benefit they get from choosing organic products is that they are not unhealthy, so there is no guilt associated with consuming them. They said more people don't choose organic because it is not well-promulgated, so awareness and availability are low, and that this lack of availability of organic choices matters to consumers. As far as information sources go, they learned most of what they know by just observing their mothers and from their parents in general. They argued that visual evidence leads people to use more organics and that more knowledge leads to more usage. The high-involvement Indian participants put more trust in reviews and buy more of those products with good reviews and that doctors' advice can really change how people respond to organic products. This group felt like they have a good understanding of organic farming, but said that they want to learn more about organics – primarily by reading more online.

While generally being positive about organic products, this group still admitted to being skeptical of the "organic" label – that packaged goods may have the label but not really be organic. But overall, this group felt that organics fit with the healthy lifestyles of especially young and more knowledgeable Indian consumers.

Low-Involvement Indian Consumers: Members of this group of consumers report having minimal experience with organic foods, but were cognizant of certain products such as cosmetics. Their interest in organics was high and attributed their lack of usage to cost and availability. They acknowledged that organic products have not made inroads into small towns, so that sometimes organic food is not available in their home towns, where few outlets are present and small organic customer bases exist. This group associated the term "organic" with being healthier, safer for consumers and farmers, without pesticides/insecticides, beneficial to the environment, and costly. As much as they expressed belief that organic foods may be healthier, they also believed, however, that there is no actual proof that organic farming is better in terms of nutrients, so they expressed some ambivalence concerning whether the higher price for organics is worth the benefits received. Interestingly, this group saw organic food as something that is bland, less tasty, and less spicy, so that snacks associated with spices and junk food cannot be organic. They were uncertain about what organic food taste is and not sure how it is different.

This group identified several organic food segments. First, mothers who make their own food and make sure that their families consume good food, as evidenced by the following quotation:

> The city I come from, moms are homemakers, and they ensure what we eat is healthy.

Second, people who have less time, so they eat out a lot and consume organic food to make up for their perception that they live an unhealthy life otherwise. Additionally, old people (50+) are more likely to buy organic for health reasons. Also, people who go to the gym, take care of their diets, and are more conscious about themselves. Indians who follow certain guru personalities and do yoga – more spiritual beings – were seen to consume organic food as well. The tendency to "ape the West" as a way to gain status was discussed in the context of organics. This group also believed that most organic products from India are exported to the West.

The low-involvement Indian participants said that choosing organic food makes you feel better about yourself and that there are definite psychological benefits that come from starting the day in a healthier way. However, there was not a whole lot of motivation to switch to organic for this group without some trigger (e.g., health problems).

They associated the color green with organic products and perceived them to be smaller in size with reusable or paper packaging material and labels that say something about supporting the organic initiative and list natural ingredients. They said that if regional language is used on the package, it leads people to think that it is more organic than if it is in English. This group also felt that something that looks perfect is not natural and that appearance is not that good for organic foods.

This group was very skeptical about the new organic movement and had doubts about what "organic" really means, with low trust in the term "organic." They felt that not everything about organic products can be wholly organic because of polluted environmental conditions. They said that many organic claims do not produce any certificate stating that the product is all organic and were not even sure whether such a certificate exists, but felt that it should. But products that are natively Indian (provenance) probably really are organic.

These participants feel a strong attachment to nature and Indian culture. They explained that since India has been an agrarian economy that was more natural historically, organics can be seen as an outgrowth of this history. Now that "chemicals" have been introduced to Indian food production, and the fast food sector is growing rapidly, this group now says that using organic products now feels as if one is returning to one's roots. Even in spite of the growth of fast food and eating out in India, this group says that most Indians believe that home cooking is healthier. Compared to the West, where people have been consuming junk food for a long time and have problems with obesity, Indians are more aware of the downside of fast food. Respondents thought that as this trend changes, awareness of organic food may increase in India.

Segmenting the Indian Millennial Organic Food Consumer

India is diverse. There are changes to food, food culture and cuisine every 200 km (Progressive Grocer 2018). Therefore, marketing in India requires the "Cadillac" of segmentation strategies (Bijapurkar 2008). It can be expected as well, therefore, that the huge cohort of Indian millennials would be similarly diverse, and, as organic food consumers, segmented. Clues for whether they are and how may be taken from organic food segmentation studies elsewhere, the majority of which originate in the West. A review of the literature on this topic collectively identifies as many as nine motivators that drive organic food consumption among Indian millennials and serve to differentiate them as organic food consumers – the desire to eat healthy, a concern for the environment, a concern for safety, a desire to support the local economy, a concern for animal welfare, a desire for wholesomeness, foods that are reminiscence of the past, and foods that are fashionable (Hughner et al. 2007; Sultan et al. 2018).

This paper extends this research to India, for which there is at best a scanty literature, and what there is tends to take a piecemeal approach to examining Indian motivations for buying organic, each paper examining the role of certain motivators but seemingly not seeking to identify a complete bundle for the Indian market. For example, Chakrabarti (2010) and Kumar (2019) find that Indian organic food consumers are motivated by its healthiness. Chockalingam and Isreal (2014) and Khare (2014) specify organic's eco-friendliness and ayurvedic properties. Similar to the latter studies, Khare and Pandey (2017) speak to the role of green self-identity.

With the aid of an Indian marketing research firm, a representative sample was solicited of 115 Indian millennials who regularly use organic products of all types. Of the 115, 48% are female, 52% male, 36% are under 30 years of age, 56% are in their 30s or 40s, 9% are over 40, 57% earn ten lacs a year or less, 42% earn more, 80% are married or with a partner, 20% are single or without a partner, 24% have children at home, and 76% have no children.

Mean ratings for organic product attributes, overall and by market segment, are shown in Table 1. All mean scores on a 7-point agree/disagree scale are above three, the point of indifference, many statistically significantly above the point of indifference, indicating that regular Indian millennial users, regardless of the market segment to which they belong, think favorably of organic products on all attributes.

Identification of Indian Millennial Organic Consumer Segments

Response to the question:

> Which of the reasons below (there are 10) is the **Most Important** reason underlying why YOU buy organic (Choose one)?

The ten reasons listed were derived from a prior set of focus groups constituted of Indian millennials who buy organic products on a regular basis and are listed in Table 2, along with the number and proportion of the 115 respondents who selected each reason. We concluded, upon inspection, with consideration of the requirements of the subsequent empirical analyses we were planning, that three of the ten offered numbers large enough to warrant inclusion in subsequent analyses, those being "Offer health benefits," (46 selectees), "Help the environment," (30) and "Are better-quality products" (15). The sum of these three counts is 91 respondents - 79.1% of the 115 respondents in this study. They constitute what we conclude are the principle Indian millennial segments that are treated in subsequent empirical analyses.

Table 1 Mean attribute ratings of organic products overall and by the three main Indian millennial market segments according to the single most important reasons why Indian millennials choose to buy organic products

Organic product attributes	Mean overall ratings	Mean ratings by market segment (7-point valence scale) I buy because organics are better-quality products	I buy because organic products help the environment	I buy because organic products offer health benefits
Offer high quality	5.70	6.13	5.95	5.67
Are healthy for the user	5.67	5.93	5.82	5.70
Are safe	5.67	6.03	5.85	5.72
Are bought by people like me	5.55	5.77	5.77	5.40
Have informative labels	5.52	5.97	5.77	5.42
Are a luxury good	5.45	6.10	5.67	5.20
Are trendy	5.43	5.70	5.53	5.45
Are sustainable	5.40	5.53	5.35	5.55
Are readily available	5.39	5.50	5.50	5.29
Take me back to my roots	5.27	5.30	5.52	5.32
Have spiritual benefits	4.99	5.27	5.02	4.86
Take a lot of effort to shop for	4.94	4.87	5.18	4.70
Are natural	4.12	3.97	4.00	4.25
Are affordable	3.68	3.80	3.73	3.87

The Association of Organic Product Attributes with Each of the Major Indian Millennial Organic User Market Segments

Inspection of the perceptual map shown in the Fig. 1 reveals what may be interpreted forming a triangular attribute space with the three market segments at it vertices. Inspection of the map and the “top box” frequencies shown in Table 3 indicate a number of attributes located in the center space between the positions of the three market segments. All but one of these is positioned there because they are highly associated with all three market segments, indicating that aspect of their perceptual profiles that they have in common. These are “Have informative labels,” “Are safe,” and “Are bought by people like me.” One other attribute position in the central area

Table 2 Frequencies for the single most important reason Indian millennials report for choosing to buy organic products

Single most important reason to buy organics	Number of respondents who specified a given reason ($n = 115$)	Percentage of respondents who specified a given reason (%)
Offer health benefits	46	40.0
Help the environment	30	26.1
Are better-quality products	15	13.0
Offer good value	6	5.2
Help farmers	4	3.5
Offer spiritual benefits	2	1.7
Are conveniently available	2	1.7
Offer sensory benefits	1	0.9
Are popular	1	0.9

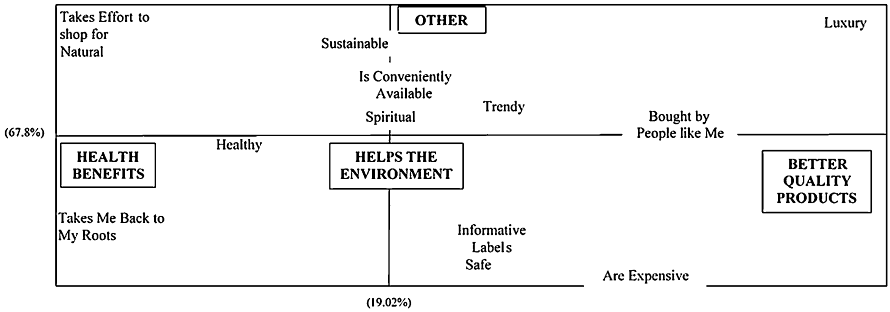

Fig. 1 The association of organic product attribute ratings with three principle Indian millennial organic market segments according to the single most important reasons why Indian millennials choose to buy organic products

with these three, “Are trendy,” is there for the opposite reason, as inspection of the Table 3 shows – that it is relatively unassociated with all three market segments, indicating that organic products are generally not seen by Indian millennials to be “trendy.”

Other organic product attributes, however, are relatively highly associated with one particular market segment and, as such, serve to define their perceptual and attitudinal profiles relative to the other two.

Profile of the “...Because They Are Healthy for the User” Segment

Those Indian millennials, who choose organic products principally because they consider them to be healthier, relatively strongly associate organic products with “Are healthy for the user,” “Are sustainable,” and “Take me back to my roots,”

Table 3 Frequencies of "top box" organic product attribute ratings of the three main Indian millennial market segments

Organic product attributes	"Top box" frequencies by market segment (6 or 7 on a 7-point agreement-disagreement scale)		
	I buy because organics are better-quality products ($n = 15$)	I buy because organic products help the environment ($n = 30$)	I buy because organic products offer health benefits ($n = 46$)
Are healthy for the user	9	15	26
Are safe	12	19	27
Are bought by people like me	12	18	22
Have informative labels	10	17	22
Are a luxury good	11	14	15
Are trendy	9	15	20
Are sustainable	8	12	22
Are readily available	7	14	18
Take my back to my roots	6	14	23
Have spiritual benefits	6	12	15
Take a lot of effort to shop for	3	12	17
Are natural	1	7	11
Are affordable	3	6	6
Global assessments of organic products			
Offer high quality	13	21	25
Are good	13	25	31
Are beneficial	10	14	29
Are positive	9	23	30
Are favorable	0	0	0
Would buy	9	23	27

indicating that they favor organic products because they see them to be generally beneficial, not only because they are healthy but because they are products they have used all their lives and are good for the environment.

Profile of the ". . .Because They Help the Environment" Segment

Those Indian millennials who choose organic products principally because they consider them to be good for the environment relatively strongly associate organic products with "Are readily available," "Have spiritual benefits," and "Are affordable," indicating that they favor and buy organic products because they see them to be good and positive. Because this segment particularly views organic products as affecting the human spirit, they appear to be less affected by pragmatic issues that others see as barriers to organic consumption, including relative lack of availability and price, and more prone to actual purchase.

Profile of the ". . .Because They Are Better-Quality Products" Segment

Those Indian millennials who choose organic products principally because they consider them to be better-quality products relatively strongly associate organic products with "Are a luxury good," indicating that this segment associated quality with status rather than performance.

Future Research and Conclusion

This research takes first steps toward more deeply understanding how Indian millennials perceive organic products, as well as the consumer behavioral processes surrounding organics. It is also a first step to understanding the growing organic market in emerging countries, represented here by India, for which there seems to be a real dearth of studies focusing on organic food consumption.

In summary, this research examines the perceptions of the Indian millennial organic food consumer, a huge segment, more than 400 million in population, who are driving the nascent but rapidly growing Indian organic food market. They tend to perceive organic foods holistically and feel a spiritual connection to them that brings them closer to the earth and back to the agricultural roots of their culture. They are traditionalists focused on organic food's societal benefits of a cleaner environment, better treatment of animals, and the improved health of farmers. Those who are not heavy users of organic foods are an aspirational market that perceives organic foods favorably and would be heavy users except for barriers such as price and availability, representing a significant future market. Current millennial organic food consumers have several motivations for buying and consuming organic foods, representing separate segments. The main ones are those who buy because they perceive organic foods to be healthier, because they perceive them to help the environment, and because they perceive them to be better quality.

Following empirical studies need to be conducted, looking at variables like gender differences, generational effects, rural versus urban variations, and so on. Reasons for differences based on level of involvement need to be tested as well. Such future studies will be helpful to marketers attempting to make inroads into the potentially huge emerging organic market.

Appendix

Focus Group Script

1. When you hear the word "organic," what first comes to mind?
   Are there any buzz words that come to mind or associations that you have with organic food?
   How about with the organic food movement in general?
   Or with people who are into organic food?
   What kinds of perceptions do you have of organic food consumers? Are they a certain type of people?
   Demographic associations?
   Lifestyle associations?
   Personality associations?
2. Do you understand what organic means? What does it mean to say something is "organic?"
   What is your experience with organic foods?
   Have you tried them?
   Do you buy them regularly?
   Do you like them?
   If you haven't tried them, why not?
   Do you see yourself as an organic food consumer?
   Have you ever looked online to find out about organic foods or products?
   Are you interested in learning more about organic foods?
3. Where do you get your information about what organic products to try or what organic products are good?
   Do you talk about it with friends? Family? Doctor? Others?
   Have you noticed any ads for organic products? Where have you seen them? What messages are they trying to get across?
4. What are the main benefits of choosing organic?
5. Think about your shopping experience when shopping for organic foods or products.
   Is the shopping process different in any way? Different how?
   Do you read the labels, to try to find out more about the products?
6. Are there any brands or companies that you associate with being Organic? What kind of stores sell organic products? Any specific stores in particular?
   Are there any product categories or types of food you associate with being organic?
7. What are the attributes that make organic foods/products different?
   What about taste?
   What about quality?

What about price? Value?
What about variety? Choice?

8. Are there any colors that you associate with organic food?
9. Have you noticed any packaging differences with organic products?
   Any differences in size?
   How about package types or shapes?
   What about packaging material?
   Labels? Logos?
10. Do you trust the term "organic?"
    Do you have any doubts or worries about what organic really means?
    Is it worth your time, money, and effort to go out of your way to consume organic?
11. How does it make you feel about yourself as a person when you choose organic?
    What is your main motivation or driving force for buying (or not buying) organic?
    What do you think it says about yourself to others?
12. When you think of [Indian, American] culture, history, and values, how do you think the concept of organic fits?
    How about organic food in particular?
    Where do you see the organic food movement going in India?

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Part IX

Agriculture and Food Science

Starches in Foods and Beverages

43

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Contents

Abstract

With a global annual production of more than 130 million tons, starch is one of the most used food ingredients due to its diverse functionalities. Starch granules are composed of amylose and amylopectin molecules, and the content and the arrangement of both molecules in the starch granules are known to impact starch usability in foods. Native starches do not always possess appropriate physical, chemical, and rheological properties for certain types of applications. This is why some key structural properties of starch can be modified in order to functionalize it and meet specific requirements. The four basic types of starch modifications are the chemical, physical, enzymatic, and genetic modification. In the present chapter, the starch molecular structure and the physicochemical and rheological

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attributes to be considered in starches when looking for food applications are presented. An overview of starch modification methods is given. The starch digestibility, the starch usage as a fiber substitute, the production of pregelatinized starches for baby food, and the starch application in food packaging are discussed.

Introduction

Starch is a polysaccharide synthesized by plants and is mainly found in cereals and legumes, as well as tubers and roots. Starch is one of the most used food ingredients due to its diverse functionalities. Due to its high availability in nature, starch has been considered as the cheapest and major source of energy for human beings (Ogunsona et al. 2018).

The global annual production of pure native starch was 133.5 million tons in 2018, and it is expected to reach 151.6 million tons in 2024; this increase is driven by the indispensable use of starch in food industries (http://www.strategyr.com/showsearchNew.asp). Several starch sources are available worldwide. Cereals and potatoes are the main starch sources used by the food industries. Starch granules are composed of amylose and amylopectin macromolecules, and the molecular and granular structure of starch granules depends on the way in which these macromolecules are associated and distributed throughout the starch granules. Factors, such as genetics, growth environment, and processing, may affect these constituents' content and/or arrangement in the granules.

The process of starch isolation should not affect the starch structure and change its properties. Additionally, it is required that the starch extraction method provides optimal extraction yields while preserving starch functionality. Starch extraction can be categorized into dry and wet milling procedures. Dry milling involves the use of hammer mills, pin mills, and air classification. These processes include very high degree of particle size reduction in order to separate the starch granules from proteins and fibers. It is to be noted that the purity of starches obtained by wet milling is generally higher than that obtained by dry milling. Sometimes proteases may be added to facilitate the starch isolation process. In order to select the appropriate diameter of the sieve to be used during the extraction procedure, it is important to know the particle size distribution of starch.

Native starches do not always possess appropriate physical, chemical, and rheological properties for certain types of applications; underlying reasons include a narrow peak viscosity range, a poor processing tolerance, the necessity of whiter starch pastes, and the occurrence of undesirable gels when during cooling or storage due to retrogradation and precipitation (Deka and Sit 2016). Thus, some key structural properties of starch can be modified in order to functionalize it and meet specific requirements. There are four basic types of starch modifications, namely, (1) chemical, (2) physical, (3) enzymatic, and (4) genetic modification. Starch modification can be conducted as a single or multiple stage process.

Chemical modification is the most widely explored modification method. Three available hydroxyl groups can be chemically modified through esterification, etherification, and oxidation (Khan and Ahmad 2013). Chemical reagents used for starch modification can be classified as monofunctional or bifunctional reagents based on their chemical properties. The physical modification of starch by moisture, heat, shear, or radiation has been gaining wider acceptance as no chemical by-products are generated. Thus, starch modified using physical means is considered to be a natural material and a highly safe ingredient, so its presence and quantity in food is not limited by legislation (BeMiller and Huber 2015). The main approaches for enzymatic modifications employ the in vitro methods using the carbohydrate hydrolyzing enzymes obtained from microorganisms or the in vivo methods that include suppressing or overexpressing the enzymes via bioengineering processes in plants (Park et al. 2008).

Starch can be used in a range of eating and drinking products, since it possesses soluble macromolecules that provide high viscosity, adhesion, and surface-coating properties, which are highly desirable throughout the food industry. Starch can be used as thickening, gelling, stabilizing, bulk, fat replacing, and texturizing agent (Table 1). Recent studies have explored the potential of starch for biodegradable film production for providing significant improvements in terms of the efficacy of antimicrobial and/or antioxidant properties (Samsudin and Hani 2018). Sometimes, starch may exhibit limitation on its structural stability under extreme conditions of pH and shearing, as a result of the hydrophilic nature of starch macromolecules. Besides, starch pasting and retrogradation properties are not always desirable for certain applications in the food industry (Mahmood et al. 2017). Therefore, in most cases, the starch functional group is modified to attenuate limitations and obtain desirable properties for its applications. The goal of this chapter is to discuss the molecular, physicochemical, and rheological characteristics of starches with a focus on applications in food and beverage industries.

Molecular Structure of Starch

Starch consists of two main glucose polymers: the largely linear and simpler amylose and the branched and complex amylopectin. About one-fourth of the polysaccharide content (by weight) of most of the starches is amylose (BeMiller 2019). This molecule possesses average molecular weight of 10^5 to at least 3×10^6 Da. The positions of linkages of the (1→4)-linked α-D-glucopyranosyl units in amylose chains give the molecules a right-handed helical (spiral) shape. Amylopectin, in turn, is a highly branched molecule exhibiting chains of (1→4)-linked α-D-glucopyranosyl units joined by α-1,6 linkages. Amylopectin is one of the largest molecules found in nature, with molecular weights of the order of 1×10^7 to 1×10^9 Da (Vanier et al. 2017).

Starch granules contain radially arranged molecules developing from the growth center called the hilum, in both semicrystalline and noncrystalline (amorphous) regions. The clustered branches of amylopectin occur as packed double helices

Table 1 Examples of applications of starches

Application	Type	Major findings	References
Crackers	Physically modified starch	Cassava starch was subjected to damage induced by mechanical activation to obtain various degrees of damage. Scanning electron micrographs showed that starch tended to cohere together to form a unique dough structure in the presence of water when damage level was not less than 11.51%. Cracker made of cassava starch had acceptable sensory quality comparable to the wheat flour counterpart	Liu et al. (2019)
Water treatment	Native starch	Fe-Pd nanoparticles with and without the use of starch as a dispersing agent or stabilizer for dichlorination of trichlorethylene (TCE) hydrocarbon was studied. Morphology analysis showed that the non-starch Fe-Pd nanoparticles were agglomerated and formed a dendritic network or flake with variable densities. In contrast, the nanoparticles of starch Fe-Pd exhibited remarkable dispersion properties	He and Zhao (2005)
Biscuits	Native starch	The effect of replacing part of the wheat flour with a resistant starch-rich ingredient was studied in short dough biscuits. From a technological point of view, the starch level influenced the consistency of the raw dough and the ease of sheeting and cutting. The sensory acceptance of the biscuits did not differ significantly	Laguna et al. (2011)
Cake	Chemically modified starch	Acetylated oat starch and deamidated and succinylated oat proteins were used up to 20% as oat flour substitutes. Acetylated starch increased batter viscosity, cake volume, and whiteness of cake crust. Acetylation increased swelling power, but gelatinization temperature and syneresis diminished	Mirmoghtadaie et al. (2009)

(continued)

Table 1 (continued)

Application	Type	Major findings	References
Frozen food	Dual starch modification	Modified starch is widely reported to be one of the important food additives in alleviating the syneresis effect in frozen food due to its unique physicochemical properties that are associated to interaction with water	Wang and Xu (2018)

and form many small crystalline regions that alternate with amorphous regions (Zhu 2018). Starches from different sources have different crystalline structures and are classified according to the packing of the double amylopectin helices as observed using X-ray diffraction patterns: A-type structure is associated with cereal starches (maize, rice whet, and oat), while the B-type structure is associated with root and tuber starches (potato, cassava etc.). The C-type structure is formed by the mixture of A and B types and is usually associated with legume starches (some beans, peas, and lentil). These crystallization patterns can also vary according to the size of the amylopectin chain; shorter chains (CL $<$19.7) favor the formation of A-type crystals, longer chains (CL $>$21.6) favor the B-type structures, while the association between the intermediate length chains leads to the formation of C-type crystals (Clerici et al. 2019). The size and morphology of starch granules varies considerably between plant species (Fig. 1). Generally, cereals possess smaller granules as compared to those found in roots or tubers.

Physicochemical Characteristics of Starches

The quality of some foods, such as grains and flours, is determined by a variety of characteristics that take on different meanings depending on the type of the product. The physicochemical characteristics of starch, which is one of the main components of these foods, are studied in depth since they are crucial for many applications in food processing (Vamadevan and Bertoft 2015).

Solubility and swelling power are often evaluated in order to characterize the behavior of starches. Starch granules are generally insoluble in cold water, but when heated in excess of water, they absorb water and swell. This occurs because the crystalline structure of the starch is ruptured due to the cleavage of the hydrogen bonds and the water molecules begin to bind with the amylose and amylopectin molecules causing the granules to swell and get solubilized. As the temperature rises, the swollen granules disintegrate and eventually break (Zhu 2017).

The swelling power of the granules, which can be determined by heating the starch sample in excess of water, is defined as the weight of the swollen sediment (g) per gram of starch. The solubility of the starch can also be determined in the same suspension; it is expressed as the percentage (weight) of the starch sample that is

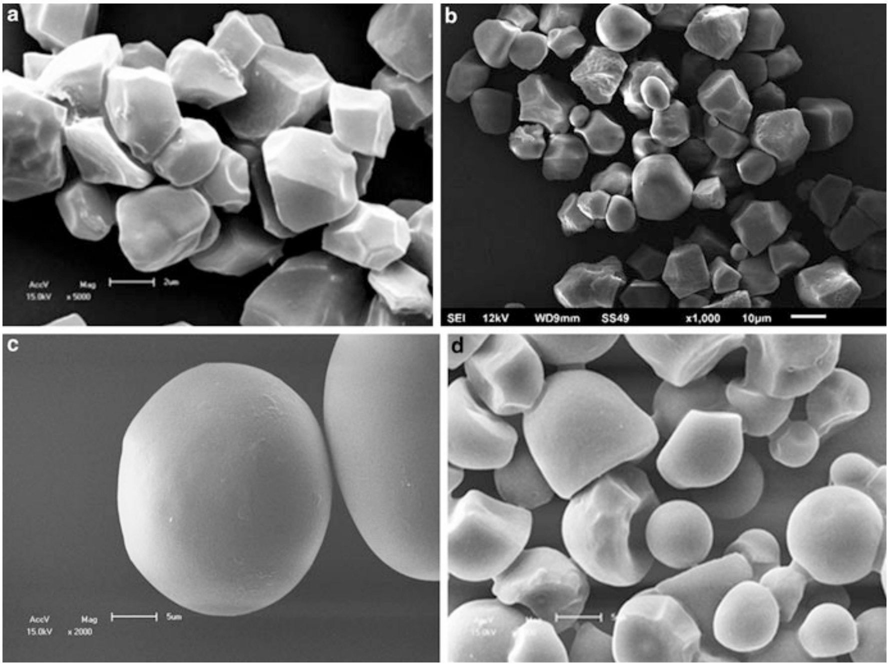

Fig. 1 Scanning electron micrographs of starch granules isolated from rice (**a**), maize (**b**), carioca bean (**c**), and cassava (**d**)

dissolved after heating. A wide range of industrial processes may provide alterations in the food structure. In the case of food texture during heating-cooling cycles, starch granules may be able to retain water and macromolecules (amylose and amylopectin) arrangement. Thus, swelling power and solubility are important determinations closely related to starch applicability in the food and beverage industries.

The swelling and solubility properties of the starches are affected by the amylose content, amylose and amylopectin structures, and granular organization, as well as by the presence of minor components, such as proteins and lipids. Removal of the surface protein from starch granules increases its swelling power in corn and wheat starch granules; however, it has less effect on starches with a lower amount of protein, such as those from waxy maize, potato, and tapioca. The residual protein content in samples of purified cereal starch is about 0.25–0.30% and is used to evaluate its purity. Regardless of the botanical source, the associated proteins occur both inside and on the surface of the starch granules. Low-molecular-weight (~5–30 kDa) proteins associated with starch granules are considered as surface proteins and can be easily extracted with saline solutions or with aqueous buffers, while high-molecular-weight (~60–149 kDa) proteins that are associated with starch granules are considered as internal proteins and require the use of stronger detergents for their extraction (Amagliani et al. 2016).

The degree of damaged starch is another physicochemical parameter that is studied because of its influence on the quality of flours. Damaging of starch granules is a result of inadequate milling conditions of wheat grains. The water absorption capacity, fermentation velocity, bread volume and color, as well as shelf-life are known to be impacted by the level of damaged starch granules observed in the wheat flour. The absorption of water allowed by the damaged starch is advantageous during the baking process mainly because it assists in the fermentation of sugar, although the increase of the volume of the mass depends only on the presence of high-quality gluten (Kadan et al. 2008).

The amylose content is one of the main physicochemical measures to evaluate the quality of some cereals. In rice, for example, the amylose content determines the firmness and sticky nature of cooked rice (Pandey et al. 2012). In the cereal endosperm, amylose and amylopectin present different mechanisms of biosynthesis. In general, starch stored in upper plants is composed of 20–30% amylose and 70–80% amylopectin. In rice, varieties can be classified based on the amylose content, such as waxy (0–2%), very low (3–12%), low (13–20%), intermediate (21–25%), and high (≥26%) (Juliano et al. 1981; Pandey et al. 2012). The high-amylose rice grains become hard on cooling, while the low-amylose rice grains become very sticky.

Pasting Properties of Starches and Their Impact on Starch Application in Foods

Gelatinization is one of the main properties of starch, which makes it viscous when in contact with water and with increasing temperature. This parameter depends on several factors such as the starch source, starch concentration, and temperature during heating. After the starch gelatinization, paste formation, a phenomenon that involves swelling of the granule, exudation of macromolecules, and eventual disintegration of the starch granules, occurs. The starch paste is a mixture of solubilized amylose or amylopectin, which forms the continuous phase and granular fragments, which represent the discontinuous phase.

The changes occurring in starch granules during gelatinization and retrogradation are determinants of the starch paste behavior, which can be measured mainly by changes in viscosity during heating and cooling of starch dispersions. These changes are generally evaluated using a Brabender Viscoamylograph or a Rapid Visco Analyzer. These equipments are configured to simulate the heating and cooling profile of actual processes. The technique involves heating a starch-water suspension and subjecting it to a constant shear. The viscosity change, that is, the pasting behavior profile, is constructed as a function of temperature and time (Vamadevan and Bertoft 2015).

In the Rapid Visco Analyzer, during the initial heating phase of the aqueous starch suspension, an increase in the viscosity is recorded when the granules begin to swell. At this point, polymers with low molecular mass, particularly amylose molecules, begin to be leached from the granules. A viscosity peak is obtained during paste formation, when most of the granules are fully swollen. During the constant temperature phase, the granules begin to break, and the solubilization of the polymers continues. In the cooling phase, solubilized amylose and amylopectin polymers begin to reassociate, and another increase in the viscosity is recorded. This second increase in viscosity is known as setback. The retrogradation characteristics of amylose and amylopectin are kinetically different. Amylose undergoes retrogradation more rapidly; this is because of its strong tendency to reassociate by forming hydrogen bonds with other adjacent amylose molecules, allowing for the formation of crystalline structures of double helices when the solution cools, which is retained for extended period of time. On the other hand, amylopectin undergoes retrogradation at a much lower rate over a long period of time, as its larger structure makes it difficult for the reassociation of the molecules (Parker and Ring 2001; Tharanathan 2002).

Starch retrogradation process influences the aging of breads and bakery products, as well as the loss of water (syneresis) from some desserts that use starch as a thickener (Tharanathan 2002). In relation to the digestibility, the retrogradation of the amylose can be associated with lower availability of nutrients during digestion. This event makes digestion and absorption, especially of the starch, lower and/or slower, resulting in a lesser glycemic response; this is desirable for several individuals such as those with obesity or glucose-related problems (Colussi et al. 2018).

Factors, such as amylose content, amylose leaching, swelling power, the friction among the swollen granules, the phosphate monoester content, and/or the proportion of amylopectin branched chains, may influence the starch pasting properties (Ao and Jane 2007). Therefore, it is worth mentioning the importance to study the pasting properties as they can influence the texture, acceptability, and digestibility of foods containing starch (Eliasson 2004).

Starch Modification from the Eating and Drinking Perspectives

Ready-to-eat, frozen, and individually packed foods are some trend in the food market. Starch may be used as basic component or low-level additive in order to improve the manufacture, presentation, or preservation of foods. When native starches do not exhibit the particular properties required for industrial use, the molecular structures of amylose and amylopectin can be modified via physical, chemical, or enzymatic methods. Different modification methods produce starches with different properties. Acetylation, cross-linking, oxidation, hydroxypropylation, and etherification are common chemical methods used to modify native starch properties. Among these chemical methods, oxidation with sodium hypochlorite has been used for at least 150 years in the paper industry, where oxidized starches are used extensively as sizing agents to improve the mechanical and film-forming properties of paper, paper board, and textiles (Vanier et al. 2017). Physical modifications are the mostly used when starch is to be used for eating purposes.

The primary interest in physical modification is for meeting the demands of the new consumers, who look for safe ingredients for consumption that are obtained by environmentally friendly methods and contribute to the trend of the clean label, thus making them acceptable as natural products. Other reasons for preference for physically modified starch that provides desirable functionalities include involvement of less expensive processing as compared to the chemical modifications and increase in the amounts of slowly digesting and resistant starch (BeMiller 2019). Processes used for physical modifications of starches are usually divided into thermal and nonthermal categories, although some treatments that are often categorized as nonthermal may have a thermal component (Schmiele et al. 2019).

Precooked starches, known as instant or pregelatinized starches in industry, are not usually considered to be physically modified starches, but they should be since the amylopectin double helices are totally or partially ruptured with this kind of treatment (BeMiller and Huber 2015). Pregelatinized starches hydrate rapidly and are cold-water soluble. Thus, they can be used without cooking, although many of the commercial products generate additional viscosity when their dispersion is heated (BeMiller 2019). Precooked starch is made in two ways. In one way, a starch-water slurry is applied to a steam-heated roll or into the nip between two nearly touching and counter-rotating, steam-heated rolls where the starch is rapidly gelatinized, pasted, and dried. Pregelatinized products are also prepared using extruders. In both cases, the dried product needs to be ground (powdered) to the desired mesh size (Schmiele et al. 2019). Other thermal treatments include heat-moisture treatments (HMT), annealing, and heating of dry starch.

Nonthermal treatments have largely been studied as these are employed during the pasteurization of food products. However, according to BeMiller and Huber (2015), in the treatments categorized as being nonthermal, although the heat is not applied intentionally, the force applied may often generate intense heat in local areas that can heat the entire system. Nonthermal treatments include ultrasound, milling, high pressure, and pulsed electric field treatments.

The enzymatic modification of starch molecules directly affects certain properties of the modified starch especially those observed for the freeze-thaw stability of gels and retardation of retrogradation during storage. Release of water due to syneresis is an undesirable feature in frozen foods. Enzymatically modified starch acts in reducing the expulsion of water from the gel structure, thus retarding amylose retrogradation.

The main approaches in the enzymatic modification of starch can be categorized as the indirect in vitro method using the carbohydrate hydrolyzing enzymes from microorganisms or the direct in vivo method involving suppression or overexpression of the enzymes in the transgenic plants (Zhu 2017). The major targets for the molecular modification of starch by enzymes include the amylose content, the molecular mass, and the structure of amylopectin chains. A-type starches tend to have higher enzyme susceptibility than B-type starches; this is mostly due to the higher amount of short amylopectin unit chains (Chi et al. 2018).

Microbial enzymes with potentials in modifying starch and starch-based foods are involved in hydrolysis, debranching, and/or disproportionation reactions. Various enzymes acting on starch have been classified into glycosyl hydrolases (EC 3.2.l.X) and glycosyl transferase (EC 2.4.x.Y), based on the type of catalytic reaction, substrate specificity, and sequence similarity (Park et al. 2008). Maltogenic amylases from various bacteria have been shown to be able to hydrolyze amylose readily but hardly attack amylopectin. Thus, maltogenic amylase has a great potential to produce starches with different amylose content. Chain distribution of amylopectin can be engineered using 4-α-glucanotransferase that disproportionate the side chains of glucan, which eventually alters the side chain length (Jiang et al. 2014).

Modification of starch also can be manipulated in plants by mutation or by transgenic technology. The enzymes involved in starch biosynthesis and degradation can be suppressed, overexpressed, or modified directly in the plants (Blennow 2018). The amylose content of starch can be controlled genetically by suppressing the enzymes, such as the granule-bound starch synthase that is responsible for amylose biosynthesis. The levels of these can be manipulated directly in the crop by mutagenesis or transgene technology in combination with breeding in order to generate entirely novel starch biopolymers in starch crops (Park et al. 2008).

Starch properties can also be altered by application of dual modifications. Babu et al. (2019) performed single and dual modifications of foxtail millet starch, using annealing and sonication treatments. According to the authors, annealing treatment leads to the interactions and reassociations of amylose and amylopectin chains, which affects the properties of native starch, whereas sonication treatment alters the physicochemical properties of starch amylose and amylopectin, which in turn can affect the pasting properties of the starch suspension. In this case, dual modification by ultra-sonication followed by annealing provided the most desirable properties to foxtail millet starch, such as high acid and shear resistance, high freeze-thaw stability, and improved gel texture.

Starch for Improving Consumer Health

Starch Digestibility

Most starches contain a rapidly digestible portion, a slowly digestible portion, and a portion that is resistant to digestion. Rapidly digestible starch (RDS), which releases glucose after 20 min, consists primarily of amorphous and dispersed starch. The slow digestion starch (LDS) is characterized as being physically inaccessible because it has a rigid amorphous structure and an imperfect crystalline structure. This type of starch is completely digested in the small intestine in approximately 120 min, thus improving satiety and control of diabetes. Resistant starch (RS), considered a desirable food component due to its beneficial physiological effects, is characterized as the portion that escapes digestion in the small intestine but can be fermented by the intestinal microflora in the large intestine to produce short-chain fatty acids.

Resistant starch performance, in some cases, is similar to that of dietary fiber. Glycemic index and starch content of foods have been established as two important indicators of starch digestibility. Low glycemic response is beneficial, especially for individuals with reduced glucose tolerance. From the nutritional standpoint, resistant starch consumption prevents inflammatory diseases of the large intestine and helps to maintain the integrity of the intestinal epithelium, as it contributes to the increase of the fecal volume, modifies the colon microbiota, and increases fecal nitrogen excretion (Perera et al. 2010).

Resistant starch can be divided into five types according to their characteristics. The first category includes a form of physically protected starch found in whole grains. The second category includes a granular form found in raw potato, green banana, and high amylose starch. The third category includes the retrograded starch (mainly retrograded amylose), which is formed during cooling of the gelatinized starch. The fourth and fifth categories include chemically cross-linked structures and complex amylose-lipids, respectively (Jeong et al. 2019).

In spite of the varied classifications that the starch can present when it comes to digestibility, a factor that can alter its digestibility is the food processing. As previously mentioned, when starch molecules are heated in excess of water, the crystalline structure is ruptured, and water molecules are bound by hydrogen bonds to the exposed hydroxyl groups of amylose and amylopectin, which causes an increase in granule swelling and solubility. Therefore, water activity or water availability is an important factor that determines the extent of the digestibility of the starch by enzymatic hydrolysis (Slaughter et al. 2002).

In general, processing increases the degree of hydrolysis of the starch. The main process that facilitates the availability of starch for the penetration of water and consequently the action of the α-amylase enzyme is cooking by heating at 100 °C. Cooking increases the rate of hydrolysis by gelatinizing the starch and making it more readily available for enzymatic attack. Processed legumes contain significant amounts of resistant starch as compared to the other food products such as cereals and tubers, regardless of processing (Singh et al. 2010). The digestibility of the starch can also be influenced by the extrusion process that, due to the shear action, promotes the loss of the structural integrity of the starch granules, thus increasing its susceptibility to the enzymatic attack (Altan et al. 2009). In cereals, processing, such as polishing, immersion, and germination, may increase the digestibility that is associated with the removal of compounds such as phytic acid, tannins, and polyphenols. These compounds generally inhibit enzymatic activity, thus reducing the starch digestibility. In addition, autoclaving, fermentation, microwave processing, roasting, and irradiation are also considered as processes that increase the digestibility of starches (Jeong et al. 2019).

Starch as a Fiber Substitute

The awareness about relationship between food and health has been growing among most consumers, causing an increase in the consumption of foods rich in fibers. Resistant starch has been gaining importance as an alternative to dietary fiber (Sanz et al. 2008), since it has physiological effects similar to dietary fibers, the following among which stand out: capacity to increase fecal volume and dilute potentially toxic and carcinogenic compounds and capacity to reduce postprandial plasma levels of glucose, insulin, triglycerides, and low-density lipoproteins. As mentioned earlier, due to the fermentation of resistant starch, short-chain fatty acids, such as acetic, propionic, and butyric acid, are produced in the large intestine. Butyric acid is extensively metabolized by the colonocyte and is the most important source of energy for the cell (Elmstahl 2002).

From the standpoint of soluble fibers, resistant starch has a positive impact on colon health by increasing the rate of cell production or decreasing atrophy of the colon epithelium as compared to the nonfibrous diets. Resistant starch consumption has also been linked to the reduction of postprandial glycemic and insulinemic responses, which may have beneficial implications for diabetes control (Tharanathan and Mahadevamma 2003).

In the development of high-fiber foods, the use of resistant starch has been considered advantageous since it possesses a low-calorie profile and can be used as a bulking agent in reduced sugar or reduced fat food formulations. Resistant starch holds significantly less water than traditional dietary fiber. Besides, it does not compete for the water needed by other ingredients and allows for easier processing because it does not contribute to stickiness. In most applications, starch does not alter the taste, texture, or appearance of the food (Chung et al. 2011). Reports in the literature show that foods, such as breads, cakes, muffins, and pasta, can be enriched with resistant starch as a replacement for dietary fiber (Sanz et al. 2008).

Resistant starch has also been studied for its potential as a probiotic food, since the fermentation of complex carbohydrates by the microflora of the large intestine is important for human health. In addition, since resistant starch passes in its intact form through the small intestine, it can behave as a growth substrate for probiotic microorganisms. The short-chain fatty acids, products of resistant starch fermentation, have emerged as important metabolic fuels for the colonocytes, besides having specific actions that promote normal colonic function (Topping et al. 2003).

Pregelatinized Starches for Baby Food

Pregelatinized starch is a type of physically modified starch with the ability to swell under cold water, exhibiting desirable paste and texture properties at this condition (Miyazaki et al. 2006). This type of starch is obtained from the gelatinization generally carried out in acidic or alkaline media at high temperatures in order to cleave the hydrogen bonds between the starch granules (Liu et al. 2017). Physical processes such as spray drying, drum drying, high hydrostatic pressure, thermomechanical processing, and extrusion followed by oven drying are used to obtain pregelatinized starches (Sacchetti et al. 2004).

In food processing, pregelatinized starches are used to obtain thickening or retention of water without the use of heat; this is being widely used in puddings, instant milk mixtures, preparation of ready mixable breads wherein increased absorption and water retention improve the quality of the product (Ding et al. 2005) and the preparation of baby foods.

Baby foods are intended for babies under the age of 12 months, when they are weaned, and for children aged 1–3 years as a supplement to their diet and/or for their progressive adaptation to common foods (European Commission 2006). The diet of infants and young children is restricted mainly to cereal-based foods (Pascari et al. 2019). One of the most important steps in the processing of these foods is the enzymatic hydrolysis, which promotes the partial cleavage of the starch contained in the cereals facilitating the bioavailability for the infant digestive system (Fernández-Artigas et al. 1999).

In baby food processing, pregelatinization consists of mixing the cereal flour with a high amount of water (60–80% w/w) and heating the mixture to 70 °C. When gelatinization is attained, a mixture of the α- and β-amylases is added, followed by a continuous stirring for 10–90 min (Pascari et al. 2019). Amylases are enzymes that hydrolyze the starch into smaller molecules to produce dextrins and other small polymers composed of glucose units (Martínez and Gómez 2016). The mechanism of action of this enzyme allows for rapid cleavage of the polysaccharide chains and decrease in the viscosity of the paste. The main products of α-amylase activity are mono- and oligosaccharides, which are generated in large quantities depending on the nature of the active site of α-amylase and the source of starch (Martínez and Gómez 2016). On the other hand, β-amylase activity leads to the formation of high-molecular-weight dextrins. Considering the high diversity and complexity of baby foods, the technological parameters vary according to the cereal species used in the formulation and the desired degree of hydrolysis (Pascari et al. 2019).

Starch Application in Food Packaging

One of the most significant requirements for packaging is sustainability, which has an impact on the development of materials from renewable sources. The increasing demand for polymers, driven by the global population growth and concerns about the environmental pollution due to non-biodegradable polymers, necessitates the development of sustainable and innovative strategies for use in the polymer industry (Mekonnen et al. 2016). Starch has attracted significant interest as a natural polymer and is currently being used for numerous industrial applications. This is because of its renewability, biodegradability, abundance, and cohesive film-forming properties (Majid et al. 2018).

The hydrophilic nature of starch alongside its brittleness, retrogradation, and thermal degradation has limited its extensive use for industrial polymer applications. Thus, in most cases, the functional group of starch, i.e., OH group, is modified to mitigate the aforementioned limitations and obtain desirable properties for its successful usage in the industrial materials application (Ogunsona et al. 2018). Some of the properties that can be achieved via starch modification, which have already been discussed above, include thermal stability, hydrophobicity, amphiphilicity, paste clarity, mechanical strength, freeze-thaw stability, and retrogradation resistances among others (Winkler et al. 2014).

By varying the type, level, and degree of modification in the modified starch, the physicochemical properties of the final starch-based material can be varied (Samsudin and Hani 2018). Maize, wheat, and rice starches are commercially available and can undergo modifications with regard to the adhesiveness, thickening, emulsion stability, binding, clouding, foam stability, moisture retention, dusting, expansion, crisping, and gelling characteristics; therefore, they are widely used in foods (Agama-Acevedo et al. 2019).

Maize starch is widely used because of its pasting properties, which could differ depending on the amylose content. It can produce a bright and translucent paste with a weak structure when used as a waxy maize starch (1% amylose); however, high-amylose starch (>50%) can produce an opaque and stiff paste that forms hard gels used in gum candies (Hadnadev et al. 2014). Wheat starch is used for moisture control, thickening, and creating adhesiveness in batters, ice creams, soups, gravies, and dressings. It is also used in the production of yogurt in order to provide thickening and gelling characteristics (Shevkani et al. 2017). Rice starch has diverse applications because it can be obtained with a wide range of amylose/amylopectin ratios, producing pastes with different textures; it is, therefore, highly used in frozen products. One example is its application in freeze-thawed cake production (Jongsutjarittam and Charoenrein 2013).

Development of starch-based active packaging materials obtained from agricultural sources has shown a growing trend. Starch is a promising option among other biodegradable polymers due to its abundant availability, low cost, and nontoxic nature, as well as due to the fact that it does not impart any flavor to the products in which it is used (Zhu 2017). Most scientific studies have reported significant improvements in terms of the efficacy of antimicrobial and/or antioxidant properties of starch-based packaging materials (Samsudin and Hani 2018).

Conclusions

The molecular, physicochemical, and rheological characteristics of starches with a focus on applications in food and beverage industries were discussed in this book chapter. Starches have been extensively used by food industries worldwide, being maize, potato, and cassava starch the most common sources. Starch can be used in a range of eating and drinking products such as fat replacers, soups, juices, sauces, dessert, pasta, bread, and cake ingredients. When native starches do not exhibit satisfactory properties for application in food and beverage industries, the physical methods of starch modification are those mostly used. It is important to consider that alternative starch sources with specific physicochemical and rheological properties are continuously explored by scientists.

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Functional Foods and Dietary Supplements 44

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Abstract

Consumption of vitamin, mineral, and botanical phytonutrient (phytochemical) products continues to evolve in supplementing consumers' diets. Shaped by their attitudes toward health, consumers use these products in their diet toward achieving well-being. Factors that influence purchase and consumption include personal experience, perceived health needs, habits and practices, referral, brand, claim, convenience, and price. Regulation and safety concerns shape the industry and the communications that reach consumers. Consumer education, positive messaging, awareness of ingredients, and associated health effects are recognized as playing important roles in guiding understanding and usage.

This chapter covers multivitamin/multimineral and botanical dietary supplements. Definitions including sources of information available to consumers are provided. Design and development challenges are followed by a discussion on sensory cues, alternative formats and perceived fit, compromises for health benefits, changing attitudes and growing awareness regarding health claims, and finally what can be done to influence consumers' acceptance and inclusion of supplements in their diet. Nutrigenomics is leading new discoveries for dietary supplements and moving us toward personalized nutrition as new technologies become available.

Keywords

Dietary supplement · Food supplement · Multivitamin/mineral · Botanical dietary supplement · Phytonutrient

Introduction

This chapter covers two specific categories of dietary supplements: Multivitamin/mineral and botanical dietary supplements. Each section offers background that covers definition(s), the nature of allowed health claims including governmental and regulatory jurisdiction and oversight, discussion on matters related to design and development challenges, and reviews of relevant consumer research that touches on consumer understanding, perceptions, attitudes, and behaviors within each category. Coverage is of a global perspective including the USA and other countries and regions. Another chapter within this book addresses protein supplementation (Kuesten and Hu, ▶ Chap. 45, "Functional Foods and Protein Supplementation").

Functional Foods and Dietary Supplements

There is no global harmonized definition and no legal or government definition of functional food. The term "functional food" is commonly used by industry and academia to refer to the food products/food components that provide benefits beyond that of nutrients. The Institute of Food Technologists (IFT) Expert Report

(Clydesdale 2005) defines a functional food as "... foods and food components that provide a health benefit beyond basic nutrition (for the intended population), examples may include conventional foods, fortified, enriched and enhanced foods, and dietary supplements". These substances provide essential nutrients often beyond quantities necessary for normal maintenance, growth, development, and/or biologically active components that impart health benefits or desired physiological effects. Similarly, according to the American Council on Science and Health, "Functional foods can be considered to be those whole, fortified, enriched or enhanced foods that provide health benefits beyond the provision of essential nutrients (e.g., vitamins and minerals), when they are consumed at efficacious levels as part of a varied diet on a regular basis" (Hasler 2002). The Food and Drug Administration (FDA) published their authorized health claim to industry based on the collective scientific evidence to guide industry and consumers (FDA 2018).

The definition of dietary supplement or similar expression varies globally; however, this terminology is actually defined in the regulation framework. According to the USA Dietary Supplement Health and Education Act of 1994 (ODS-NIH), a **dietary supplement** is ... *a product (other than tobacco) intended to supplement the diet that bears or contains one or more dietary ingredients: a vitamin, a mineral, an herb or other botanical, an amino acid, a dietary substance for use by man to supplement the diet by increasing the total dietary intake; or a concentrate, metabolite, constituent, extract, or combination of any of the aforementioned ingredients.* According to Directive 2002/46 of the European Parliament, a **food supplement** means "...foodstuffs the purpose of which is to supplement the normal diet and which are concentrated sources of nutrients or other substances with a nutritional or physiological effect, alone or in combination, marketed in dose form, namely forms such as capsules, pastilles, tablets, pills and other similar forms, sachets of powder, ampoules of liquids, drop dispensing bottles, and other similar forms of liquids and powders designed to be taken in measured small unit quantities," and vitamins and minerals are meant as nutrients in this regulation (European Parliament 2002). Under the Association of Southeast Asian Nations (ASEAN) regulation, **health supplements** are "... products used to supplement a diet, with benefits beyond those of normal nutrients, and/or to support or maintain the healthy functions of the human body." Health supplements contain one or more, or a combination of, ingredients, such as (a) vitamin, minerals, and amino acids (natural and synthetic) and (b) substances derived from natural sources, including nonhuman animal and botanical materials in the forms of extracts, isolates, and concentrates, and are presented in any of the dosage forms such as capsules, softgels, tablets, liquids, syrups, and any other dosage forms deemed suitable by the health authority to be administered in small unit doses by the Health Sciences Authority (HSA-Singapore).

In China, **health functional food** refers to "... food which is claimed to possess specific health function or with the purpose to supplement vitamin(s) or mineral(s), and is suitable for consumption by specific population groups to regulate body function, it is not intended to treat disease, and must not cause any acute, subacute or chronic harm to human body. . .." Therefore, one category is simply for vitamin/ mineral supplementation as a nutrient supplement and another category is for specific function. Currently, there are 27 functional claims allowed in China, though they are subject to revision in both claim verbiage and the scope of claims.

In India, according to the Food Safety and Standard Act "**foods for specific dietary uses, or functional food or nutraceuticals or health supplement**" means foods which are specially processed or formulated to satisfy particular dietary requirements which exist because of a particular physical or physiological condition or specific diseases and disorders and which are presented as such, wherein the composition of these foodstuffs must differ significantly from the composition of ordinary foods of comparable nature, if such ordinary foods exist (Food Safety and Standard Act 2006). They may contain one or more ingredients derived from plants/botanical, vitamins/mineral/protein/amino acids (whose amount should not exceed the RDA for Indians) or enzymes within permissible limit, substances from animal sources, and dietary substances for human use to supplement the diet by increasing total dietary intake. However, drug substances, *Ayurveda*, *Siddha*, and *Unani* drugs defined in the respective law, are not allowed; similarly, narcotic drugs or psychotropic drugs defined in the respective law and rule are not allowed. The "food for special dietary use or functional foods or nutraceuticals or health supplement or similar such food" should be distinguished from conventional food; therefore, such products may be formulated in the form of powders, granules, tablets, capsules, liquids, jellies, and other dosage forms (except for parenteral) which are meant for oral administration.

In Korea, the term "**health functional food**" means food manufactured or processed in a form of tablet, capsule, powder, granule, liquid, pill, etc. with ingredients or components that possess the functionality useful for the human body (Korea Health Functional Food Act, enacted by Act No 6727, Aug 26, 2002 with subsequent amendments).

In general, no matter how it is defined, a dietary supplement is not intended to diagnose, prevent, or treat any disease. In the USA, a health claim describes the effect a substance has on reducing the risk or preventing a disease, e.g., "calcium may reduce the risk of osteoporosis." A health claim requires FDA evaluation and authorization prior to its use. A structure/functional claim describes the role of a substance intended to maintain the structure or function of the body; structure/function claims do not require preapproval by the FDA. A qualified health claim is supported by less scientific evidence than an authorized health claim. The FDA requires that qualified health claims be accompanied by a disclaimer that explains the level of scientific evidence supporting the relationship. Unlike authorized health claims, the FDA does not issue regulations for qualified health claims (FDA 2005).

Multivitamin/Multimineral

Introduction

Multivitamin/mineral (MVM) supplements are widely used in many populations. The strongest markets based on market size worldwide include the USA, China, Italy, and India with projected growth through 2020 in most global markets (Mintel 2018).

The Recommended Dietary Allowance (RDA) is the estimated amount of a nutrient (or calories) per day considered necessary for the maintenance of good health. The RDA is periodically fine-tuned as new knowledge on requirements for different age and gender groups is obtained. Evidence suggests that most people do not consume an optimal amount of all vitamins in their diet and insufficient vitamin intake is apparently a cause of chronic diseases such as cardiovascular disease, cancer, and osteoporosis; therefore, it appears prudent for all adults to take vitamin supplements, tailored to specific age, sex, and physical activity levels (Huang et al. 2006). Not all nutritionists agree, however. Based on a summary of peer-reviewed nutritional literature, McCormick (2010) concludes readily available diets are sufficient to supply our nutritional needs – that is, a healthy mix of fruits, vegetables, cereals and dairy products, and meats is the usual way to obtain the recommended dietary allowances for the majority of the population, aside from the minority who suffer from genetic-based causes of malnutrition or abnormal absorption or metabolism. Some nutrition experts suggest most of us think we are eating a lot better than we actually are and offer tips to avoid nutrition mistakes and make better choices for both foods and supplements (Bouchez 2019). Findings of long-term use studies of MVM findings indicate they are safe – even in consideration of the other fortified foods consumed (Biesalski and Tinz 2017).

Based on the dietary supplement intake information collected in past National Health and Nutrition Examination Survey (NHANES) surveys, MVM samples were collected from nationwide retail outlets and direct-to-consumer sales channels in the USA. The typical nutrient labeling values of MVM (for adults, children, and prenatal) are listed in Table 1. The label value of the vitamin/mineral in MVM varies, for example, the mean value of calcium is 221 mg/day, the median value is 200 mg/day, ranging from 0 to 500 mg/day among the adults' MVM.

European Union (Directive 1925/2006) provided a guidance on vitamin/minerals that are permitted to be added into food. For vitamin, vitamins A, D, E, K, B1, and B2, niacin, pantothenic acid, vitamin B6, folic acid, vitamin B12, biotin, and vitamin C are allowed, while for minerals, calcium, magnesium, iron, copper, iodine, zinc, manganese, sodium, potassium, selenium, chromium, molybdenum, fluoride, chloride, and phosphorus are allowed. This directive also provided a list of substances allowed to provide vitamin/minerals in food, and subsequentially, a list of permitted health claims (not disease-risk reduction claim and children's development and health) were published (EFSA 2012). Similarly, the China Food Drug Administration released a guideline on the permitted vitamins (i.e., vitamins A, C, D, B1, B2, B6, and B12, niacin, folic acid, biotin, choline, vitamin K, pantothenic acid, and vitamin E) and minerals (i.e., calcium, magnesium, potassium, manganese, iron, zinc, selenium, and copper) in nutrient supplements. This guideline defines the vitamin mineral target dose for different age groups and life stages, as well as the technical specification of each approved vitamin/mineral source materials; however, the claim was limited to "supplementation single or multiple vitamin/mineral" (Hu 2019).

Table 1 Common label level of nutrients in MVM sold in US market. (Summary from MVM report, Dietary Supplement Ingredient Database, https://dietarysupplementdatabase.usda.nih.gov/)

Amount	Adult MVM	Children (>4 years old) MVM	Nonprescribed Prenatal MVM
Folic acid (μg)	400	400	800
Niacin (mg)	20	13.5	20
Riboflavin (mg)	1.7	1.7	1.7
Thiamin (mg)	1.5	1.5	1.8
Vitamin A (IU)	3500	2500	4000
Vitamin B12 (μg)	6	6	2.6
Vitamin B-6 (mg)	2	2	8
Vitamin C (mg)	60		120
Vitamin D (IU)	400	400	400
Vitamin E (IU)	30	30	30
Calcium (mg)	200	100	200
Chromium (μg)	120		
Copper (mg)	2	2	2
Iodine (μg)	150	150	150
Magnesium (mg)	50	20	100
Phosphorus (mg)	20		
Potassium (mg)	80	100	10
Selenium (μg)	55		100
Zinc (mg)	15	12	15
Iron (mg)		18	
Manganese (mg)			2

Benefit of Multivitamin/Mineral Use

Multivitamin/mineral (MVM) is probably the most abundant dietary supplements in the marketplace, given its convenience to take. Though MVM supplements are widely available worldwide, it seems that there is no standard or regulatory definition for this category – such as variety and quantity of nutrients in the formula (ODS-NIH 2015; Yetley 2007).

Blumberg et al. (2017) proposed that MVM provide at least 100% of the Recommended Daily Allowance (RDA) or Adequate Intake (AI) for at least nine vitamins and minerals (Blumberg et al. 2017) or should "contain at least the micronutrients relative to their recommended intake within country/region, and doses should be present in the amount approximating recommended intakes within the safe dose for subgroup unique requirement reflecting for their age, sex and/or life-cycle stage" (Blumberg et al. 2018b), and it's not uncommon that vitamin/mineral contents in these once-per-day supplements exceed their RDA level (ODS-NIH 2015). However, it is also common that MVMs do not contain high doses of minerals such as calcium, magnesium, potassium, and phosphorous due to their high DRI values (Blumberg et al. 2018b). The prevalence of using MVM varies between gender, life stage, and country (Cowan et al. 2018; Gong et al. 2018). Compared to men, women have higher prevalence of MVM use (Gahche et al. 2017; Knapik et al. 2016), elderly have a higher prevalence in using MVM than the younger generation. The prevalence of MVM use was 1.01% among Chinese elderly residents (60 years old and above) in a 2010–2012 survey (Gong et al. 2018) compared to ~40% among US residents of a similar age group during the same period (Gahche et al. 2017). Among American adults, MVM use has been above 30% since 2000 (Kantor et al. 2016); the 31.2% MVM use prevalence among US adults was higher than the 8.87% prevalence among Malaysian adults (Cowan et al. 2018; Zaki et al. 2018). About 80% of food supplement users admitted the use of MVM in Italian students (from high school to university) (Sirico et al. 2018).

According to the US Office of Disease Prevention and Health Promotion (ODPHP), while nutritional needs should be met primarily from food, dietary supplements are beneficial in providing one or more micronutrients that otherwise may be consumed in less than recommended levels. The NHANES 2007–2010 showed that 44% of population (age $\geq$4 years old and non-multivitamin/mineral users) cannot meet their dietary calcium requirement, compared to 39% for MVM users who do (Wallace et al. 2014). Similarly, NHANES 2011–2014 showed that 33 $\pm$ 3.1% of toddlers had inadequate daily dietary calcium intake (Demmer et al. 2018). Frequent use of MVM plays a role in closing the gap (Blumberg et al. 2016). The prevalence of dietary supplementation was higher among those with diabetes compared to nondiabetic subjects (Wilson 2019), and MVM use among adults was 31% (Kantor et al. 2016). A recent survey conducted by the Council for Responsible Nutrition (CRN) indicated that multivitamins are widely used among dietary supplement users in the USA, from 83% of young adults (18–34 years old) to 70% of senior adults (>55 year old) (CRN 2018). The motivations for dietary supplement use were improving and maintaining overall health as well as supplementing the diet (Gahche et al. 2017).

The benefits of MVM include to supplement or increase nutrient intake and its potential to promote health and prevent certain chronic disease according to Office of Dietary Supplements/National Institute of Health (ODS-NIH 2015). The nutrient functional claim of the vitamins and minerals from dietary supplements is defined within different countries' and region's regulation code such as the European Union European Food Safety Authority (EFSA) and Japan Ministry of Health (EFSA 2012; MOHLW 2018) which also requires the quantity of such nutrient within the specified range and warning information to be displayed on the product. A global consensus of MVM has been proposed among the global scientific community (Blumberg et al. 2018b), including the purpose of using the micronutrient supplement for the general population to close the gap of inadequacy of dietary intake in that particular region. Such supplementation should be safely formulated for the respective subpopulation based on the nutrient required for age, sex, and/or life stage. At the population level, the use of daily MVM reduces the prevalence of inadequate intake of the contained micronutrients and is safe for healthy adults as long as the nutrient content is within the upper limit level.

Supplementation with multivitamins/minerals for 4 weeks in a double-blind placebo-controlled clinical trial resulted in a significant increase in blood vitamin B levels in healthy young adults, lowered homocysteine, and showed improvement of mood (White et al. 2015). The same group of researchers also demonstrated a single dose of multivitamins/minerals with herbal supplementation reduced perceived mental stress, but with no benefits to depression and performance rating as well as cognitive benefit among healthy older women (Macpherson et al. 2015). Isakov et al. found MVM formulated with phytochemicals not only improved circulating vitamins levels but also reduced heart health risk biomarkers in an 8-week double-blind placebo-controlled healthy subjects study (Isakov et al. 2018). Phytochemicals with high antioxidant potential combined with MVM improved subjects' oxidative defense and prevented DNA damage in a clinical trial (Kang et al. 2019).

Design and Development

Many functional components have an impact on sensory quality and their integration into products often requires trade-offs or compromises on formulation, functional clinical efficacy, and palatability. Sensory effects become more challenging when imposed against necessary ingredient formulation and desired efficacy health claims. Modification usually means that the sensory quality changes in a negative manner from expected which can reduce the hedonic pleasure value of the product. Changes to improve the sensory characteristics may effect transformation that affects bioactivity/bioavailability of the functional compounds. A quality by design approach is recommended (Khan and Smillie 2012). "Quality by design" for supplements entails several dimensions including a better scientific understanding of natural products, herbals and botanical dietary supplements, authentication of the starting material, safety, integrity, efficacy, and commercial quality.

Novel technologies to improve the solubility of bioactives with proven therapeutic health benefits have been successfully pursued (Recharla et al. 2017), to enhance solubility and bioavailability of phytochemicals, which play key roles in the benefits of functional foods and dietary supplements.

Sensory Cues and Perceived Fit

Common formats for delivery of vitamin and mineral supplements are tablets and softgels. Novel formats are being introduced to consumers including vitamin gums (Khoo et al. 2018), as well as sachets and dissolvable strips (Watson 2011) and other formats such as chews, straws, gummies, and sports beans (jelly beans containing vitamins and electrolytes). These novel formats deliver health-related ingredients yet fun experiences for consumers – offering different formats for different use occasions, different consumer segments, and fitting consumer perceived desires/needs.

Compromise: Taste Versus Health?

Vitamin and mineral supplements generally come in pill or tablet formats with actives that are encapsulated or coated, thus delivering minimal sensory effect upon ingestion; consumers take these for their general health and well-being without compromise. Users are tolerant of these and even other formats (such as liquids, shots, syrups, etc.) that may impart more sensory impact for their health with compromise on taste. Some consider undesirable aromas and flavors as a sign of potency and effectiveness and are willing to consume these more odiferous and stronger tasting products – for their perceived enhanced efficacy. Figure 1 highlights some important short- and long-term beliefs experienced by consumers regarding supplement usage that emphasize these and other trade-offs.

Consumer Growing Awareness, Changing Attitudes, and the Future

The future for vitamin mineral supplements (VMS) seems intrinsically linked to personalization with the field of personalized nutrition continuing to advance with new technologies that provide access to easy, low cost, and personalized nutritional diagnostics that can enable individuals to better understand their own deficiencies or needs and track the effects of dietary changes. Researchers have demonstrated the efficacy of a NutriPhone (a mobile system) to quantify vitamin B12 status from just

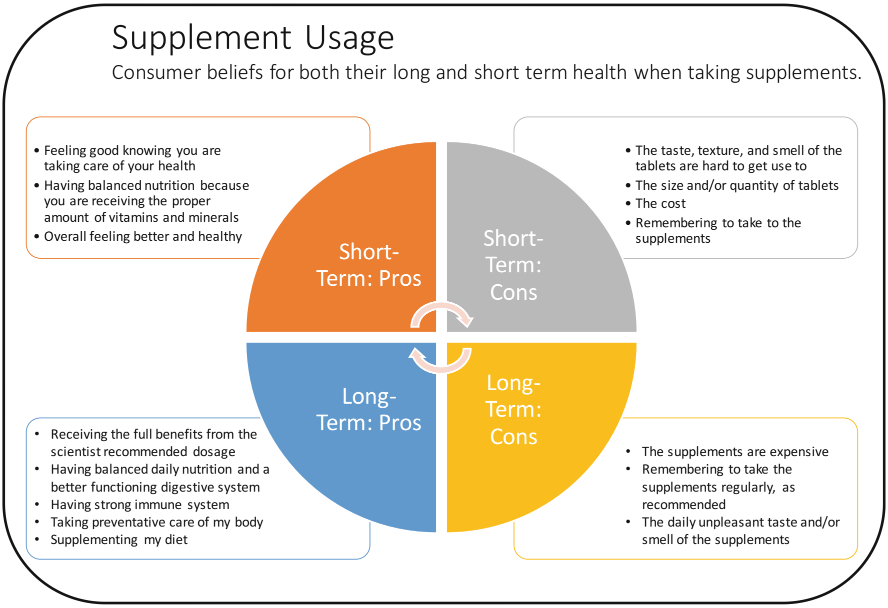

Fig. 1 Consumer beliefs associated with short- and long-term supplement usage. (Adapted from a Market Research Online Community (MROC) study conducted by Market Vision (2014))

a drop of finger prick blood (Lee et al. 2016). An active patent exists to determine and provide a personalized nutritional supplement program to improve overall health (Sullivan 2010). Having learned that every individual has unique nutritional needs, some are taking ownership of their health and in doing so are seeking more information and ways to do so effectively and efficiently (Astarita and Langridge 2013; de Roos 2013; Kambouris et al. 2018; National Academies of Sciences 2018; Rana et al. 2016). Nutrigenomics, the scientific study of the interaction of nutrition and genes, holds promise for progress in the field of personalized nutrition (Sikalidis 2018).

Health Claims Consumers' Understanding of Health Claims and Their Willingness to Try

Determinants of nonusers' willingness to try and use VMS products were found significant for attitudes, subjective norms, perceived dread of risk, risk familiarity, and willingness to use vitamin/mineral supplement (VMS); implications suggest health practitioners should attempt to focus on attitude change methods and communications aimed at reducing dread by explaining likely outcomes and benefits (O'Connor and White 2010). A systematic literature review of how health claims influence consumers was conducted providing an overview of the context with six thematic categories emerging, namely, knowledge/awareness of dietary issues, effects of health claims on purchase decisions, effects of health claims on perception/attitudes/beliefs, sources of information and trust, framing of health claims and disease-risk reduction and health-enhancing claims as well as consumer purchase decision (Pothoulaki and Chryssochoidis 2009). These findings inform direction for future studies, including the role of consumers' education for healthier dietary choices and evaluation of health claims. An important issue highlighted by this work is the need to streamline regulations for globally acceptable health claims. Yet, the criteria to assess consumer understanding of health claims leads to contradictory and ambiguous results and needs further study and interpretation.

Awareness of dietary issues has an incoherent picture, varying socio-demographically based on gender, age, marital status, and education. For example, women with higher socioeconomic status are most concerned about healthy diets. Regarding health claims, findings indicate potential risk that health claims may not play an important role in influencing purchase behavior, over price and taste, rather that purchase is driven by habits, experience, and behaviors. Other explanations include consumers' tendency not to read labels, lack of understanding of the information, confusion on the exact benefits of the claims, or similar wording on health claims contributing to the clutter, lack of differentiation in the consumers' minds, and subsequent commoditization of food products. It's been demonstrated that health claims may effect perception of healthiness (Grunert and Wills 2007), belief systems may be not be affected.

Consumer trust is related to sources of information, whether from health authorities and professionals, producers, or media; some consumers being more skeptical than others. The impact on consumers by how health claims are framed tends to be inconsistent and it's difficult to ascertain how they evaluate the information. Impact may be associated with other factors beyond framing of the claims – an individual's nutrition knowledge, personal dietary and health issues, and familiarity with certain products such as functional foods (Peng et al. 2006). Consumers have been shown to prefer shorter health claims and pay more attention to information presented in prominent positions (Wansink 2003; Wansink et al. 2004). Consumers find disease-risk prevention claims (especially those they may experience) more appealing and convincing than health-enhancing claims (Bogue et al. 2005; Croft et al. 2002; Dean et al. 2007; van Kleef et al. 2005). Pounis et al. (2011) hypothesized and concluded that consumer perception of iron fortification was associated with nutrition knowledge and highlighted the importance of focused nutrition education for consumer informed choices.

The reputations of vitamin supplements were examined to determine if the extent of reputations corresponded to established science; the study sought to determine consumer lay beliefs about the value of vitamin supplements across gender and ages assuming dietary intake was adequate (Oakes et al. 2005). Numerous factors may be cited which have led to the evolution of current supplement consumption beliefs and behaviors – namely, the discovery of vitamin deficiency diseases, fears that food-processing depletes essential nutrients, and concerns about over-farming depleting nutrients from soil – and the food industry's response with food enrichment and fortification. VMS products have evolved to fill nutrient gaps and are promoted for their health benefits. Results showed older participants were more likely to take vitamins, whereas young and middle-aged women believed vitamin supplements more important for health as compared to men. The study highlights the problematic incongruence and disharmony in the scientific literature and general public perception, calling out the importance of messages from nutritional authorities to be congruent with nutritional facts and established science in order to foster trust and compliance. Further research showed the vilification of certain nutrients in foods (e.g., fat, sugar, salt) by health media, and the food industry influences perceptions of the amounts of other nutrients in those same foods (beliefs that fat, sugar, and salt deplete vitamins and minerals), suggesting that more care and caution should be used when disseminating nutritional information (Oakes 2005).

Influencing Consumer Acceptance

Much of the knowledge about consumer acceptance of specific supplements is held by the companies selling the products and is particular to their business. Consumer research suppliers such as Mintel, Euromonitor, and others follow new product launches and product and consumer trends. Survey reports and database holdings from such suppliers offer insights into the category.

At a high level from these intelligence information sources, we may conclude that challenging factors impacting VMS purchase and use include maintaining daily regime, doctor's recommendation, products previously purchased, price, brand, format, and the overwhelming number of options (sheer number and variety of products, claims, and promotions). Occasional or lapsed use is a common concern that limits delivery of the intended efficacious dosage of active ingredients. This may be due to intentional temporary use to mitigate a deficiency or ailment, efficacy concerns, pill fatigue, or forgetfulness. Value incentives, reminders, and other mechanisms to nudge consumers into taking their supplements routinely could be ways to improve adherence. Wearable devices are being used by some as reminders to take their supplements. Emphasis on the role that these supplements play in overall health, healthy ingredients, how they are absorbed, and follow-through on claims may aid and encourage regular use. Some segments are known to be more trusting (less skeptical) of the category; some have greater interest in proactive products such as VMS to keep themselves healthy.

Opportunities for the category according to Mintel include easing the consumer online shopping experience, emphasizing healthy lifestyle, increasing consumer awareness, expanding varieties, and widening natural and organic (Mintel 2017). A doctor recommendation has the most impact on purchase decisions; in store decisions are more complex and harder for consumers to make choices with category confusion by users. Many consumers feel the shopping experience for these products is overwhelming but agree the online experience is easier, and they prefer to buy online. E-commerce is poised to make selection processes easier for consumers with ready access to information and the guidance desired; online purchasing lends effortlessly to the repurchase cycles needed for VMS.

Sebastian et al. (2007) set out to measure nutrient intake adequacy of vitamin/mineral supplement users and nonusers and to identify predictors of supplement use. They found attitude about the importance of following a healthful diet was a consistent predictor of supplement use for both men and women, though older men and women varied with level of education playing a role in the differences and the importance of a diet consistent with expert recommendations varying by sociodemographics as well. Of relevance to note, however, attitudes related to the perception of the adequacy of one's own diet were not related to supplement use, though supplement users reported more nutritious diets than nonusers. In summary, developing positive healthful diet attitudes in combination with nutrition guidance and appropriate supplement information were encouraged; further research was advised to investigate possible avenues for intervention to encourage healthful behavior.

An example of encouraging messaging to targeted consumers comes from a pediatric dietician supporting the UK Department of Health, who published a review article entitled "Who needs vitamin supplements?" Healthy Start vitamins are targeted toward women who are pregnant or breast-feeding and children under 5. The article includes the following highlighted citation "The Department of Health recommends certain vitamin supplements for certain groups, including the under-fives, pregnant and breast-feeding women, even when a healthy, balanced diet is followed" and covers why supplementation is necessary and why the new Healthy Start supplements fill previous gaps (Moore 2007).

Summary

According to market research (Mintel 2017), the VMS category is growing (slowly relative to other categories); trust and expense are barriers for consumer purchase despite benefit perceptions. Recent developments confirm that the personalization trend continues to evolve in new forms with many more options segmented to consumers' age and gender (EuroMonitor International 2016).

Future advances in personalized nutrition will be possible through use of targeted studies to examine interactions between nutrition and genetic variants. For example, the ongoing COcoa Supplement and Multivitamin Outcomes Study (COSMOS) is expected to build on this research and provide additional insights into these areas (Blumberg et al. 2018a).

Botanical Dietary Supplements

Introduction

Interest continues to grow for consumers, researchers, industry, and regulators into the health benefits of bioactive compounds derived from plants (fruits, vegetables, herbs, etc.). Mentioned above, a phytonutrient (or phytochemical) is defined as a non-vitamin-/non-mineral-based plant constituent that is all natural and is known to offer established health benefits (as per the literature, traditional medicine, and clinical evidences). Often sold in convenient dosage formats, these supplements contains botanical ingredients imparting natural plant constituents/products with known health benefits (Kuesten et al. 2014). A distinction can be made between plant-based protein supplements and botanical supplements. Plant-based proteins are typically sold as powders to be dissolved in water or milk or as ready-to-drink (RTD) shakes or beverages and are consumed primarily for their protein content (comprised of whole proteins, peptides, and/or essential amino acids); protein is a macronutrient, whereas phytonutrients are considered micronutrients. Plant-based protein supplementation is covered in a separate chapter in this handbook. Usage of botanical dietary supplements continues to increase with users believing these are important to their health and well-being. Recommended dietary guidance and intake limits for botanical ingredients would help to educate consumers by providing assessment of the safety of these substances but is yet to be addressed for bioactives (Yates et al. 2017).

The Dietary Supplement Label Database (DSLD) from the National Institutes of Health (NIH) contains information taken from the labels of approximately 76,000 dietary supplement products available in the US marketplace. Launched in June 2013, this free resource has grown to include most of the different dietary supplement products sold. Botanicals are among the most popular dietary supplements cited at 20%, trailing vitamins and minerals at 43% in the DSLD (Brown 2017).

Benefits of Botanical Supplements

The prevalence of botanical/herbal supplements was reported as 9.0% among the older population group in the USA compared with 69.7% prevalence of MVM (Gahche et al. 2017). In a survey conducted in six European Union member countries, 18.8% of survey respondents used at least one plant food supplement (Garcia-Alvarez et al. 2014). Ginkgo, echinacea, garlic, and ginseng apparently were the four most commercially important botanicals, though both echinacea and ginseng could be considered part of the registered herbal medicine (Vargas-Murga et al. 2011). Ganoderma, *lycii fructus, panax quanquefoliu radix, astragali radix,* and *ginseng radix et rhizome* are among the most popular botanical herbal ingredients in the registered Chinese health food category, particularly for immune function (Hu 2019).

Active components from botanical or plant food supplements are called phytochemicals (and sometimes referred to as phytonutrients) which are a variety of bioactive nonnutrient plant compounds naturally occurring in plant food that contribute to alter biochemical reaction(s) and consequently influence human health after ingestion (Chang et al. 2016; Liu 2003; Marcus 2013). Commonly known phytonutrients (or phytochemicals) in botanical dietary supplements include flavonoids, anthocyanin, catechin, anthocyanins, carotenoids, polyphenols, triterpenoids, phenolic acids, echinacoside, chlorogenic acid, phytosterols, etc. Numerous studies have been published in the past two decades regarding the biological activities and benefits of these botanical constituents. The consumption of the polyphenol-dietary component is thought to be consistent with the dietary guideline on the improved portions of fruit and vegetables per day (Williamson 2017). Botanical dietary supplements are consumed in the forms of teas, decoction, tinctures, extracts, softgels, capsules, tablets, and other forms (ODS-NIH, botanical dietary supplement: background information, https://ods.od.nih.gov/factsheets/BotanicalBackground-HealthProfessional/).

Botanical supplements are strongly associated with traditional knowledge originating from complementary medicine. The regulation of botanical supplements varies from food regulation to complementary medicine regulation under different product regulatory jurisdiction (Low et al. 2017). When selecting botanical and herbal ingredients for application in dietary supplements, inconsistency exists in efficacy studies of botanical dietary supplements, suggesting the needed requirement for future rigorous and reproducible research in this field (Shipkowski et al. 2018). It is critical to evaluate the history of use and exposure from food and supplements (Schilter et al. 2003); botanical source of information such as its identity, growth condition, harvest and postharvest process, storage, extraction and product preparation, and phytochemical profile information is critical in evaluating the safety of botanical supplements in conjunction with epidemiology or intervention clinical trial outcomes (Abdel-Tawab 2018; Low et al. 2017; Roe et al. 2018). Due to the diversity of botanical supplement regulation, the botanical dietary products vary from food to complementary medicine; therefore its regulation varies from market to market (Low et al. 2017).

A reliable health claim of botanical dietary supplements should be substantiated by the totality of scientific data and weighing the evidence, subject to the specific condition of use (EFSA 2017; Pravst et al. 2018) and compliance to the regulatory requirements. Scientific conclusion can only be drawn based on the totality of scientific evidence, which includes all scientific evidence regardless of strength, through an objective, transparent, and rigorous evaluation process (Abdel-Tawab 2018). This approach is particularly critical for evaluating the health benefits provided by botanical/herbal supplements, since this product category covers a variety of products involving numerous botanical ingredients with different depth of research and history of use. Some botanicals may have been used a long time in some cultures, while it's new to different markets. Some products may contain only one active ingredient, while others are formulated with multiple ingredients as well as different preparation methods. Therefore, botanical supplement efficacy substantiation is rather challenging. The European Food Safety Authority (EFSA) published scientific guidance on both general and more specific health claims relevant to common claims in dietary/food supplements such as function of nervous system, physical performance, bone, joint, skin, oral, weight management, blood glucose, cardiovascular health, and gastrointestinal tract health (Pravst et al. 2018). Since regulatory agencies require more human efficacy data these days to substantiate botanical dietary supplements, the design of human intervention studies is critical to generate reliable data as strong evidence to substantiate claims (Lucey et al. 2016). In general, randomized double-blind placebo-controlled clinical studies are needed (EFSA 2015; Pravst et al. 2018).

In addition to the efficacy of botanical/herbal supplements, it's equally important to evaluate the safety of such botanical/herbal constituents (Abdel-Tawab 2018; Pravst et al. 2018). Though many of these botanical/herbal ingredients have been applied in traditional medicine and local food industries for a long time, many uncertainties remain. A thorough safety assessment is always required before a botanical/herbal ingredient is approved to be used in the formulation (Abdel-Tawab 2018; Gurley et al. 2018), to ensure the safety of the botanical/herbal supplement when ingested. A good botanical/herbal supplement should have a short ingredient list to ensure the ingredients have the chance to be present in physiologically relevant amounts and is quantifiable (Abdel-Tawab 2018); this not only supports the quality requirement but also meets the consumers' trending need for transparency and clean label.

Design and Development

Botanical ingredients are used for flavor, color, technical properties (e.g., preservative), and also their medicinal or therapeutic properties in supplements (Schofield 2018). The structural design of natural plant-based foods to promote nutritional quality is discussed by (Van Buggenhout et al. 2012). The botanical supplement industry challenges and opportunities are reviewed (Cardellina 2002). The greatest challenge cited in this review centers on quality, safety, and benefit with the key conclusion that the industry scientific base has not kept pace with the manufacturing and marketing of these products; recommendations are offered. Further, a major challenge to face is the standardization of biological materials from natural sources (Liu and Wang 2008). New technologies are being evaluated to modernize ancient remedies and traditional herbs into mainstream products, these botanicals having received attention among medical, governmental, as well as the general public that may be useful in mitigating certain ailments (e.g., Alzheimer's disease, schizophrenia, metabolic syndrome, etc.) where contemporary therapies often lack desired effectiveness. Following vigorous scientific validation and appropriate regulatory procedures is required. A few recently approved botanical prescriptions in the USA and Europe have opened a window of opportunity in terms of regulatory passages in the West for this complementary approach.

Within nutrition, an increasing number of functional foods and dietary supplements, each with their own health claim, are marketed with their health claims; these food items are considered to be positioned between traditional foods and medicines at the so-called drug-food interface. According to Eussen et al. (2011), health technology assessments should be used more to compare the cost-effectiveness and benefit-risk ratios of drugs, functional foods, and dietary supplements.

Sensory Cues and Perceived Fit

Many, if not most, bioactive compounds are bitter, acrid, or astringent and therefore aversive to the consumer (Drewnowski and Gomez-Carneros 2000). Despite this fact, botanical supplements are finding their way into food forms as food can be used as a vehicle for the delivery of bioactives and micronutrients. For example, the use of encapsulated green tea extract was explored for quality in bread (Pasrija et al. 2015). The food and supplement industries should take sensory factors and food preferences into account when incorporating phytonutrients for health. Research shows consumer emotions can be evoked by just the aromas of phytonutrient supplements suggesting hedonic, sensory, and emotional attributes represent different dimensions in consumer choice and consumption behaviors (Kuesten et al. 2014).

The consumption experience itself is important for sustained and consistent long-term use. Botanical supplements are most often provided in tablets and softgels. These formats come in a variety of sizes, shapes, and coating materials which may impact the ease of swallowing. Dysphagic individuals may encounter trouble swallowing supplements. A scintigraphic study investigation (a nuclear medicine diagnostic test) showed coatings to improve ease of esophageal transit with oval shapes showing faster transit with lower incidence of slow transit than caplets (Wilson et al. 2003). Further, coating parameters to enhance the wet slip and appearance (gloss) properties of coated tablets proved a novel film coating system to provide exceptional wet slip behavior and improvement in tablet mobility in the oral cavity (Gimbel et al. 2018).

Compromise: Taste Versus Health?

Research efforts continue to focus on taste as a primary concern in delivering health for botanical supplements. A phytonutrient is a non-vitamin-/non-mineral-based plant constituent that is all natural and is known to offer established health benefits (as per the literature, traditional medicine, and clinical evidences). A phytonutrient supplement tablet contains botanical ingredients that imparts aroma and flavor from the natural botanicals. For example, the effect of extraction methods on the chemical components and taste quality of green tea extract has been examined (Xu et al. 2018; Zhang et al. 2016) to assess the sweet aftertaste for green tea using tannase. And, the nutraceutical benefits of value-added fruit products were determined consumer acceptable to add value to surplus fruit delivering total phenolics and total anthocyanins; oxygen radical absorbing capacity (ORAC) was determined higher than those of commercial dried fruit purchased at a natural food store (Threlfall et al. 2007). ORAC is a measure of the antioxidant potential or activity of a food; the measure is considered an indication of protection from oxidation by the free radicals.

Consumer Growing Awareness, Changing Attitudes, and the Future

Consumer awareness and use of botanicals have an ancient history for nutrition. The introduction and classification of common herbs used in cosmetics are reported by Sumit et al. (2012); the term “cosmeceuticals” is used to describe the over-the-counter (OTC) skin care products that claim therapeutic benefit by addition of plant-based active ingredients such as alpha-hydroxy acid, retinoic acid, ascorbic acid, and coenzyme Q10. Ingestibles for “beauty-from-within” are trending now in the marketplace. Thus, nutrition is being investigated and applied for consumer outer beauty benefits (i.e., healthy skin) delivered through nutritional biologically active ingredients which claim to have benefits, including antiaging effects.

Mesonutrients (so-called superfoods) and a new consumer buzzword refers to the active compounds or antioxidants inherent in foods that are beneficial to the body. Meso-dosing (ingesting more of these natural solution actives) is becoming more popular in the USA and Australia where botanical medicine is on the rise (Mintel 2019).

Consumers’ Understanding of Health Claims and Their Willingness to Try

The regulatory scope, scientific risk assessment, and claim substantiation use of botanicals are covered by Coppens et al. (2006). In-depth consumers’ associative networks of plant-based food product communications are provided covering different health perspectives on nutrition, clean label, and sustainability (Peschel et al. 2019). A study utilizing food values in conjunction with willingness to pay (Pappalardo and Lusk 2016) suggests health is not the only factor motivating purchases but also includes values related to origin, safety, naturalness, price, etc. Ares et al. (2009) offer advice following a conjoint study involving ingredients, ingredient names, and health claims based on segment attitudes. Recommendations as a result of this conjoint study are as follows: (1) the use of which ingredients most resonant with consumers will likely depend on the group; women and older consumers were found to be more positive than men toward particular ingredients, (2) compound or scientific names may have a negative impact on consumers and therefore might not be recommend, and (3) to achieve a positive association between ingredient and health effect, listing the ingredient with the scientific name should be accompanied with a health claim on the label. Interestingly, contrary to others, Ares et al. did not find dissimilar consumer attitude toward "enhanced function" and reduced disease-risk claims.

Influencing Consumer Acceptance

Limited research is available on botanical supplements as what is known is confused by report of the general class of vitamin/mineral supplements. The literature tends to focus on efficacy and safety concerns of plant food supplements (PFS) as noted for immune function (Mancamaa et al. 2013). An overview of current knowledge about the users and the determinants of usage of PFS has been provided by Egan et al. (2011). Their research indicates educated, higher-income older white females are higher users, but demographic and health-related factors also play a role in PFS consumption such as increasing age of the population, mistrust of conventional medicine, and perception that natural is healthy. Doris (2017) in discussing vegan and flexitarian millennial consumers suggests the future is in plant-based food.

Summary

Interest and markets continue to grow for botanical supplements. Consumer health conscientiousness and aspirations to live a quality life are reshaping consumer behaviors within this product category. With vested interest in their health, consumers are more well-educated, seeking solutions and making informed decisions about the choices they make. Trends on customization mentioned (EuroMonitor International 2015) include supplement packs, custom supplements based on lifestyle assessments, and use of genetic testing to personalize formulation.

The recent nutrition evolution has shifted to a more holistic focus with the recognition of the complexities of nutritional, dietary, social, behavioral, genetic, and environmental factors (Shao et al. 2017). Several trends are noteworthy in the dietary supplement marketplace. These trends include marketplace convergence, accelerated growth, cobranding, focus on science and claims validation, growing demand for sustainable and eco-friendly products, health conscious consumers, innovative dosage and delivery formats, and millennials as the next wave-seeking healthy lifestyle products (Hilton 2017).

Consumers seek to make informed decisions for their use of functional foods and dietary supplements – reliable information and education is key. Ultimately the onus is on the consumer for the choices made; these choices are based on diverse considerations including perceived health benefits, convenience/availability, safety, acceptability, and a variety of cultural, social, and marketing influences (Bagchi and Nair 2017). Responsibilities must be shared in order to optimize health and wellness benefits and involve the food and supplement manufacturers, governmental regulatory agencies, nutritionists, and medical professionals working together with consumers toward optimizing personal health with product availability in balance with environmental sustainability.

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Functional Foods and Protein Supplementation

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Carla Kuesten and Chun Hu

Contents

Abstract

Consumption of functional foods and dietary supplements containing protein forms an important and growing source of nutrition in consumers' diets. Consumers use these products in their diet to achieve a healthy nutrition lifestyle. Plant-based protein sources are widening as consumers become more focused on nutrition and health expectations. Factors that influence purchase and consumption include sensory appeal, referral, brand, claim, convenience, price, and concerns for the environment. Interest in personal health, naturalness, organic, non-GMO, and clean-label is driving category growth. Providing premium plant-

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based protein supply that meets global growth and demand will continue to put pressures on agricultural production and the food industry to deliver safe, healthy, and sustainable protein. As consumers take on a more holistic approach to optimizing their own health, consumer education and awareness are recognized as playing important roles in guiding understanding, the choices, and trade-offs that consumers make.

This chapter covers protein supplementation. Sources of information available to consumers are provided. Further, the challenges associated with design and development are briefly shared, followed by discussion on sensory cues and perceived fit, the compromise or trade-off of taste consumers are willing to make (or not) for their health, consumers' growing awareness and changing attitudes that revolve around their understanding of health claims, and finally what can be done to influence consumers' acceptance and adoption of protein functional foods and dietary supplements. The future of protein is moving through disruptive changes as consumers are becoming more comfortable with plant-based proteins.

Keywords

Protein supplement · Protein · Dietary supplement · Functional food · Food supplement · Nutraceutical

Introduction

This chapter covers protein supplements, offering background that covers definition(s) and the nature of allowed health claims – including governmental and regulatory jurisdiction and oversight. It also provides a discussion on matters related to design and development challenges and reviews of relevant consumer research that touches on consumer understanding, perceptions, attitudes, and behaviors for this category. Another chapter within this book covers Multivitamin/mineral (MVM) and botanical supplements (Kuesten and Hu, Functional Foods and Dietary Supplements).

Protein Supplementation

Introduction

Feeding the global population, now predicted to reach 9.8 billion by 2050, is a worrisome challenge facing the food industry. The future of protein in our diets is changing through disruptive innovation (Hoogenkamp 2018a). This evolution is driven by consumer lifestyle trends with the desire for fuller, more experiential lives, consumers' understanding that diet can influence wellness/well-being, and environmental concerns for the planet (Mintel 2019). Eating behaviors have changed with fast-paced lives and desynchronized time with others; healthier protein products are sought out throughout the day or for specific use occasions (in particular, breakfast, snacking, and protein choices associated with exercise). Consumer awareness and attention to protein has increased dramatically, yet consumers generally have a poor understanding of the function of this macronutrient in their diet (Banovic et al. 2018). Health ownership and personalized nutrition have entered the scene. Personalized nutrition is an approach "to assist individuals in achieving a lasting dietary behavior change that is beneficial for health" (Glbney et al. 2016). These matters pose challenges for the food industry to satisfy the rapid global understanding and evolving consumer appreciation and needs for protein. The food industry is reacting by exploring and developing new options with alternative, plant-derived sources of protein using technologies that deliver on solutions that are more sustainable and healthier for the planet (Global Food Forums® 2017). Within this competitive protein product landscape, companies are striving to innovate and differentiate (Kantar Consulting 2017, 2018). Consumer acceptance and adoption of these advancing solutions is key to successful progression in healthful protein consumption.

Benefit of Protein

As an essential nutrient for humans, protein is primarily obtained from the diet; ingested protein helps us to build and maintain muscle, skin, and bones. Meat, poultry, fish, dairy products, nuts, and beans are primary dietary protein sources. In general, protein from meat and animal sources are considered as complete protein, meaning that it provides all the essential amino acids (EAA) that cannot be synthesized by humans. However, plant protein-rich food not only provides a balanced and diversified variety of food source but also additional nutrients beneficial to overall health.

The current protein daily recommended intake (DRI) for adult males and females is 56 grams and 46 grams, respectively – based on a 0.8 kg/kg body weight (bw) protein requirement (global accepted consensus). For physically active and healthy subjects, protein supplementation is thought to enhance muscle mass and performance if the training stimuli are adequate (Pasiakos et al. 2015). Evidence shows consuming protein supplements with meals instead of between meals, concurrently with resistance training, may be more effective in promoting weight control and fat mass loss without influencing improvement in lean mass (Hudson et al. 2018).

Popular ingredients used in protein supplements include dairy-based whey and casein as well as plant-based proteins such as soy, rice, and pea. Whey protein is a derivative from dairy and contains all the essential amino acids and is considered a complete protein. Whey protein also contains high amounts of branched-chain amino acids (BCAA) such as valine, leucine, and isoleucine. Since these BCAA deplete fast during resistance training, they are commonly found in sports nutrition supplementation to support and maintain the muscle tissue. Soy protein consumption (with the existence of isoflavones) may be beneficial to both total and LDL cholesterol levels compared to animal-source protein as part of the whole diet (Chalvon-Demersay et al. 2017). Soy protein is considered a healthy alternative protein source (FDA 2017). Pea protein is also a complete protein similar to whey with high BCAA. Rice protein is known to the dietary supplement industry for its hypoallergenic property. In addition, faba bean (*Vicia faba*), lupin (*Lupinus angustifolius*), rapeseed press cake (*Brassica rapa/napus* subsp. *oleifera*), flaxseed (*Linus usitatissimum*), oil hemp seed (*Cannabis sativa*), buckwheat (*Fagopyrum esculentum*), and quinoa (*Chenopodium quinoa*) are considered alternative plant-based protein choices (Mattila et al. 2018).

Protein supplementation is popular among athletes, military personnel, and those involved in resistance and endurance training. Resistance training accretes myofibrillar protein and increases size of skeleton muscle (Staples et al. 2011). The American College of Sports Medicine recommends a protein intake of 1.2–2.0 g/kg bw/day for those with resistance and endurance training in comparison to 0.8 g/kg bw/day for healthy individuals (Thomas et al. 2016). Adequate protein intake, particularly EAA is required for muscle protein synthesis and repair. Timing of protein supplementation and source of protein play a critical role in supporting the maintenance, repair, and synthesis of skeleton muscle protein (Cintineo et al. 2018; NIH-ODS 2017; Thomas et al. 2016).

Though dietary protein intake in affluent countries is no longer a major nutritional issue, underconsumption of protein is more prevalent among the elderly population (Krok-Schoen et al. 2019). For example, sarcopenia (the loss of skeleton muscle mass and strength associated with aging) is known among elders. Limited intervention studies have shown that EAA supplementation improved muscle mass and functional parameters among sarcopenia subjects, while protein supplementation showed inconsistent outcome in muscle mass and function (Cruz-Jentoft et al. 2014).

In addition to sports nutrition applications, protein powders and drinks are sometimes marketed as meal replacements for weight management. However, it is always advised that meal replacements should not completely substitute for food, as a balanced diet provides not only protein but also carbohydrate, fat, vitamins and minerals, fibers, and other beneficial phytonutrients to support body function and nutrition need.

Design and Development

Beyond the nutrient content profile (i.e., protein, carbohydrate, fat, vitamins, minerals, etc.), protein product beverage formulators seek ingredients that deliver flavor superiority and are easily dissolvable in liquids (water, milk, etc.). Acid tolerance may be required, depending on the application. Extensive research has been conducted on bioactive protein hydrolysates and peptides with broad scope of functionality (i.e., mitigation of noncommunicable diseases and risk factors and contribution of healthful biological properties) (Li-Chan 2015). Many bioactives including peptides tend to be bitter, the taste being considered less relevant against the important biological functions offered by peptides. Agglomerated proteins, while more soluble than their non-agglomerated origins, tend to deliver a coarse mouthfeel and residual particles. Protein agglomeration is a process to instantize the protein, making protein powders easier and faster to disperse in water. Linde et al. (2009) provided background on the taste impediments of hydrolyzed proteins and bitterness of peptides which limits use in human foods. Sensory-guided fractionation and “sensomics mapping” (a combination of sensory tasting and analytical mass spectroscopy) is a recognized approach to identify bitter peptide sequences (Liu et al. 2013). At least five or six members of the human T2R bitter taste receptor family are activated by amino acids and peptides, and study reveals a highly complex interaction of amino acids, peptides, and derivatives associated with bitterness (Kohl et al. 2013). The use of experimental design and focus on critical process parameters (CPP) that affect critical quality attributes (CQA) is necessary to evaluate the hydrolysates, not only for taste but also peptide separation and recovery (Li-Chan 2015). Bioinformatics are now used to accelerate the discovery of new functional peptides therein bringing ongoing challenges to commercialization.

Designing functional foods or dietary supplements containing protein begs the question of “for who?” Vantages from a variety of stakeholders weigh in on the complexities of decision-making that impact whether (or not) new technologies and products make it to the global marketplace, including marketing, safety, intellectual property and regulatory experts, formulators, growers, supply chain, manufacturing, and others (Bagchi and Nair 2017). Regulatory and safety concerns involve formulation, sourcing and manufacturing, as well as preclinical and clinical research to ensure efficacy and safety. Understanding factors influencing consumer choice is key to success in the diverse functional foods’ marketplace. Launching new products for functional food health benefits involves market analysis, concept development, and marketing strategies to target consumers’ needs. Trending new advanced analytics such as mind genomics and cognitive economics are methods being used to focus marketing messages to specific targeted consumers.

A plant-based diet is considered essential for future sustainability – but not just in terms of the quantity and availability; protein quality also needs to be considered in the design and development of protein products. Definitions of protein performance quality measures PDCAAS (Protein Digestibility Corrected Amino Acid Score) and DIASS (Digestible Indispensable Amino Acid Score) are defined (Hoogenkamp 2018a). Alternative plant-based protein choices beyond rice, soy, wheat, and pea are becoming viable options, including novel sources of protein such as potato, ancient grains – quinoa, amaranth, sorghum, canola, fonio, and hemp – microalgae such as chlorella and water lentils, myco- and vertically grown fermentation technologies, fruit flour and coffee proteins, and plant-formulated milks and cellular dairy milk (without the cow). See Table 1 for a comprehensive though non-exhaustive list of plant-based proteins; organic variants of each are more expensive to source. Some cited have been in the marketplace a long time (soy, wheat, and pea); others are so new the supply chain is not yet able to supply demand (cranberry and fruit flours); a few are such that protein extraction is still too costly to market effectively (sacha inchi, amaranth, and millet). Successful business propositions are cited for plant proteins – cost efficiency, “green” labeling, non-GMO,

Table 1 Plant-based protein sources

Grain	Nuts/seeds	Fruit	Vegetable	Legume	Microalgae and fungus
Brown rice	Canola	Cranberry	Potato	Soy	Chlorella
White rice	Grape seed	Coffee	Kale	Pea	Water lentils (duckweed)
Wheat	Almond	Fruit flours	Spinach	Chickpea	Spirulina
Quinoa	Pumpkin		Broccoli	Fava bean	Mycoprotein
Amaranth	Hemp			Lentils	
Sorghum/millet	Chia				
Fonio	Sunflower				
Oats	Sacha inchi				
	Peanuts				

enhanced nutritional benefits, sustainable and reliable supply, etc. (Hoogenkamp 2018b). Yet as Hoogenkamp, a futurist speaking for plant-based protein, calls out, "the word 'healthy' is not usually a synonym with good taste" (preface) . . .. "Taste is still the single largest disadvantage of plant protein" (*p.69*).

Sensory Cues and Perceived Fit

Continuous improvements on plant proteins is ongoing. A challenge for soy protein is the beany, grassy flavor (Zhao et al. 2018); reducing the hexanal, a compound associated with these flavors, thus improving the sensory quality of soybean proteins.

A protein powder product benchmarking study provides insights that highlight the variability in sensory quality for protein powder products for the top global sales volume leaders. These products were sourced from across the globe and include brands from the USA, China, Japan, Korea, Thailand, and India. Sensory quality is interpreted with this data as a product that delivers an appropriate identifying flavor, full, balanced and blended flavor, no or minimal off-notes (described as metallic, catty, animal/wet dog, soapy, fecal/dirty, yeasty, cardboard/wet brown paper bag, etc.), compatible mouthfeel (minimal powderiness, grittiness, astringency, etc.), and a short, clean aftertaste. All samples were prepared in water following package instructions and profiled by a trained descriptive panel (N = 9). Data were analyzed using principal component analysis (PCA) and mapped. Figure 1 illustrates selected plain, unflavored protein powders; Fig. 2 shows flavored, sweetened protein powders.

Among the plain, unflavored samples (Fig. 1), Sample A is considered highest in sensory quality and is the most "bland" delivering more soy notes but with a low intensity of any off-notes and aftertaste, including low bitterness. Sample F on the

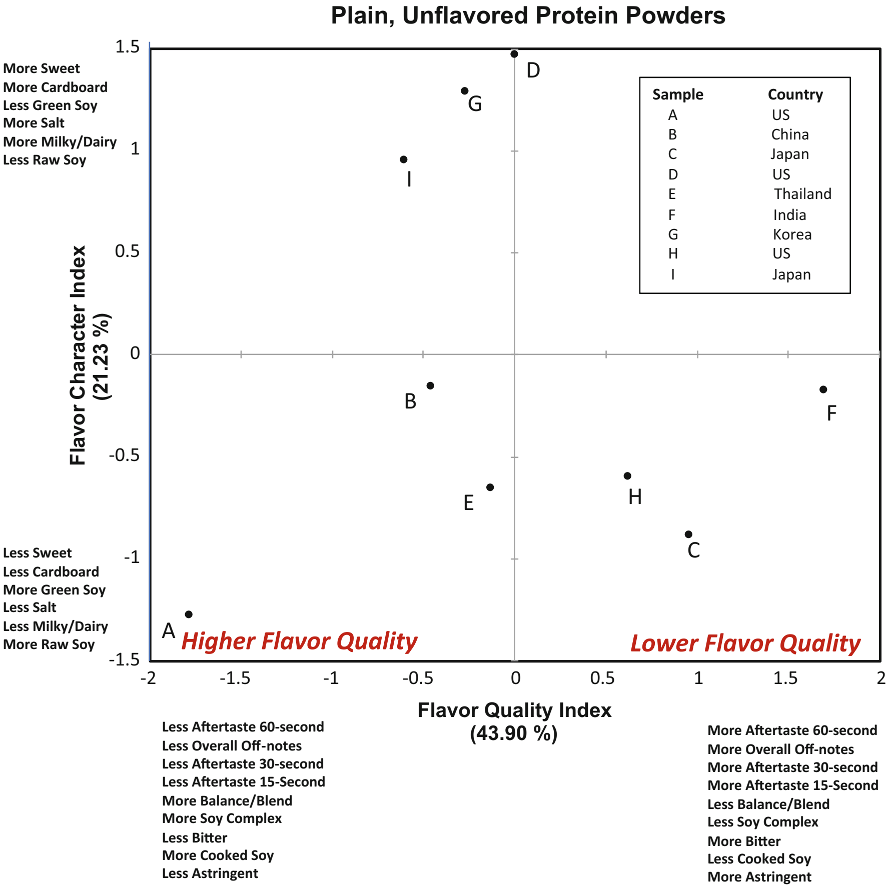

Fig. 1 PCA map of plain, unflavored protein powders – descriptive panel profile data

other hand is ranked lowest in sensory quality imparting low balance/blend, high off-notes, aftertaste, and bitterness. Sample D falls midrange in sensory quality among this set and is the most naturally sweet and more milky/dairy like than others. Examining both sets of protein powders closely against their associated sales indicates sensory quality does not necessarily correlate or order directly with sales volume suggesting; while sensory effects are important drivers, other factors play a role beyond sensory quality – such as consumption/use behaviors with the powders (preparation), perceived functional benefits, and marketing factors that drive purchase and use. That said, taste continues to be the primary obstacle to the consumption of protein powders.

The macro ingredient composition defines the flavor quality of protein powders. Flavors and sweeteners are often added to protein powder ingredients to help mask or mitigate the underlying protein ingredient characteristics. Increasing fiber and

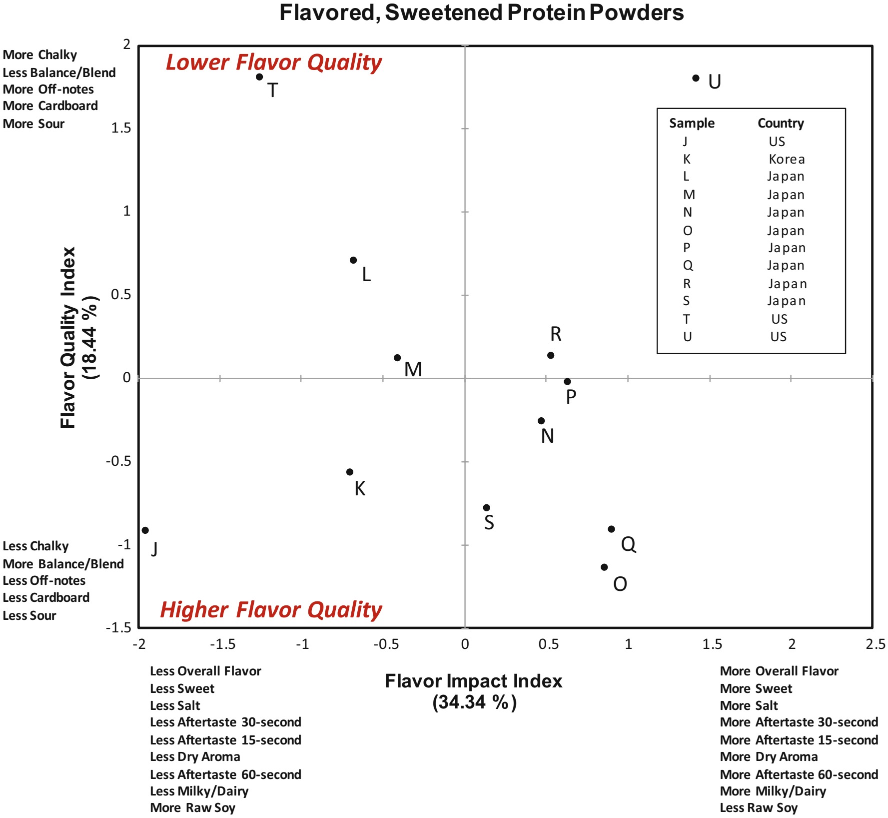

Fig. 2 PCA map of flavored, sweetened protein powders – descriptive panel profile data

protein typically decreases sensory quality, and increasing fat and sugar (to an optimum level) increases quality. Among the flavored, sweetened products (Fig. 2), Sample J was considered the highest in sensory quality delivering a relatively low flavor impact overall; Sample T showed the lowest quality for similar reasons as cited above for the other sample set. Sample U, even though the sweetest, was deemed the least quality product, failing by its chalky aromatics, lack of balance/blend, and off-notes. Products varied within brand across countries where they were sourced.

Undesirable plant-based protein aromatics and textural challenges (i.e., powdery mouthfeel, grittiness, and residual particles – not shared here) are the major differentiators for both sample sets. Our findings indicate that the majority of protein products may benefit from significant improvement in flavor and/or texture quality. There are also some for whom product consistency is a problem. Flavor quality is critical for meeting consumer expectations. Flavor consistency is critical for repeat purchase and builds brand loyalty. Flavor quality and consistency should improve as manufacturers continue to optimize process and product formulations.

With the plethora of new protein products, consumers today have more product choices than ever before. As a result, food and beverage companies face increasing competition for "share of stomach." Flavor benchmarking provides marketers, manufacturers, and suppliers with objective flavor quality information to:

1) Identify the current flavor leaders – the products to meet or beat.
2) Select appropriate flavor quality targets.
3) Quantify the flavor quality gap between the market (or flavor) leaders and second-tier products.
4) Assess the product improvement opportunities and provide a road map for product optimization.
5) Measure flavor consistency, which is a key determinant of repeat purchase.
6) Discover new product opportunities by uncovering underrepresented flavor dimensions.
7) Drive sales!

Acceptance of functional foods or dietary supplements may to some extent depend on the specific carrier and ingredient (Krutulyte et al. 2011). Examining elderly consumers' acceptance of carriers for protein-enriched food, van der Zanden et al. (2015) and van Kleef et al. (2005) found willingness to trial and repeat purchase protein-enriched carriers were considerably higher for tailored, familiar product formats. High protein supplementation was pointed out as a market growth opportunity for senior consumers (Mintel 2019).

Quantifying consumers' ($n = 1158$) attitudes, Urala and Lähteenmäki (2004) found seven factors behind consumers' willingness to use functional foods. The best predictors among the seven factors were (1) perceived reward, a dimension associated with improving one's health and performance and thus giving consumers a tool to take care of themselves and (2) confidence in functional foods. Notably, there were no taste-related statements loading on these factors; the last factor captured the conflict between the health benefit offered by functional foods and trade-off of pleasant taste with three paraphrased statements in brief as follows: (1) good taste more important than health effects, (2) prepared to compromise on taste if functional, and (3) do not buy functional food unless know how it tastes. These researchers concluded from this work that functional food scales could be used for monitoring consumers' attitudes and to predict the success of functional food products and concepts.

In a follow-on study, to further develop and shorten the attitude assessment, these same researchers constructed three measurements: reward from using functional foods, necessity for functional foods, and confidence in functional foods. Because the factor structure changed from the prior study, they concluded that the attitudes for functional foods are not stable and predicted that reported behavior differs depending on the target product. These researchers stress the tool is sufficiently flexible to assess both conventional and functional foods even at the product development concept level. Thus in contrasting and comparing conventional foods to functional foods, they conclude that functional foods in Finland may be approaching the status of conventionally healthy foods, that is, their benefits may become standard options for healthiness (Urala and Lähteenmäki 2007). In other words, what was once a new benefit of value for a functional food may have lost leverage in the marketplace. Perhaps competitors (or in this case, conventional foods) are meeting the specification; the characteristic is still important, but making further improvements will have little impact on consumer choice, i.e., it no longer has leverage in the competitive marketplace. Most characteristics reach a point where further improvement is no longer desired or valued by consumers. Investments in technology need to be focused on high-leverage items in order to deliver greater value to the consumer versus competition; a framework for decision-making is described elsewhere (Paap and Katz 2004).

Sensory techniques continue to advance in support of research on protein products. For example, the daily experience of oral nutritional supplements was examined (Thomas et al. 2018) with liking-thirst-hunger scales using the Alternated Temporal Drivers of Liking (A-TDL) method on full servings of oral nutritional supplements (ONS) administered as ten small glasses taken as a single sip for each of two products. The A-TDL method combines Temporal Dominance of Sensations (TDS) and dynamic liking evaluations; it was applied to reproduce the full daily experience of an ONS (twice daily, morning and afternoon). Observation of 62 older adults demonstrated little reduction in hunger, an increase in thirst during the test session, and differentiation in liking responses over multiple sips during consumption.

Compromise: Taste Versus Health?

Are consumers willing to compromise on taste for health? Evidence abounds to indicate the answer is "No, not likely." Taste matters. Consumers prefer to trust communication on efficacy and dietary advice from experts such as doctors, nutritional scientists, research institutes, and governance but make the final decision on compliance and usage based on tolerance and acceptability. They do not want to suffer undesirable flavors and textures for functional food health benefits.

The rise in senior populations globally offers an opportunity for clinical nutrition products. It is interesting to note that the clinical literature focuses on efficacy and compliance of oral nutritional supplements (ONS) for treating disease-related malnutrition with little attention to the consumer palatability and acceptability of such products (Cawood et al. 2012; Hubbard et al. 2012). ONS are used to increase energy, protein, and micronutrient intake. In fact, mention was made that ONS may be seen as a "medication" by patients, and it was noted that palatability of the ONS used as well as any encouragement or education given about the role of ONS may also have been important, but these were not typically recorded in the studies cited for these meta-analytic reviews.

Verbeke (2006) investigated the sociodemographic and attitudinal determinants of consumer willingness to compromise on taste for health in the specific case of the functional foods category concluding counting on consumer willingness to compromise on the taste of functional foods for health is a highly speculative and risky strategic option. This conclusion is further supported by a study on hedonic versus utilitarian impact on consumer decision-making for food product choices researched by Cramer and Antonides (2011) who showed more participants preferred to keep their hedonic good than their utilitarian good. Even with the knowledge that soy protein isolates and associated isoflavones are dietary constituents that are effective in decreasing risk of cardiovascular disease and cancer, during early development efforts, people found it difficult to comply with long-term protocols using rather unpalatable soy ingredients that had distinctive flavors and textures (Klein et al. 1995). In fact, several earlier studies have documented that pleasantness overrides perceived healthiness when it comes to choice (Tuorila and Cardello 2002). Table 2 provides a list of some publications that focus on examining consumer trade-offs of healthful vs. hedonic choices. Notably many choice-based studies can be found that examine the choices consumer make in regard to ingredients, carriers, and health claims; fewer present actual consumer response to experimental work on the taste acceptability of functional foods.

Consumer Growing Awareness, Changing Attitudes, and The Future

Consumers are exposed to a plethora of health-related information. An authoritative source, the National Institutes of Health (NIH) Office of Dietary Supplements provides a wealth of information for consumers (https://ods.od.nih.gov). Other sources of information come from the Internet, companies marketing their products, consumer interest groups, and other media. The European Centre for Disease Prevention and Control published a technical report, a literature review which cites health information-seeking behaviors on the web for both health consumers and professionals (Higgins et al. 2011). Numerous types of online sources are mentioned; gaps and barriers to use are identified. The Association of Southeast Asian Nations (ASEAN), which is comprised of ten independent countries, includes a healthcare sector that covers regulatory aspects of health supplements and entails an ASEAN Traditional Medicines and Health Supplement Scientific Committee (ATSC) created to assist in providing scientific information and recommendations. Trusted sources of information are sought out by consumers and healthcare professionals worldwide.

Consumers’ Understanding of Health Claims and Their Willingness to Try

A comprehensive review of the literature contrasting the pros and cons of protein supplements indicates a large segment of the global general population relies on protein supplementation for meal replacement, weight reduction, and purported health benefits (Samal and Samal 2018). The understanding and interpretation of health claims by consumers is an important topic to address; consumers may not interpret claims in the same way nutrition and regulatory experts do. Survey categorization of health-related (nutrition and health) claims on foods – how consumers make sense of them and how to appropriately optimize them for understanding –

Table 2 List of research publications of healthful vs. hedonic consumer choice

Reference	Year	Product category	Country	Subjects (N)	Type of stimuli	Scale	Result
(Tuorila and Cardello 2002)	2002	Fruit juices	USA	78	Fruit juices with KCl	9-point hedonic and intensity scales	KCl decreased all ratings of liking; consumption of a functional food will be inversely related to the severity of off-flavor and to the required frequency and duration of consumption
(Verbeke 2006)	2006	Functional foods category	Belgium	1st- N = 2552nd- N = 205	Functional foods survey	Acceptance 5-point Likert scale	Health benefit belief from functional foods emerged as the strongest positive determinant of willingness to compromise on taste, but unconditional compromise on taste decreased over time
(Menezes et al. 2011)	2011	Acaí-based products	USA	155	Energy drink, juice, sorbet, smoothie with acaí	9-point hedonic, 7-point intention to purchase and agree-disagree scales	Consumers' preferences were driven by flavor and aftertaste with identified likes and dislikes of acaí; North Americansrevealed an interest in comprising on taste for functional

							foods, butothers declared that good taste is more important than health effects in a food product
(Hur and Jang 2015)	2015	Healthy meal	USA	870	Hypothetical advertisementthat promoted a healthy meal in a QSR setting	Self-administered questionnaire with a scenario-based survey method designed to measure four constructs (perceived healthiness, anticipated guilt and pleasure, and behavioral intentions), dietary concerns, and demographics	Anticipated pleasure positively influenced behavioral intentions and mediated the relationship between perceived healthinessand behavioral intentions, whereas anticipated guilt did not influence behavioral intentions. Low dietary concerns group was more susceptible to anticipated pleasure compared to the high dietary concerns group
(Lawless et al. 2012)	2012	Juice blend (concord grape and blackberry)	USA	47	Experimental auction sessions with juice and statements of positive benefits of anthocyanins	Willingness to pay (WTP), acceptance, and satisfaction	Contrast effect caused by treatment order (juice or health statement). WTP not correlated to agreement with potential health statement. In-store taste sessions to introduce consumers

(continued)

Table 2 (continued)

Reference	Year	Product category	Country	Subjects (N)	Type of stimuli	Scale	Result
							to product sensory properties recommended
(Tu et al. 2012)	2012	Soy foods	FranceVietnam	French N = 13Vietnamese N = 15	Commercial soy yogurts	Focus groups, samples tasted, questionnaire derived	French and Vietnamese differ in terms of taste and price. Both groups reported positive attitudes toward health benefits of soy foods.
(Maksan et al. 2014)	2014	Functional foods	Croatia	570	Functional foods as topic	Self-administered survey covering knowledge, purchasing behavior, importance, motives, and attitudes toward functional foods	Young consumers (18–30 years old) are buying for health and safety reasons; three functional food segments identified lovers, indifferent, and suspicious
(Jeżewska-Zychowicz and Królak 2015)	2015	Cereal	Poland	1000	Bread, pasta, and biscuits fortified with fiber	Food technology Neophobia scale (FTNS), motives of food choice (health, quality, and hedonic value), and intention to eat	Consumers' willingness to eat cereal products fortified with fiber was significantly determined by attitudes toward new food technologies, health, quality, and

							pleasure as motives of food choice but also by sociodemographic profile
(Ruijschop et al. 2009)	2009	Satiety	NA	NA	Possibility of using sensory triggers, particularly flavor, for inducing or increasing satiation	Covers design of functional foods for durable suppression of appetite	Different aspects influencing sensory satiation are described, and opportunities to design food products that boost satiation by applying specific tools and technologies are discussed
(Durham et al. 2015)	2015	Fresh market potato varieties	USA	2664	Six unreleased varieties and one commonly available Variety of potato, the Yukon gold	Effect of antioxidant information Purchase, liking, price, gender, age, education, income, potato Usage frequency, health interest, and food interest	Hedonic ratings and price had significant Positive and negative effects, respectively, on purchase intent; Information increased purchase intent; personal health interests interact in conjunction with the information

suggests three key dimensions for a consumer typology: (1) familiarity with the nutrient, substance, or food, (2) simplicity/complexity of the claim statement, and (3) relevance of the claim (Hodgkins et al. 2019). Agreeing, Lähteenmäki (2013) contends though health-related information is used on food products, we still know relatively little about consumer understanding of the message content in claims, and more emphasis should be put on including contextual influences and realistic conditions in assessing consumer understanding and use of health claims in purchase decisions. Further research is ongoing and encouraged to explore consumer understanding of health claims in more ecologically valid environments and to apply consumer information models to bring insights into consumer-derived constructs.

Health claims are to be scientifically founded yet are difficult and cumbersome to communicate to consumers; consumers have been found to respond favorably to nonscientifically phrased "soft" health information. Aschemann-Witzel and Grunert (2015) explored to what extent health claims presented in the context of scientific phrasing of health information impact health inferences and attitudes toward a product when compared to "soft" health-related information framing in a study that was conducted in the USA and Denmark. Impact toward a product was compared in the face of contradictory information to assess the robustness of consumer opinions using mock-up media reports. Results showed soft information positively influenced health inferences and attitudes in Denmark, while in the USA scientific information positively influenced health inferences but not attitudes. These researchers concluded communication of nonscientific information can be more powerful, but both informational context and country background are important considerations for consumer perception of health claims.

Rifnaz et al. (2016) report that consumers with the strongest functional food interests and usage demonstrate the strongest motives toward general well-being and health. Perceived health status of respondents was significantly associated with their concerns on degenerative disease, attitude toward functional foods, food consumption motives, and information-seeking behavior. Users' and nonusers' underlying benefit beliefs about protein supplements were compared to find health- and well-being-related beliefs that were associated with an increased likelihood of higher protein supplement intake (Hartmann and Siegrist 2016) thus concluding that users should be better informed to prevent misguided health beliefs. Additionally, other consumer concerns can influence beliefs and decisions. For instance, consumers with concern and perception of "clean-label," referring to what is seen as little processed and "natural" or "free from" negatively associated ingredients, showed communicational framing had very little impact based on categorization (ingredient, function, and value) in their decision-making for purchases (Aschemann-Witzel et al. 2019).

Regulatory authorities and governmental organizations with oversight on nutrition and health claims around the world examine interests in health matters. Legislation is being enforced to help consumers make well-informed decisions. For example, European legislation on nutrition and health (NH) claims, enacted into force January 2007, set out conditions for claim use (ensuring consumers understood the beneficial effects expressed in the claim), a system for scientific evaluation, and created a list of authorized claims. Leathwood et al. (2007) examined consumer understanding of NH claims focusing on the information needed for the average consumer to understand the claim; a stepwise procedure for assessing consumer understanding of NH claims was proposed. Six potential pitfalls are pointed out for the scientific substantiation of claims and possible discrepancies associated with consumer understanding that may impact public health (Mariotti et al. 2010). These six pitfalls include: (1) consumer understanding of terms that are used; (2) misunderstanding of the scientific evidence assessed by experts; (3) differences between specific foods vs. overall diet; (4) consumption of appropriate quantities – is more better (or not); (5) understanding of the impact of genetic, environmental, and dietary parameters; and, lastly, (6) appreciation that nutritional status varies between individuals and populations. The US Food and Drug Administration's regulatory authority over health claims was clarified with the Nutrition Labeling and Education Act (NLEA) establishing mandatory nutrition labeling and placing restrictions on the use of food label claims characterizing the levels or health benefits of nutrients in foods. The significant scientific agreement (SSA) set high scientific standards under which the FDA may authorize health claims. Subsequent legislation known as the Food and Drug Administration Modernization Act (FDAMA) provided an alternative to FDA review of the health claim. Now qualified health claims can be made that are not substantiated to SSA standards, with a qualifying statement. Rowlands and Hoadley (2006) provide an overview of FDA's regulations and evidence-based method for evaluating health claims.

Health claims from the USA, Australia, Canada, Brazil, and European countries are reviewed from the extent of the claims' influence on consumers (Pothoulaki and Chryssochoidis 2009). A synthesis of findings in six thematic categories emerged, namely, knowledge/awareness of dietary issues, effects of health claims on purchase decisions, effects of health claims on perception/attitudes/beliefs, sources of information and trust, framing of health claims and disease risk reduction, and health-enhancing claims as well as consumer purchase decision.

Based on this review, it was unclear whether consumers hold a basic knowledge of essential dietary issues; sociodemographics (gender, age, marital status, and education) play a strong influencing factor. Health claims do not appear overall to affect consumers' beliefs and pre-existing notions about products, though repeated exposure to claims can influence product liking. Sources of information and trust should be examined in addition to consumers' attitudes and beliefs; consumers are usually confused regarding exact benefits of the health claims. Societal and cultural issues may influence consumers' trust and habits/practices. Contradictory evidence exists as to whether consumers are affected by the nutrition information that accompany health claims or by the health claims themselves; consumers' knowledge should not be taken for granted. Disease risk prevention seems to be more appealing to consumers than health-enhancing claims, especially the ones that relate to an illness they may experience. Health claims may impact purchase decisions, but findings are not firmly substantiated – health claims may not play as important a role in purchase as price and taste. Widespread common or similar wording for health claims may turn food products long-term into commodities. Agarwal et al.

(2006) describe the different types of claims that can be made and point out the important role that food/supplement package labels play as educational tools in helping consumers make healthy choices.

Regarding claims, Ares et al. (2009) offer advice following a conjoint study involving ingredients (antioxidants and fiber), ingredient names (common vs. scientific name), and health claims (no claim, "enhanced function" and "disease reduced risk" claims) based on consumers' attitudes (perceived healthiness and willingness to try). The results suggest different health claims could be attractive to different consumers, and, therefore, health claims should be designed accordingly. Recommendations as a result of this conjoint study are as follows: (1) the use of which ingredients resonant most will likely depend on the consumers, (2) compound or scientific names may have a negative impact on consumers and therefore might not be recommend, and (3) listing the ingredient with the scientific name should be accompanied with a health claim on the label to achieve a positive association between ingredient and health effect. Women and older consumers were found to be more positive than men toward particular ingredients. Interestingly, contrary to others, Ares et al. did not find dissimilar consumer attitude toward "enhanced function" and reduced disease risk claims.

In closing the discussion on claims, we are reminded, despite all the work, to ensure the veracity of claims, of the difficulty and challenge in delivering clearly understood, and scientifically based nutrition health claims. To illustrate, despite all the basic and clinical research on probiotics, claim applications failed for probiotic health claims (Rijkers et al. 2011) leading these researchers to recommend open dialogue between basic and clinical scientists, regulatory authorities, food and nutrition industry, and consumers to bridge the gap between science and marketing of probiotics. Implicated in the failure were lack of clear-cut criteria for design and evaluation of studies, restrictions on clinical endpoints, and validated biomarkers for gut and immune health in relation to reduction in disease risk.

Influencing Consumer Acceptance

Numerous consumer studies have been conducted to assess variables that may influence consumers' acceptance of functional foods. Krystallis et al. (2008) set out to identify the functional foods most frequently purchased and to define the most important functional food attributes that affect consumers' purchasing decisions, concluding that functional foods should deliver health benefits above and beyond the standard (high) perceived quality required by consumers from any common food product. Siro et al. (2008) provide a product development, marketing, and consumer acceptance review for functional food. Historically, determinants of consumer behavior include personal, psychological, cultural, and social and features of the functional food itself. Consumers want to be involved in the effort (co-creation) that has impact on their future food choices and diets. Bleiel (2010) focuses on consumer insights, the top 10 mega trends, health concerns, and market opportunities for functional foods Orientation at consumer insights (including co-creation) and translation into relevant, noticeable benefits are deemed necessary to potentially impact the market.

Trust in health-related information and belief in the health effects of functional foods is crucial for consumers' acceptance (Verbeke 2005) and intention to consume (Cox et al. 2004). Finnish peoples' trust in health-related information plays an important role in functional food choices (Urala and Lähteenmäki 2007); trust in functional foods seeming to differentiate Finns into three categories: (1) trustful, (2) doubtful, and (3) unconcerned (Niva et al. 2003).

Environmental safety and sustainability have become competitive driving forces in the marketplace. A study was conducted (Hartmann and Siegrist 2017) to address whether consumers are aware that meat consumption has a large environmental impact and to assess if they would be willing to reduce and accept meat substitutes and alternative proteins in order to create a more sustainable and environmentally friendly food supply; they concluded that awareness and willingness are low and further studies are lacking to motivate behavior change. In contrast, Stranieri et al. (2017) have more encouraging news with their goal of investigating determinants behind purchase of healthy foods with environmentally sustainable attributes revealing positive relations with consumer food shopping habits, food-related environmental behavior, gender, income, and knowledge. In examining barriers and facilitators toward adopting a more plant-based diet, Reipurth et al. (2019) indicate consumers are aware of recommendations toward healthier and more sustainable food consumption, but often they do not follow them. Barriers included negative attitudes about protein content, satiety effect, taste, and environmental and health effects, while the ease of cooking, taste, protein content, satiety effect, and availability of plant-based foods were found as positive attitudes suggesting targeted health campaigns toward promoting plant-based diets.

With a more specific target in mind, Stratton et al. (2015) examined food neophobia associated with acceptance of and willingness to consume functional foods in the elderly. Those with higher degree of food neophobia were less willing to try a new functional food, and most barriers included availability and concern about contradictions with prescription medications. Relatedly, den Uijl et al. (2017) found older adults do not always meet their recommended protein intake. They explored mealtime functionality as a basis for tailoring protein-enriched (PE) meal concepts.

In conclusion, influencing consumers in the realm of functional foods, especially for protein products that are migrating through disruption innovation spaces, poises a complex, dynamic challenge and growing opportunity – for all involved. An integrated view wherein consumers (with their myriad of experiences, beliefs, interests, and trust), food product developers and all their external partners, nutrition and regulatory experts, as well as governmental organizations involved with health and nutrition will need to connect and engage for success.

Summary

The plant-based products industry is still burgeoning with new proteins being integrated into the marketplace; today's challenges remain, namely, regulatory hurdles and mainstream acceptance, driven by consumer confidence and concerns about quality and nutritional value (L.E.K. Consulting 2018). The challenge of providing better nutrition at the trade-off or sacrifice of lower sensory quality and use experiences remains a major obstacle for industry to acquire and maintain consumer acceptance. Personalized nutrition is underway by the use of technology via devices and nutrition apps as well as through understanding and management of diet-gene interactions using evidence-based research methodologies.

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Edible Insects

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Arnold van Huis

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Abstract

In the tropics more than 2000 insect species are eaten. Most are only seasonally available, and the local population uses a number of techniques to harvest them. In the western world, insects are not known as food. However, alternative protein sources are needed as the agricultural land available in the world is not enough to satisfy the growing demand of meat. Among those sources are algae, mycoproteins, cultured meat, plant proteins, and insects. The nutritional value of insects is comparable to meat products. The environmental impact from rearing insects is much less than livestock production: insects emit less greenhouse gases and need much less land and water. When insects are promoted as food, harvesting more from nature is not an option and they need to be farmed as mini-livestock. The interest in the western world to use insects as food is growing. This is exemplified by the exponential growth of the number of publications as

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well as the number of start-up companies. Major hurdles in western countries are the creation of a legislative framework, automation to reduce the cost price, and the development of strategies to convince consumers. Consumer strategies are: an affordable price, developing tasty products, incorporating insect ingredients in familiar products and to give consumer a taste experience. Producing insects as food may become a new agricultural sector.

Introduction

The increased demand for meat products cannot be satisfied in the future because the area available for livestock will be insufficient. Eighty percent of all agricultural land is already used for livestock (3,400 million ha as pastures and 500 million ha as crop land). Livestock also decreases food supplies, since the grains used as feed could be used for human consumption (Van Huis and Oonincx 2017). About a third of the world's cereal production is fed to animals. On environmental impact, a comparative study between mealworms and livestock showed that a gram of edible protein from beef requires 8–14 times as much land and approximately 5 times as much water, while broiler chickens are associated with 32–167% higher greenhouse gas emissions, and beef cattle emit 6–13 times more CO_2 equivalents (Oonincx and de Boer 2012).

Research on alternative protein sources is concentrated in vitro cultured meat, seaweed, duckweed, canola/rapeseed, microalgae, mycoproteins, and insects. In this chapter, we focus on insects.

The Consumption of Insects Worldwide

Insects can be used either as human food or as feedstock for pets, fish, poultry, and pigs. One could argue whether it is a good idea to feed insects to production animals, which are then in turn eaten by humans (two conversion cycles). When the insects are fed with the same substrate as the production animals, the conversion process is probably prohibitively expensive. In this chapter, we will only deal with insects as human food.

Often when referring to the eating of insects the word "entomophagy" is used, derived from the Greek words "entomon" (insects) and "phagia" (to eat). It is a somewhat derogatory word for a food habit which is often considered primitive by western people. Probably because the practice is alien to western people while it is customary in tropical countries. However, more and more, people in western countries discover the benefits of eating insects as a sustainable, nutritious, and healthy food source. More and more the eating of insects is considered a normal food habit and not much different from eating shrimps, which are very closely related to insects. This is exemplified by the growing number of private enterprises rearing and marketing edible insects and the increasing number of articles in the popular press and in peer reviewed scientific journals (Shockley et al. 2017).

In general the consumption of insects by early humans has been undervalued in comparison to food plants and wild meat. It seems that insects were an important dietary component, because (1) insects are eaten by virtually all nonhuman primates; (2) insects are an important part of the diet of many traditional societies; and (3) there is archaeological evidence of insectivory by hominids (Van Huis 2017).

It is estimated that there are about 5.5 million insects species in the world and only 1 million of those have been described (Stork 2018). Most of these species are beneficial: producing honey and silk and providing ecological services such as pollination, decomposition, recycling, and biological control of pests through parasitoids and predators. Only 5,000 (less than 0.1%) are considered harmful for humans, animals, pets, and plants (Van Lenteren 2006). Concerning edible insect species, there are worldwide more than 2100 species and most of those occur in tropical countries where they are collected and harvested from nature. The species can be divided into the following categories: beetles (31%), caterpillars (17%), ants, bees and wasps (15%), grasshoppers (13%), true bugs (11%), dragonflies (3%), termites (3%), cockroaches (2), spiders (1%), and others (2%) (Fig. 1) (Jongema 2019). Some countries have a very high number of recorded species. This may be a matter of more extensive research, for example, in Mexico, where one person authored many publications on the topic (Pino Moreno 2016). Most insect species are harvested from nature. But there have been examples where the local population enhanced their occurrence before harvesting. One example is the palm weevil, which is a snout beetle of the genus *Rynchophorous*. If you deliberately cut the tree, palm weevils are attracted by the rotten odor, lay their eggs in the trunk, and the hatched larvae develop on the trunk tissue which can then a few weeks later be harvested as food by the local population (Van Itterbeeck and van Huis 2012). This palm weevil is considered a delicacy in Africa, Asia, and Latin America.

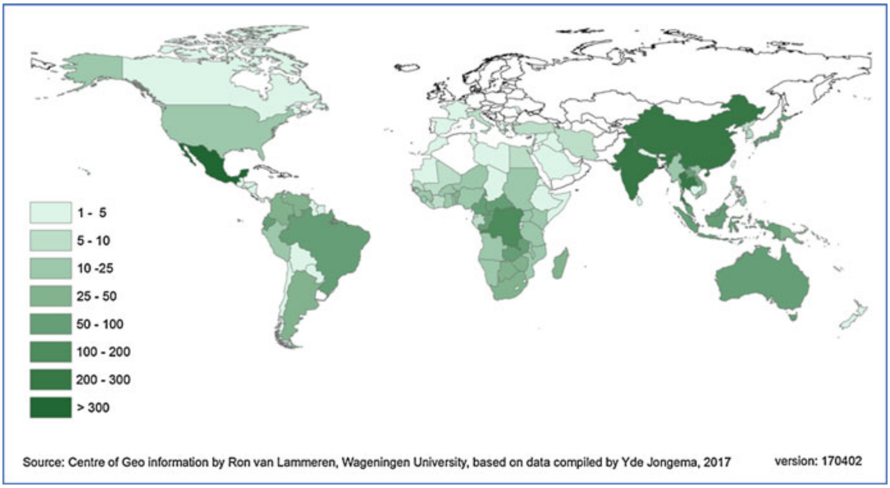

Fig. 1 Recorded edible insect species in the world (Jongema 2019)

Collection is often done by hand, but some insect species like the grasshopper *Ruspolia differens* in East Africa are collected during a certain time of the year by using light. Attracted by street lights they are often collected by women and children, because of the traffic a dangerous undertaking. Commercially they can also be collected, such as in Kampala Uganda by using electric lights shining into the sky. The attracted grasshopper falls on corrugated iron sheets folded to a cone shape and leading to a large collection bucket (Mmari et al. 2017). Light is also used to collect winged termites, which emerge from holes near the termite hill after the first rains following the dry season. The most common way to collect them is by placing a light above a receptacle with water. The attracted termites fall into the water, loose their wings, and are then scooped out.

However, procurement of insects by harvesting from nature is likely to become less common. The causes are: urbanization, limited availability because of seasonal occurrence, unpredictability, diminishing occurrence due to overharvesting and pollution, in particular of waterways (Van Huis and Oonincx 2017). To become a regular food source, insects need to be reared like livestock ("mini-livestock"). Experience in the large scale rearing of insects is mainly available in pest management, either by companies that rear insects as biocontrol agents or for the production of males in the sterile insect technique. In March 2019 there were 241 companies listed worldwide to produce edible insects (Bug Burger 2019).

The scientific interest in edible insects is growing exponentially. Searching the Web of Science (consulted March 2019) using "edible insects" resulted in the number of 196 publications in 2017 and 2018 compared to 162 for the preceding 10 years (2007–2016).

Which Insect Species Are Consumed in Western Countries

A number of companies that started to rear edible insects were already producing insects as feed for birds, reptiles, and aquaria fish. In order to comply with food laws, they needed to modify rearing techniques and procedures, like producing under more stringent hygienic conditions and to install a track and tracing system. For newcomers on the market, the problem is that they have to start from scratch, as most companies do not reveal how they produce the insects and which kind of substrates they are using. The most common insect species reared for human consumption are the following:

Beetles. Three mealworm species of the family Tenebrionidae are often used: the yellow mealworm (*Tenebrio molitor*) (Fig. 2), the lesser mealworm (*Alphitobius diaperinus*), and the superworm (*Zophobas morio*). Palm weevils, curculionid beetles, are popular food throughout the tropics.

Crickets, locust, and grasshoppers. The most common reared cricket is the house cricket (*Acheta domesticus*) (Fig. 3). However, other cricket species can also be considered such as the tropical house cricket (*Gryllodes sigillatus*) and the two-spotted cricket (or African or Mediterranean field cricket) (*Gryllus bimaculatus*).

Fig. 2 The larvae of the yellow mealworm, *Tenebrio molitor* (Coleoptera: Tenebrionidae). (Photocredits and copyright: Hans Smid – www.bugsinthepicture.com)

Fig. 3 The house cricket, *Acheta domesticus* (Orthoptera: Gryllidae). (Photocredits and copyright: Hans Smid – www.bugsinthepicture.com)

The migratory locust (*Locusta migratoria*) and the desert Locust (*Schistocerca gregaria*) are both reared for human consumption. These insect species can also be consumed by Muslims and Jews.

Caterpillars. The greater wax moth or honeycomb moth (*Galleria mellonella*) is considered by some a delicacy (Martin 2014; pp. 35 and 232) (Fig. 4). Also, the pupae of silk worms (such as *Bombyx mori*) are consumed as food.

Bees and wasps. In the Central region of Japan, the wasp *Vespula flaviceps* is a seasonal delicacy, which can be captured in the wild but they can also be raised in people's backyard (Payne and Evans 2017). Also bee drones are used as food and even a cookbook is based on this (Ambühl 2017).

Fig. 4 Caterpillar of the greater wax moth or honeycomb moth, *Galleria mellonella* (Lepidoptera: Pyralidae). (Photocredits and copyright: Hans Smid – www.bugsinthepicture.com)

Maybe there are other insects around that can be reared for food and we can choose from the list of more than 2100 (Jongema 2019). The major criteria of selection will be how appetizing they are, how easy they can be reared, and whether a cheap feeding substrate can be found.

Nutrition

Because of the many species that are eaten it is difficult to generalize. However, some studies have reviewed the literature. Rumpold and Schlüter (2013) concluded from more than 200 edible insect species that many provide sufficient energy and protein, meet amino acid requirements for humans, and are high in monounsaturated fatty acids (MUFA) and/or polyunsaturated fatty acids (PUFA) and rich in several micronutrients such as copper, iron, magnesium, manganese, phosphorous, selenium, and zinc as well as riboflavin, pantothenic acid, biotin, and in some cases folic acid. Payne et al. (2016) using the Nutrient Value Score found that crickets, palm weevil larvae, and mealworms were significantly healthier than beef and chicken. The high iron content of some insect species like crickets and caterpillars is beneficial considering that one quarter of the world population is at risk of iron deficiency anemia. However, bioavailability remains an issue to be studied (Mwangi et al. 2018). Bauserman et al. (2015) administered a caterpillar cereal to infants in the Democratic Republic and found that fewer were anemic.

The nutrient content of edible insects not only depends on the species but also on diet, developmental stage harvested, and environmental conditions (Finke and Oonincx 2014). The fatty acid content, unlike the protein content, can be very much influenced by the diet. For mealworm it was shown that saturated fatty acids (SFA) and PUFA percentages and an n-6/n-3 ratio could be made more suitable for human consumption (Dreassi et al. 2017). For example, Francardi et al. (2017) added linseed as a source of n-3 acid to the diet of yellow mealworm to lower the n-6/n-3 ratio in order to make it more suitable for human consumption. This is more useful for the secondary prevention of cardiovascular diseases. Recently it was found that insects like migratory locusts, house crickets, and yellow mealworms can synthesize vitamin D de novo and that the amounts depend on ultraviolet irradiance and exposure duration (Oonincx et al. 2018).

The taste of caterpillars tends to be close to the plants that they eat. For example, the taste of the cassava caterpillar *Elaphrodes lactea* is like that of its leaves (Malaisse 1997; p. 209). We know that diets can influence the nutritional value of insects (Finke and Oonincx 2017); however, there is not much research about the possibility to influence the taste of insects by feeding them special substrates.

Health Benefits

The exoskeleton of insects is composed of chitin, a modified polysaccharide that contains nitrogen. Humans and other mammals have chitinase and chitinase-like proteins that can degrade chitin. Humans do not synthetize chitin and thus it is considered as a potential target for recognition by the immune system (Elieh Ali Komi et al. 2018). Chitinases seems to play a crucial role in regulating the immune response in relation to bacterial infections and inflammatory diseases and can be used as diagnostic and prognostic markers for numerous diseases (Di Rosa et al. 2016).

Stull et al. (2018) evaluated the effects of cricket powder on gut microbiota composition. They found that cricket powder supported growth of the probiotic bacterium, *Bifidobacterium animalis*, which increased 5.7-fold, while levels of a pro-inflammatory cytokine were reduced. Therefore, eating crickets may improve gut health and reduce systemic inflammation; however, more research is needed to understand these effects and underlying mechanisms.

Other health effects have been summarized by Roos and van Huis (2017). Some insect species stimulate angiotensin-converting enzyme (ACE) inhibitors which may reduce blood pressure. There are also indications that some insect species, like yellow mealworm, have bioactive compounds to induce weight loss and that silk-worms reduce symptoms of Parkinson’s disease.

Food Safety

What are the risks for human health when consuming insects? They could be chemical, microbiological, and allergenic hazards and prions. The risks have been reviewed by Van der Fels-Klerx et al. (2018). This review deals with insects as food and feed. When insects are used as feed, several species are of particular interest when grown on low quality substrates. We will deal only with insects used as food.

In yellow mealworm several heavy metals, like cadmium, lead, and arsenic, accumulate with increasing concentration in the substrate, although for the first two not beyond permissible levels. Their levels seem to decrease during molting and metamorphosis. Several studies showed that mycotoxins are metabolized by the yellow mealworms but do not accumulate. Few studies deal with the accumulation of resides of pesticides, veterinary drugs, and hormones.

Microbiological hazards for human health in insects are affected by a combination of the substrates used and the processing steps applied after rearing.

Proper heat treatment before consumption may eliminate most microbiological hazards and has been shown to be effective in particular against Enterobacteriaceae, although bacterial spores are not affected (Van der Fels-Klerx et al. 2018). Particular attention should be paid in the storage of processed products and in the household treatment of fresh insects. It is possible to produce end products with low microbial numbers that could be kept low during storage, especially by the use of modified atmosphere packaging (Stoops et al. 2017).

Concerning allergic reaction when eating insects, cross-reactivity may occur in patients allergic to house dust mites and crustaceans. The main allergens identified are the protein tropomyosin and arginine kinase (Verhoeckx et al. 2014). van Broekhoven et al. (2016) showed that heat-processing might decrease, but not eliminate, the risk for allergic responses when consuming mealworm species. Evidence for the association between consumption of insects and allergenic effects of chitin is lacking.

When insects are reared on organic by-products, one should be aware of contaminants. Some insect species can deal with chemical contaminants. For example, Van Broekhoven et al. (2017) showed that the yellow mealworm degraded and excreted the mycotoxin deoxynivalenol, although it remains to be studied whether possible resulting metabolites would be toxic.

Insect Food Products

Insects as food can be brought on the market as whole insects such as the bamboo caterpillars in the Lao People's Democratic Republic (Fig. 5). In the western world, they are often disguised in insect products such as pastas from mealworm or cricket flour (Fig. 6), jungle bars, protein bars, cricket flours, snack packs, insect candies, and biscuits, among others.

In South Korea, a high-protein yoghurt was prepared by adding different concentrations (0%, 0.5%, 1%, and 2%) of powder of the grasshopper *Oxya chinensis sinuosa* (Kim et al. 2017). However, except for color and texture, taste, flavor, and overall acceptability decreased with increasing proportions of the powder.

Manufacturing 3-D printed snacks from wheat flour dough enriched with ground yellow mealworm larvae has also been attempted (Severini et al. 2018). Baked under certain conditions, the enrichment with the insects significantly increased the total essential amino acid and protein digestibility corrected amino acid score. There was no adverse impact on quality.

In Mexico, the grasshopper *Sphenarium purpurascens* is a pest of corn, bean, and alfalfa and it can be controlled by pesticides, but the insects can also be captured and used as food (Cerritosa 2008). Extruded snacks have been made based on nixtamalized maize enriched with grasshopper meal (8/100 g of maize) without

Fig. 5 Packed bamboo caterpillar, *Omphisa fuscidentalis* (Lepidoptera: Crambidae) on the Tlat Dong Makkhai market near Vientiane, Lao People's Democratic Republic. (Photo by author)

Fig. 6 Cricket pasta. (http://tinyurl.com/yyhdvrk4)

affecting the physicochemical properties and acceptance of the snack (Cuj-Laines et al. 2018).

A patent was filed for the consumption of a scorpion in a novelty drink form (Turner 2019). The edible scorpion is suspended in a mixture of alcoholic or nonalcoholic fluid. It is prepared in a fashion that poses no health risk if consumed, either swallowed with the beverage or consumed thereafter once the beverage is finished. There are also websites that recommend which kind of wine or beer pairs with an insect snack (Jimini's 2019). Also red wood ants (*Formica rufa*) have been used to make a gin, the ants bringing the citrus flavor (Evans et al. 2017; p. 222).

The cockroach *Diploptera punctata* does not lay eggs but larvae. The developing offspring are nourished directly by the mother from the brood sac wall. This assures a rapid development of embryos that are able to drink and, importantly, store complete nutrients (protein, carbohydrate, and lipid) concentrated in crystalline form (Banerjee et al. 2016). Researchers isolated in vivo-grown crystals from the mid-gut of an embryo. A single crystal is estimated to contain more than three times the energy of an equivalent mass of dairy milk. Researchers have the sequence and hope to be able to produce the crystal in much larger quantities, making it more efficient than extracting crystals from cockroach's guts.

There are companies that produce ice creams from insect milk, apparently made from the black soldier fly (Bessa 2018).

Consumer Attitudes

There are several strategies that have been proposed to increase the acceptance of insect based products (van Huis 2016): (1) deliciousness; (2) providing information about nutritional value, sustainability and food safety; (3) stressing the proximity between crustaceans and insects; (4) giving people a taste experience, such as bug buffets; (5) using role models like political figures, film stars, or cooks, such as those of the world famous insect serving restaurants like NOMA in Denmark and D.O.M. in Brazil; (6) writing cookbooks for insects available in the country; and (7) targeting children as they are not biased yet. A study by Hartmann and Siegrist (2017), reviewing 38 articles dealing with alternative proteins, showed that the sustainability angle may not be convincing enough to motivate people to eat insects: their willingness to reduce or substitute meat (e.g., by insects) was not very high. Consumers apparently are not very much aware that meat production has a high environmental impact. But consumers are able to enumerate manifold substitutes for meat, as studies in Germany, France, and the Netherlands showed. However, traditional eating habits (liking the taste of meat) and lack of knowledge how to prepare meat-free meals seem to be major impediments to reducing meat consumption (Weinrich 2018). Therefore, it seems that substituting meat once or twice a week is a more realistic option. Tan and House (2018) suggested to focus on demand-side factors (changing consumer perceptions) and supply-side factors (creating tasty, usable, distinctive, and accessible products). They emphasize that initial motivations to eat insects and repeated consumption are two different things, and the two should be distinguished in future scholarly and commercial efforts. Interestingly, consumers of insect and vegetarian products are perceived as more health conscious, environmentally friendly, imaginative, brave, interesting, and knowledgeable than meat consumers (Hartmann et al. 2018).

In a representative survey in Belgium, about 80% of the people were aware of the fact that foods with insects can be bought, 11% had already eaten foods with processed insects, 32% had no experience but were willing to try, and 57% had no experience or interest in tasting such products (Van Thielen et al. 2018). Of potential consumers and depending on the product about 50–60% accepted invisible processed mealworms in energy shakes, energy bars, burgers, soup, sandwich spreads, unfried snacks, and fried snacks. Consumers indicated that the presence of insects should be clearly declared on the package and that they wanted to be able to buy these products primarily in the supermarket. In the same country, an experiment was conducted in which consumers were asked to taste insect burgers and rate them for quality and nutritiousness (Schouteten et al. 2016). This was done by giving a control group no information while the treatment group received information about insects having high-value proteins and their production being beneficial in terms of sustainability and the food safety. The liking for the insect-based burger was significantly higher among the informed than the noninformed consumers. The main conclusion of this study is that deliciousness is crucial. When consumers are willing to try the insect burger, but do not like the taste, they might not be willing to eat it again.

A study in Germany using mealworms suggests that higher prices lead to higher willingness-to-pay (Berger et al. 2018b). This is based on the assumption that introducing insect-based foods by means of “luxury consumption” may actually help to kick-start (initial) demand. The same authors (Berger et al. 2018a) also looked at motivations to eat insects: utilitarian benefits (environment and health) or hedonistic (taste). Their results show that hedonic claims of insect-based products lead to higher expectations, which then result in higher consumption probability and higher taste ratings. Based on these findings, they propose when marketing insect-based foods to use hedonic instead of utilitarian messages.

One has to be careful with the term “insect eating.” This because of the large variety of insect species that can be eaten and the preferences of certain consumer groups. Van Huis (2003) already showed that neighboring ethnic groups in sub-Saharan Africa may eat different insect species. A nice example of cultural differences is given by Tan et al. (2015). They conducted focus group discussions to explore the different consumer perceptions and expectations regarding insects as food in two different cultural contexts – one where insects are eaten (Thailand) and one where insects are generally not eaten (The Netherlands). One of the insects studied was mealworms which are sold as food in the Netherlands but not in Thailand. The Thai participants were strongly repulsed by mealworms, due to the association with larvae that they often see in decaying matter. This shows that the preference towards certain species depend on cultural background and individual experience.

Challenges

In addition to the “general food hygiene requirements,” the production and marketing of insects as food in Europe is governed by the so-called “Novel Foods” legislation – i.e., Regulation (EU) No 2015/2283 (IPIFF 2019). This legislation applies to all categories of foods that “were not used for human consumption to a significant degree” within the European Union before 15 May 1997, which is the case of insects and insect-derived products. Novel food applications have to be submitted to the European Commission. In several EU countries, insect producers may continue to commercialize their products, even in the absence of EU novel food authorization. This is a transitional measure that aims to ensure that products which were lawfully commercialized in a Member State of the EU before 1 January 2018 – i.e., date of application of the “new” novel food legislation – may remain on the market of this particular country for a given period of time, subject to certain conditions.

Another challenge is the cost price. A large part of the cost price is labor costs. For that reason, many companies are engaged in developing automation processes. This will require the cooperation of engineers (Kok 2017). The techniques and methods used are also called entotechnology which deals with: organisms and feeds, process types, reactor types, environmental requirements, heat and mass transfer, materials handling, process control, air conditioning, waste management, cleaning, strain breeding, culture maintenance, population synchronicity, and safety. Because a lot of trial and error is involved, the companies are very secretive about their production procedures. Another way to cut the cost price is the use of cheap organic side streams. For example, crickets can be reared on cassava leaves (Caparros Megido et al. 2016) and certain weeds (Miech et al. 2016). Also mealworms can be reared on organic side streams (Oonincx et al. 2015; van Broekhoven et al. 2015) and vegetable and fruit remains (Ramos-Elorduy et al. 2002), although in the last case the larvae were used as poultry feed. In the case of organic side streams, one has to be aware of food safety issues.

Although we know many insect species that are eaten in the world, only very few are currently on the western market. The reason is that those insect species were already reared as pet food. It will require some research to find out if we can also rear some of the more than 2000 edible insect species that are known to be eaten around the world.

To convince consumers to eat insect-derived products is another major challenge. According to Tan and House (2018), regular insect consumption is determined by previous experience, culinary knowledge, wider cultural associations, established routines of food provisioning and eating, and the availability, price, form, and taste of products. Insects may be eaten out of curiosity and that is often done once. However, making it a regular consumed food item is something else. The willingness to consume is not necessarily translated into sales. The importance of taste is often stressed (Van Thielen et al. 2018) and the target group are those consumers, who are open to try novel foods and interested in the environmental impact of their food choice (Verbeke 2015).

A major question often asked: what about insect welfare when insects are farmed as mini-livestock? The Council on Animal Affairs in the Netherlands produced a report (RDA 2018) in which they recommend to respect the intrinsic value of insects and to treat insects in captivity as “sentient beings.” Although there is no scientific evidence to date that invertebrates are capable of suffering, there is no evidence to the contrary either. There are indications, however, that certain invertebrate families (such as octopuses and bees) can experience states resembling emotions. Investments in the welfare of insects would also seem to be in the producers’ own interests. Adapting farms to suit the needs and developmental stages of certain species as much as possible not only increases production, but is also important for the social acceptance of the insect industry. This adaption has to do with husbandry requirements, welfare protocols, and killing methods for edible insect species.

Conclusion

Insects as food is a new upcoming agricultural sector and it has only been realized since about 10 years that this may be an interesting food source in terms of nutrition and the environment. In particular because the search for alternative proteins is considered a priority by many governments. Business as usual with regards to proteins is not an option anymore. Authorities may consider it a promising sector, but also a new one with much uncharted territory. The anticipated growth necessitates answers to questions regarding the relevant interests of humans, animals and the environment. For that reason, it is important that stakeholders nationally and internationally collaborate and challenge public institutions to create a conducive environment for the industry to develop.

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Part X

Food Service

An Overview of the Foodservice Industry 47

John S. A. Edwards

Contents

Abstract

This chapter is the first of two chapters which together provide an outline, an overview, of the foodservice industry – the second chapter considers the consumer of foodservice.

The foodservice industry is heterogeneous, complex in its organizational structure, and with very little agreement either nationally or internationally, in

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areas such as definition and classification. As a result, it is often difficult to get reliable data on which to compare performance and gain a true understanding of the foodservice industry.

This chapter seeks to clarify some of the semantics involved before suggesting a possible definition of foodservice.

The chapter then goes on to outline organizational structures firstly noting that globally the foodservice industry comprises primarily small independent units rather than chain operations as is often assumed. Two prevalent organizational structures, franchising and contracting out, are covered in outline.

Food production and the service of food can be undertaken in a number of ways, and the more popular are considered, although in practice many are actually a hybrid of these.

The types and styles of menus are considered, and then, in an industry often described as a "people industry," the labor element is outlined.

Introduction and Overview

In many organizations, business, commercial, and government (BSR 2018; Murray 2007; USDA 2018), foodservice is often regarded and considered to be part of and allied to the "food (agriculture) industry," particularly where it is associated with feeding in the public sector. Elsewhere it is generally regarded as part of the "hospitality industry," or the "hospitality and tourism sectors," and therefore a "service industry." The latter approach has been adopted here in the introductory chapters.

Irrespective of this delineation, to say that the foodservice industry is large, complex, and diverse would be an understatement. The hotel, catering, and tourism sectors combined produce an estimated 3% to 4% of gross domestic product (GDP) in most of the world economy and employ approximately 3% of the world's total labor force (ILO 2018).

In 2016, the global foodservice industry had total revenues of US$3,628.6bn which, between 2012 and 2016, represented a compound annual growth rate of 4.5%, (Business Wire 2018). As in the illustration (Fig. 1), the amount of money spent in one country (China) on eating out exceeds the total gross domestic product of a number of countries, while the total spent on eating out in the top countries is given in Fig. 2.

Chapter Aim

The introduction to foodservice is divided into two chapters. The purpose of this chapter is to offer an overview, an introduction to foodservice, and the foodservice industry. It commences by firstly providing and clarifying the semantics often found both in practice and in the literature; it identifies what foodservice actually is and how it might be categorized, the shape, size, and nature of the foodservice industry,

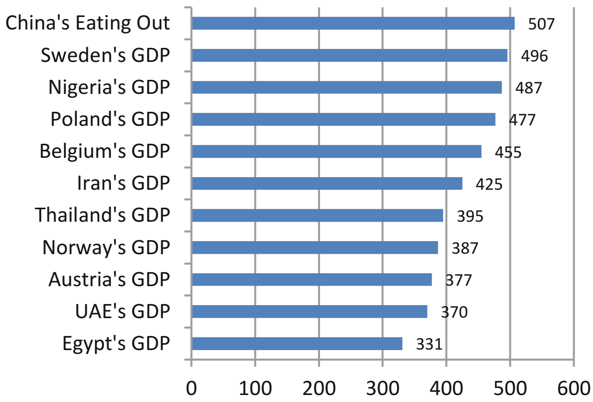


Fig. 1 China's expenditure (US$bn) on eating out in 2016 compared with gross domestic product of selected countries. (Source: Huang 2017)

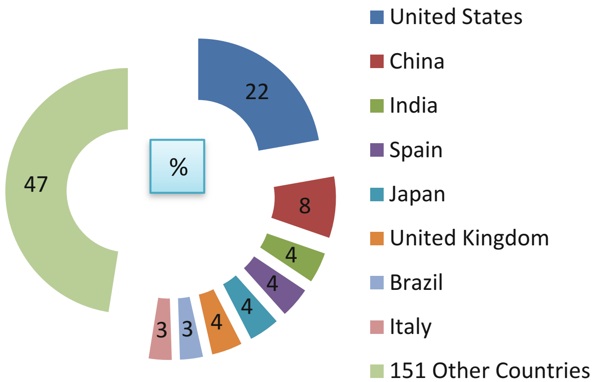


Fig. 2 Countries with highest spending on eating out (US$). (Source: Cushman and Wakefield 2017)

before considering some of the more common characteristics that can be found which distinguishes it from other industries.

However, in order to fully understand the intricacies and nuances of foodservice, it is also important to consider and outline "the other side of the coin," which is the demand side (as opposed to the supply side). ▶ Chapter 47, "An Overview of the Foodservice Industry" therefore, considers consumer aspects of foodservice in order to better understand the consumer and put the foodservice industry into context.

The Foodservice Industry

Terminology and Semantics

The first issue to be addressed is one of semantics, where the terminology in use is often confusing, used interchangeably, and can have different meanings, even in different parts of the English-speaking world.

As noted earlier, the foodservice industry is generally regarded as part of the service sector, as opposed to business and industry, which in turn can be classified as part of the hospitality industry and/or hospitality and tourism sectors, hence the all-embracing term “hospitality.”

The food and hospitality industry is about providing food, drink and accommodation. It also involves entertainment, fitness and leisure workers in the hospitality industry. (Collins 2018)

Another commonly used term is food and beverage, often found, for example, in hotels to identify that part of the hotel responsible for delivering the function, hence “food and beverage (F&B) manager” or food and beverage agent (Hilton 2019).

The more commonly found terms are “foodservice” (USA), “food service” (UK), and “catering” (both in the USA and the UK). The variation in the two spellings of foodservice is generally attributed, in the USA at least, to the two words being combined in order to help avoid any confusion and to better emphasize and differentiate it from the actual service of food.

Where confusion does often occur is with the words “foodservice” and “catering” which tend to be used interchangeably but which have different connotations and meanings, certainly on each side of the Atlantic. Foodservice in the USA is used when referring to the industry, whereas catering tends to refer more to the physical provision of food by a caterer, for example, at a “catered event” such as a wedding. In the UK, catering is used to embrace both the industry (the catering industry) and also all other aspects associated with the provision of food and service at other events. Interestingly, the United States Department of Agriculture (USDA) uses the term “food service” (USDA 2018), although another English-speaking country, Australia, uses the term “foodservice” (Australian Food News 2019). More recently the use of the term food service (foodservice) has become prevalent in the UK and often used synonymously with catering. The terms foodservice and catering have been adopted in this publication.

Other examples where different expressions or words may be used in different parts of the English- speaking world, such as “takeaway” and “takeout,” are identified in the appropriate section of this chapter.

What is Foodservice?

What then are foodservice and the foodservice industry; how might they be defined?

As already alluded to, the foodservice industry is large and complex and comprises a vast number of elements or segments, and in terms of its size and diversity, it is truly heterogeneous. What exactly then is foodservice?

Definitions abound, although there is no one agreed or standard definition, and any Internet search highlights endless possibilities and includes dictionary, academic foodservice textbooks, market research organizations, professional and trade associations, and government organizations. Historically, an academic definition might be along the lines:

> *The provision of food and beverages away from home.* (Davis et al. 1998)

However, this type of definition does not fully capture what might be the full function of the foodservice industry and raises a number of other issues:

If a prepared roll, sandwich, or "donut" is purchased from a sandwich shop, bakery, or café and consumed on or off the premises (foodservice), is that different if the same item was to be purchased from a supermarket (retail) or is it still foodservice? The answer often given is that the café provided an element of service not found in a supermarket. However, the content could be similar, as would be the labor element in the preparation and sale (the service component), so how should they both be classified? If that same sandwich came from a vending machine, there is a service element involved in its preparation but not sale; is that now a foodservice or retail operation?

Similarly, a "ready meal" (meal replacement) could be purchased from a supermarket; a very similar meal could be served in a restaurant or ordered over the Internet/telephone and be delivered to a home. Are all of these scenarios still foodservice?

If a meal is consumed in a hotel restaurant, is that part of the foodservice industry or the hotel/hospitality industry? A guest staying in a hotel for "bed and breakfast" and where breakfast is included, is that a foodservice activity or a hotel function?

This clearly illustrates the difficulty of defining exactly what foodservice is and, as shown in the following section, the difficulty in classifying the foodservice industry, hence the challenges that it also presents. A working definition of foodservice, for the moment at least, is offered thus:

> *The **serviced** provision of **prepared** food and beverages, **including meals, that are either consumed on the premises or taken or delivered to another location, such as a home.***

Classifying the Foodservice Industry

Just as there is no internationally agreed definition of foodservice, there is no general international agreement as to how the foodservice sector should be categorized or segmented.

A number of organizations provide their own classifications:

At an international level, the United Nations (UN) uses an International Standard Industrial Classification of all Economic Activities (UN 2008):

> *Food and beverage service activities*
>
> *. . . includes food and beverage serving activities providing complete meals or drinks fit for immediate consumption, whether in traditional restaurants, self-service or take-away restaurants, whether as permanent or temporary stands with or without seating. Decisive is the fact that meals fit for immediate consumption are offered, not the kind of facility providing them. Excluded is the production of meals not fit for immediate consumption or not planned to be consumed immediately or of prepared food which is not considered to be a meal . . .*

with outlets grouped thus:

Restaurants and mobile food service activities
Event catering and other food service activities
Beverage serving activities

At a pan-national level, the European Union (EU) has adopted a similar classification (Eurostat 2018) and interestingly both specifically exclude:

> *. . . the production of meals not fit for immediate consumption or not planned to be consumed immediately or of prepared food which is not considered to be a meal . . .*

This aspect adds a further dimension to our foodservice definition:

> *The serviced provision of prepared food and beverages, including meals that are either* ***intended for immediate consumption*** *on the premises or taken or delivered to another location, such as a home.*

Other classifications have been provided, for example, by governments (e.g., North America (NAISC 1997), industry and consultants (e.g., CHD Expert 2018), trade and professional associations (e.g., NRA 2017), and trade publications and academe (e.g., Barrows and Vieira Jr (2013)); the latter reviewed and evaluated five existing classifications and recommended yet another of their own.

This resulting lack of a standard international definition and classification provides a number of challenges when trying to assess the true shape, size, and nature of the industry, quantifying aspects such as its value, its employment, and its economic contribution, thereby providing data which can then be reliably compared within and without various parts of the foodservice industry, both nationally and internationally. “McDonald’s,” for example, is often classified both as a fast-food and a quick-service restaurant – and what is the difference anyway!

A generally accepted classification aimed at illustrating the broad range of foodservice outlets divides the industry into two broad segments or categories: firstly, the *commercial sector*, also called the *profit sector*, where the modus operandi is the operation of foodservice outlet(s) in pursuit of profit, and secondly, the *public sector* also called the *cost sector* or *subsidized or welfare sector* where the modus operandi is the provision of foodservice, perhaps as a “support” activity, working within an agreed budget and specifications. Clearly though, there is a lot of overlap, for example, hospitals can be in both the *private* and *public sectors*. An example,

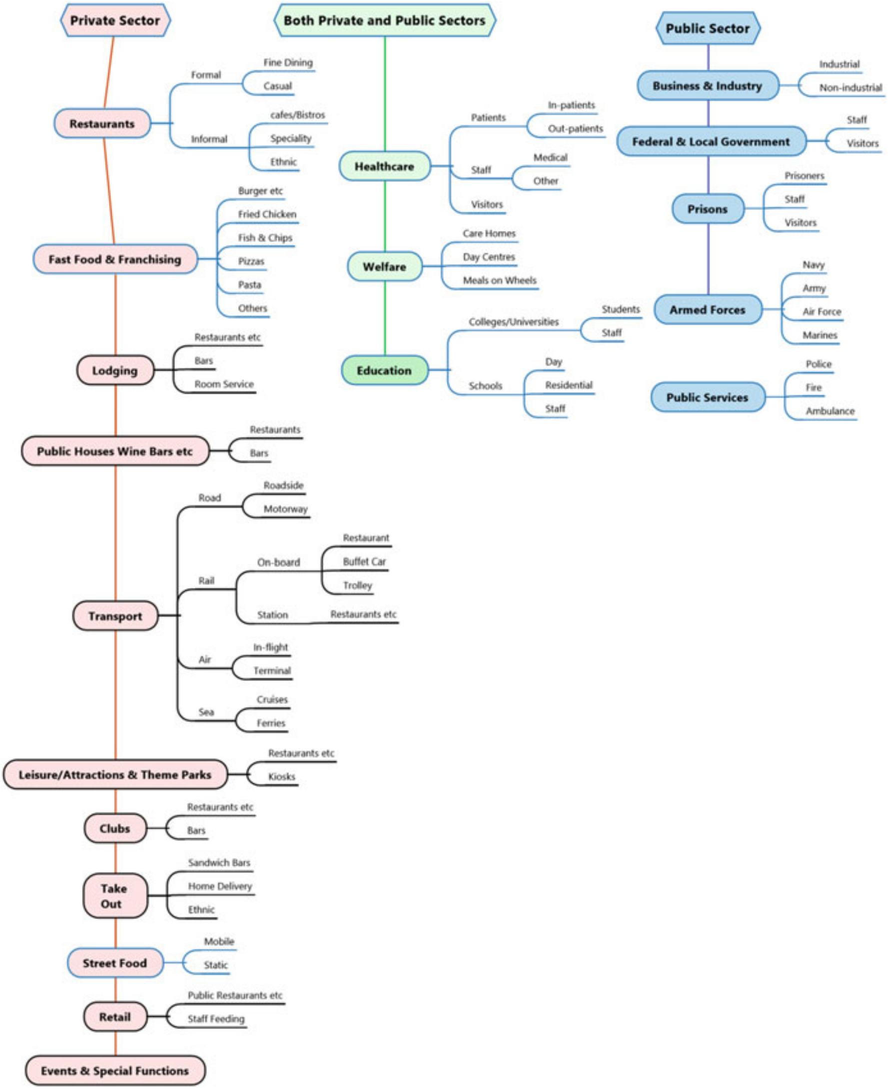


Fig. 3 Examples of the foodservice industry

illustrative of this type of categorization or organizational structure, is given in Fig. 3. This is not designed to provide yet another classification of the foodservice industry but primarily to illustrate the diversity and types and range of operations involved.

Notwithstanding, it is fair to say that the foodservice industry is international and highly diverse and includes a range of outlets that serve food and beverages, perhaps for payment, to people who want them, although this may or may not be the primary goal of the business.

Shape, Size, and Nature of the Foodservice Industry

Operating Structures

What then are the shape, size, and nature of the foodservice industry? As might be expected with such a heterogeneous industry, there are endless possibilities for both organization and structure. Common within the industry are large and small groups or "chains" and franchised and outsourced operations along with individually owned and operated outlets.

"Chain" vs Independent Operations

It is often assumed, with good reason, that the foodservice industry, particularly the fast-food sector is dominated by chain restaurants, the majority of which, for the time being at least, are American dominated, as shown in Fig. 4.

Despite the seeming ubiquity of McDonald's, Subway, a sandwich chain, has the most outlets of any restaurant worldwide. In 2017, Subway had 43,912 stores globally; McDonald's was in second place with 37,241; and Starbucks in third place with 27,339 locations.

However, while McDonald's and Starbucks have mostly grown their sales every year for the last 5 years, Subway sales have been slipping since 2014, and the number of customers is down 7.6% over the last 12 months. Shortly after this slump began, Subway started closing stores with more than 350 being shut in 2016; more than 800 in 2017; and another 500 in 2018. This in part is thought to be because of a lack of innovation. McDonald's and Starbucks continually create new products and store designs in response to changing consumer preferences and demands; Subway lags behind although there are now efforts to address this (CNBC Restaurants 2018).

The high profile of these chain restaurants may, in part at least, be due to the high spend associated with advertising, which, for example, in the case of McDonald's, it may have fallen from 1 billion US dollars in 2014 to 633 million in 2017, still represents a substantial expenditure (Statista 2018a).

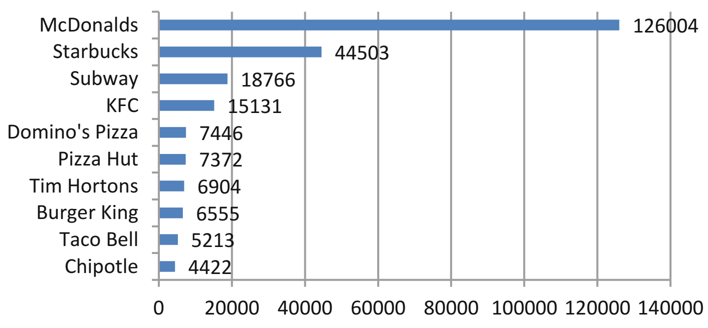


Fig. 4 Worldwide value (US$m) of the top fast-food brands (2018). (Source: Adapted from Statista 2018)

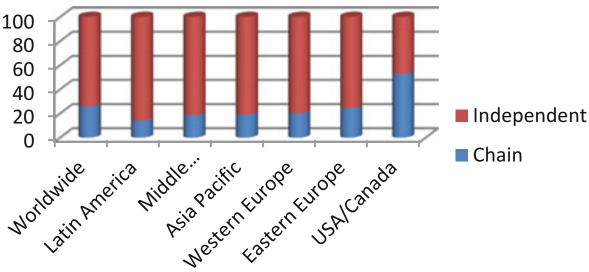


Fig. 5 Worldwide distribution of independent and chain foodservice sales. (Source: Adapted from Statista 2018b)

However, the assumption that the foodservice industry is dominated by chain restaurants is not the case, and worldwide some three-quarters of foodservice outlets are actually independently owned and managed (Fig. 5).

Prevalent among the organizational structures in foodservice are *franchising* and *contracting out* (*outsourcing*).

Franchising

Franchising has become increasingly popular as an operating model for foodservice outlets, and although it is generally thought to be a relatively new phenomenon, this may not necessarily be the case. It could be argued that franchising owes its routes to a system of tax collecting in England in the Middle Ages, an activity which was often entrusted to a third party.

In foodservice, public houses (pubs) in the UK fall into broad categories; they could be owned and managed by the brewer often through tenancies where independent publicans rent the public house from the brewer or owned outright by an individual or chain. Under an exclusive supply deal, the "beer tie," where pubs are owned by the brewery, tenants were required to buy their brewers' products, thereby guaranteeing the brewers an outlet for their products. Alternatively, where public houses are owned outright by an individual or company, the owners could choose to purchase their products on the open market (free house) or could, if they so wished, enter into a relationship with a brewer. In exchange, perhaps for an interest-free or low-interest loan, they align or "tie" themselves to that brewer and agree to purchase exclusively their supplies (tied public house) (Helsey and Seely 2015) – hence, an early type of franchise.

In more recent times, franchising in the foodservice industry is generally attributed to Ray Kroc who developed it as a business model as a means of expanding his fast-food operations (McDonald's). The first McDonald's restaurant was opened in 1948 by two brothers Maurice and Richard McDonald in San Bernardino, California, but Kroc, who at the time sold appliances, saw an opportunity to expand through the business model of franchising. In 1955, he opened the first McDonald's franchise in Des Plaines, Illinois, subsequently starting the McDonald's Corporation, buying out the McDonald brothers in 1961, before publically trading in 1965 (Encyclopaedia Britannica 2018).

Franchising can be defined in a number of ways, but in essence, it is a continuing relationship in which a franchisor (the owner of the franchise) provides a licensed privilege to the franchisee (the person who wants to run an outlet) to do business and offers assistance in organizing, training, merchandising, marketing, and managing, in return for a monetary consideration (Entrepreneur 2018). Franchising also enables the "parent business" to expand the number of outlets using funding provided by others who want to operate their own business.

Today in the foodservice sector, franchising can be used in a number of business settings including fast-food, quick-service, and full-service restaurants; takeaways such as pizza, sandwich/bakery products, coffee, ice cream, and frozen yoghurt; and vending. In practice, almost in any setting where the product is "standardized" and the production and service elements are easily replicated or "operationalized," franchising offers a number of advantages and also disadvantages in foodservice; not least of all is the buying in to an established organization where the brand is well-known. This is generally thought to reduce business failure rates, but this many not necessarily be the case (Stanworth et al. 1998).

The exact number of international foodservice franchises is difficult to determine, but in the main, franchising tends to be dominated by US operations both in the USA, where the market has become quite saturated, and internationally where countries wanted to bring the American concept to their homeland, where there was a perceived need; hence they have expanded quite considerably. For example, there are 14,344 McDonald's restaurants in the USA and 21,914 internationally; there are 4391 KFCs in the USA and 15,029 internationally; in Burger King, the number is reversed with 7126 restaurants in the USA and 7246 internationally; Pizza Hut has still more outlets in the USA with 7,908 and 7,697 internationally although this latter number is quickly catching up. The operator with most total restaurant locations, with 43,154 restaurants, is Subway with US locations outnumbering international locations 26,958 to 16,196, although internationally, Subway continues to grow (Daszkowski 2018). The total number of food franchises within the top 20 of all franchises is given in Table 1.

Contracting (Contracting out, Outsourcing, Foodservice Management)

One organizational structure, which has become much more prevalent in recent years, particularly in the public sector, is contracting, also termed contracting out, outsourcing, and foodservice management. It is estimated that the global contract

Table 1 Foodservice franchise operations in the world's top 20 franchises. (Source: Franchise Direct 2018)

Rank	Name	Country	Industry
1	McDonald's	USA	Fast food
2	KFC	USA	Chicken
3	Burger king	USA	Fast food
4	Pizza hut	USA	Pizza
8	Dunkin' donuts	USA	Bakery and donut
10	Subway	USA	Sandwich and bagel
11	Baskin-Robbins	USA	Ice cream
12	Domino's pizza	USA	Pizza
13	Taco bell	USA	Fast food

catering market will reach revenues of around US$264 bn by 2023, providing an annual growth rate of approximately 5% in the period 2017 to 2023. It is dominated by five major players who are expanding their international presence and creating strong brand images for their services (Cision 2018). Leading global players in the industry include:

Compass Group, *Sodexo*, *Elior Group*, *Aramark Services*, and *WSH*.

Although contracting is dominant in the public sector, clearly the areas using contract caterers vary annually and by country, but a broad indication of the involvement is given in Fig. 6.

A number of definitions for contracting exist such as:

> *. . . the part of the foodservice industry that supplies meals to third-party organisations. This encompasses a wide variety of businesses and institutions . . .*. (Mintel 2017)

Catering contracts are legal agreements entered into between the client requiring the service and the foodservice operator, the latter providing a range of services including the planning and design of the foodservice facilities, staffing, recruiting, etc. in the workplace, for a specified period. In essence, the contractor, an expert in the area, assumes responsibility for operating the noncore activities of a particular organization, thereby freeing up the parent organization to concentrate on the primary focus of their business. Furthermore, many catering contractors take over and operate other noncore activities of the organizations (a multi-activity contract, facilities management) to include aspects such as security, laundry, and maintenance, almost any function not associated with the main activity of the client company.

There are many different types of catering contracts, with a number of variants, each with its own advantages and disadvantages, and include:

Fixed price: the contractor supplies the required service to the client for a fixed price which may also include an agreed subsidy. Fixed price contracts had the

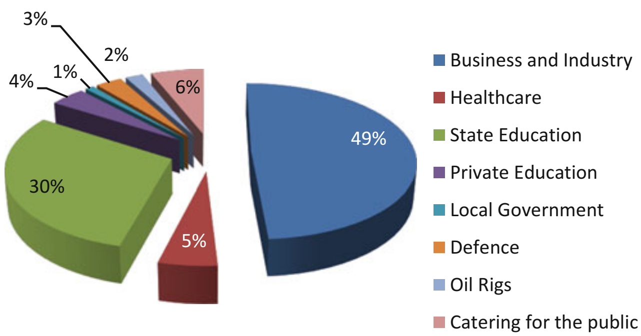
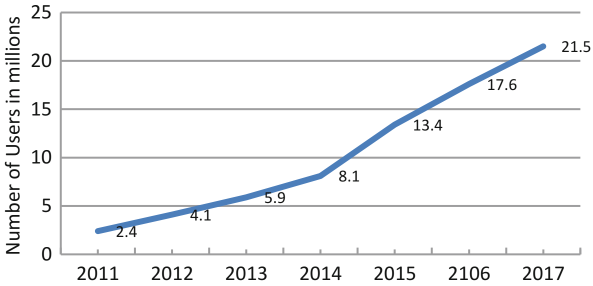


Fig. 6 An indication of the size distribution of the contract catering market

Fig. 7 Worldwide active users of "Just Eat" (m). (Source: Adapted from Statista 2018c)



largest market share in 2017 and are estimated to grow at a compound annual growth rate of approximately 5% during the period between 2018 and 2023 (Arizton 2018).

Cost plus: the contractor supplies the required service to an agreed budget plus an operating coast or management fee.

Nil subsidy or cost: the contractor supplies a service, as agreed, but the contractor is able to operate as a commercial venture at no cost to the client company.

Food Delivery

A further area where considerable expansion has taken place recently is in the takeout/takeaway/home delivery market – online food ordering and delivery platforms. A number of companies, for example, *Just Eat*, *Uber Eats*, and *Deliveroo (Roofoods)*, all of which are rapidly expanding internationally, act as an intermediary specializing in the delivery process, acting as a go-between for operators (primarily takeaway outlets) and customers who order their chosen food online or over the telephone, which is then delivered to the desired location. The growth of one such operator is given in Fig. 7, and it is further estimated from a survey of 13,000 people worldwide that online food ordering could grow from US$35bn today to US$365bn by 2030 (kbbrereview 2018).

Food Production and Service Styles

Along with various organizational structures and operating systems, there are alternative systems which can be deployed in the production and service of the end product. According to some organizations (TMR 2018), there are four types of foodservice systems – conventional, centralized, assembly service, and ready prepared – although alternative classifications can be found worldwide.

Food Production Techniques

Traditional (Cook-Serve and Assemble and Serve)

In an "ideal world," fresh, locally sourced food would be prepared and cooked and then served immediately in surroundings appropriate for the type of customer, nature of the business, and cost of the operation/selling price. However, this type of operation is more complex to manage, in terms of food procurement and storage and the labor required, which needs to be imaginative, have flair, and be highly skilled in order to prepare and serve it. The skilled staffing elements are often difficult to find and costly; hence this type of operation tends to be expensive and reserved primarily for the top slice of the industry. This style of operation is often referred to as a traditional or a cook-and-serve operation.

A variation of this style of operation uses "convenience" or "convenient food," that is, pre-prepared foods, frozen, chilled, canned, or dehydrated, and bought-in as ready-made dishes or component parts, which are prepared or finished prior to service by personnel with a different skillset to those of cook-and-serve operations. This style of operation provides a level of foodservice, the primary advantages of which are standardized meals and a standardized service component, which have controlled or known costs. Hence it is a system that has been adopted by outlets such as quick-service restaurants. This style of operation is often referred to as an assemble-and-serve operation.

However, the primary disadvantage of cook-and-serve operations is that production is coupled to consumption, in that food is produced and held, in anticipation of a demand; the latter, which of course may not materialize, may fluctuate, while in the meantime the food quality deteriorates, resulting in increased overall costs and a greater likelihood of food wastage. It also means that food production staff need to work hours to coincide with operating/opening hours, which may be unsocial, and historically has meant working a "split shift," in that staff commence work in the morning, take a break after the midday meal service, and return later for the evening meal service.

Cook-Freeze, Cook-Chill, and Sous Vide

The coupling of production and consumption was addressed in the 1960s with the introduction of cook-freeze, with cook-chill in the 1970s, and with sous vide (under vacuum, i.e., vacuum packed) in the 1980s, whereby food production was separated or decoupled from the service of food. Under each system, food is prepared centrally, in a factory-style operation, by less skilled staff who produce either complete meals or individual meal components, which are then either blast frozen, chilled, or sous vide prior to being placed into storage. These products would then be sent to end-user kitchens, be they restaurants, hospitals, or schools, where the dishes are finished, reheated, if required, before being served. This uncoupling of production from service means that:

- Food can be prepared centrally using factory production techniques in a controlled, hygienic environment, by fewer staff, with lower skills, thereby controlling costs, while being overseen by a skilled supervisor.
- Economies of scale can be achieved and 24-hour meal availability offered.
- Production can be standardized and the quality of the end product better guaranteed.
- A wider, more adventurous menu choice can be offered which is not dependent on the skills of the end kitchen staff.

- Food production can take place during "normal" working hours and stored, rather than employing staff at unsocial hours.
- Fluctuations, that is, peaks and troughs in demand/supply, can be smoothed out or eliminated.
- End kitchens in the final locations can be smaller, and with little preparation required, there is no duplication of equipment and no production staff needed.

As might be expected, there are a number of disadvantages, the primary being:

- High initial capital outlay.
- Not all dishes are suitable for this production style.
- Difficult to personalize and a perception of "standardization" and "institutionalization."

This style of foodservice became extremely popular in the public sector, such as hospitals and schools, where the cost advantages were soon appreciated. Notwithstanding, it is often used in other styles of operation as part of the total production system, where a hybrid of these styles has proven to be successful. They are also used in more upmarket restaurants where, for example, dishes surplus to immediate requirements can be sous vide, chilled, and then stored until needed.

Food Service Styles

When considering the physical act or style of service, a number of possibilities exist, which can be classified or grouped in different ways, with terminology often used interchangeably; such a classification is given in Fig. 8. Clearly there are a number of occasions where there is overlap between each style, and a hybrid system might be used.

Fig. 8 Types or styles for the service of food

Assisted Service	**Self Service**
Table Service	***Cafeteria***
French	Straight Line
Silver (Russian)	Free Flow
Guéridon	Carousel
Plated (American)	***Buffet***
Banquet	***Carvery***
	Counter or Bar
	Takeaway and Drive-thru
	Vending (cash or cashless)
	Trolley

Table Service

French and Silver (Russian)

The most popular style of food service, for more formal meals in large houses up to the beginning of the nineteenth century, was *Service à la Française* or French service. This consisted of two, sometimes three, courses (stages or services), each of which included a number of dishes that were placed on the table with diners helping themselves (if they could reach). This style of service lasted until the early 1800s when an entirely new style of service, used in the Court of the Czar of Russia, was introduced. *Service à la Russe* or Russian service (invariably now termed silver service) retained the structure of the meal in terms of dishes offered, but what did change dramatically was the presentation and service of the meal. Instead of all dishes for the first course being placed on the table simultaneously, before diners entered the room, each course, now comprising one dish, was brought in and offered to the guest who, using a spoon and fork, helped himself/herself or was served by a "waiter" with the amount of food desired (Cracknel and Nobis 1985).

Although this latter style of service immediately became popular and is widely used today, the earlier style of service can be still seen in many countries, for example, in Eastern Europe, parts of the Middle East, and the Mediterranean, where a variety of dishes are put on the table together ("mezze"). This is also found with other ethnic cuisines, for example, tapas, curries, and a number of Asian dishes which can also be placed simultaneously on the table in front of diners.

Guéridon

Guéridon service is often referred to as "the seen service" (Fuller 1964), for it is in the restaurant or dining room in front of the diner where it takes place. Perhaps considered as passé or old-fashioned, it can be still be found in a number of restaurants where the actual cooking or final finishing of the dish takes place adjacent to the diners. Using a guéridon trolley, the waiter (or chef) might prepare and cook a dish in front of the diner on a spirit lamp or flambé (flame) or finish a dish with a flambé as a finale for effect.

Plated Service (American)

Plated food service has been around for many centuries although its introduction into modern foodservice has been attributed by Cracknell and Nobis (1985), to the USA with the advent of the "blue plate special" during the 1920s. The exact origin of the blue plate special is uncertain, but it was probably used to describe a meal or main course plated in the kitchen. This was offered at a lower or fixed price and was originally served on blue patterned plates with a number of "compartments" into which the various items were served.

Plated service has a number of advantages, for example, it provides better portion control and requires the services of less skilled waiting staff. Although initially it was used at the cheaper end of the market, it has become popular at the top end of the market, primarily with the introduction of Cuisine Nouvelle. This style of service assembles and dresses food on a slightly larger plate, enabling the chef to show individuality and flair and to "arrange" (critics might suggest "paint") food on the plate in an artistic fashion. As a result, it has been argued that the waiters' duties have now largely been confined to placing the plate in front of the diner and some confrontation between the relative skills of the front and back of house.

Banquet

Banquet service is invariably used when a large number of people need to be fed simultaneously with the same meal/menu. Used a lot on more formal occasions such as banquets, wedding, breakfasts, or conferences, diners sit down together, and then all are served the first course. Once diners have finished, plates are removed simultaneously and the next course brought in and served until the entire meal has been served.

The actual service of food might be silver or plated, depending on the skills of the staff, but a large number of diners can be fed, in perhaps a confined space, where the occasion could be either business or social.

Self-Service

Cafeteria (Straight Line, Free Flow, or Carousel)

Cafeteria service is used more in the public sector where costs are perhaps tightly controlled, such as in an industrial canteen; here, food is offered at a counter for diners to help themselves – or with some dishes they may be assisted. Diners collect a tray and plate at the beginning of the line, move along selecting dishes of their choice, with eating utensils collected at the end, before finding their own table to eat.

The cafeteria line could either be straight (metaphorical) in that diners start at the beginning and work their way along the counter until the end; free flow where diners go to different stations or counters to collect various parts of their meal; or a carousel. The latter is rarely seen today but entails a revolving counter where diners can select dishes as the carousel rotates.

Buffet

Buffet service can be used in almost any type of meal, for example, breakfast, lunch, or dinner, a finger buffet or fork buffet. Similar in style to a cafeteria, but where food is normally laid out so that the diner can see what is offered, plates and cutlery are to hand. Diners would normally help themselves to their food before finding somewhere to sit/stand and eat. Buffets, like cafeteria service, are less labor-intensive, and the food could probably be offered prepaid or at no cost.

Carvery

Again it is a similar style to cafeteria, but normally used for lunch or an evening meal. Customers go up to the counter, the expensive protein component may be carved or served, and then diners are free to help themselves to potatoes, vegetables, and/or salad.

Counter or Bar

Here, diners go up to the counter; select, place, and pay for their order; and either wait for it to be prepared or for it to be delivered to their chosen table.

Takeaway (Takeout) and Drive-Thru

Again diners go/drive up to the counter/serving hatch; select, place, and pay for their order; and wait while it is assembled before taking it elsewhere for consumption.

Vending

Vending is often considered to be the less attractive form of food service, but it is particularly useful for out-of-hours service or on remote sites. Cash/card is often used, but many companies provide employees with a pre-loaded "cash card" which they can use on any vending machine throughout the company site.

Trolley

Trolley service is where an individual physically wheels a trolley, or perhaps caries a tray containing food, which is then offered or served to the potential customer. Trolley service can still be found in places such as offices to provide beverages and light refreshments to staff, on trains for an "at-seat service," and in hospitals.

It can be seen, therefore, that there are a number of options with variations for both the production and service of food. Neither one is necessarily better than the other, some are simply more suited to the circumstances under which the foodservice operation provided and the customers being served.

Menus

In the sixteenth century, eating out was more the custom of the wealthy, although townsfolk might eat at a tavern or take an "ordinary" (a fixed menu and the forerunner to a table d'hôte menu) at a chop house or public house (Burnett 1979).

Although restaurants, of sorts and by any other name, have been around for centuries, the origin of the word "restaurant" is generally attributed to a Monsieur Boulanger. In Paris, up until the late 1700s, only those who were either innkeepers, *rôtisseurs*, or *traiteurs* were able to sell whole pieces of cooked meat. Monsieur Boulanger, an enterprising bouillon or soup vendor in the Rue Bailleul, France, wanted to increase his menu and in 1765 hit on the idea of adding a new dish of sheep's feet in a white sauce which he called "restaurer," (translated – to restore) and so started the first restaurant (Montagné 1961).

This action was quickly followed by others, for example, Roze and Pontaillées, who in 1766 opened a maison de santé (house of health) (Lang 1988). However, the first restaurant as we might know them today, was opened in France in the Rue de Richie by Beauvillers in 1782, and called the Grande Taverne de Londres. Here, the new idea of listing dishes offered on a menu, providing tables and chairs, and opening for fixed hours came into being (Lang 1988).

The purpose of a menu, be it an chalkboard or a leather bound tome, is to inform, to communicate to the consumer what is being offered, but at the same time also keep all members of staff up to date. As such, a menu can take a number of physical formats, although the presentation of what food (and drinks) are being offered tends to follow four basic structures.

Table d'hôte Menu, Set Meal or Set Menu, and Fixed Price Menu (*menu à prix fixe*)

These terminologies often have different connotations in various parts of the world, but in essence, a table d'hôte menu (menu of the host) is one where a complete meal is offered, with a relatively limited number of choices, probably a starter, a main course, and a dessert, with maybe a choice within each course for a set price (fixed price). To increase the variety of a table d'hôte menu or include additional food items which might be a little more expensive, these could be offered and the dish annotated to show the increased price for that dish offered.

A fixed price menu can often be seen in a cafeteria or restaurant, where they might have a limited number of staff or restricted budget. Here, a complete meal is provided to customers for a fixed price and may incorporate a dish of the day.

A set menu, as the name suggests, is set and is limited by little or no choice and offered at an agreed or set price. Again a set menu would contain a number of courses and would be offered on occasions such as a function, a banquet, or a wedding where there are a large number of diners to be served at any one time (a function menu).

À La Carte Menu

In contrast, an à la carte menu offers a variety of dishes for each course and where the diner makes his or her selection from dishes available. Historically, this type of menu, because of the additional complexity, food procurement and storage, and the skills of the staff needed to prepare and serve, would be offered in more upmarket restaurants, with of course associated cost implications.

A variant of the à la carte menu is now perhaps one of the most popular forms of menu found in places such as quick-service restaurants. Here, the menu has been simplified so the diner can chose from a range of starters at set prices a main course that might include potatoes, vegetables, and/or salad, again at set prices, and a dessert.

Selective Menu

A variation on or adaptation that sits between a table d'hôte and à la carte menu is a selective or selected menu. This offers a set meal of a number of choices, from which the dinner can choose but where the price of the meal is based on the cost of the main course.

Static Versus Cyclical Menus

Menus can be either static or cyclical in that static menus, particularly an à la carte menu, because of the extensive choice and variety offered, generally remain unaltered, changing perhaps by seasons or special occasions.

On the other hand, cyclical menus change on a regular basis, maybe, daily, weekly, or monthly. These are common in the public sector, such as hospitals and in the private sector, such as canteens, where a table d' hôte style of menu might be offered but one which changes on a very regular basis. This is important in where diners eat there often but where it is important to offer a choice which changes on a regular basis.

Foodservice in Today's Society

The foodservice industry does not work in a vacuum, in isolation, and needs to be aware of many issues which affect the local, national, and global environments. These issues are beginning to be explored by the European Union within the remit of food and nutrition security (European Commission 2017). The combined effects of factors, such as the scarcity of natural resources, the effects of climate change, and population growth, require that the approach to global foodservice and food systems should be underpinned by sustainability encompassing the entire "food value chain." This approach, it is argued, should incorporate the issues outlined in Fig. 9.

- **Sustainability**: the sustainable use of scarce natural resources, land, inland, and marine waters, on which food production relies
- **Resilience**: adapting to climate and global change, extreme events, and migration
- **Responsibility:** being ethical, transparent, and accountable
- **Diversity**: being receptive and open to a wide range of technologies, practices, approaches, cultures, and business models
- **Competitiveness**: to providing jobs and growth
- **Inclusivity**: engaging all food system participants in helping to address food poverty and provide healthy food for all

The foodservice industry, its suppliers, operators, staff and end users, and customers, have a responsibility to consider these issues, not only because they are becoming increasingly important globally but also because companies providing

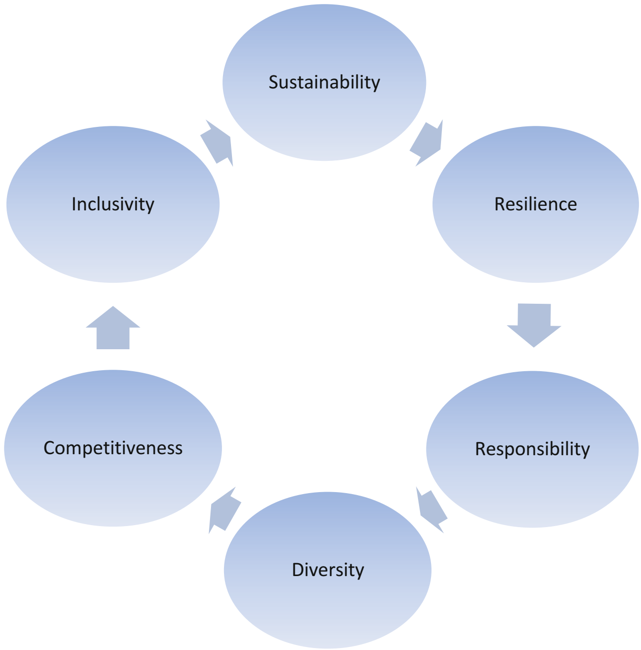


Fig. 9 Factors to be considered in the development of food and nutrition security. (Source: Adapted from European Commission 2017)

and diners using the foodservice facilities are becoming more aware of these issues and will start to demand it.

Furthermore, institutional food service has additional responsibilities in respect to:

- Food wastage
- Traceability
- The use of local food produce

The Labor Force

Globally, the hotel, catering, and tourism industry employ approximately 3% of the world's total labor force although its true economic and employment importance is greater when considering that each job in the sector generates estimated one-and-a-half additional indirect jobs. In some regions, direct and indirect labor are estimated to be between 8% and 10% of the working population. If both direct and indirect employment are taken into consideration, the total economic contribution to the global economy is estimated to produce as much as 11% of GDP (ILO 2018).

However, on average, foodservice workers earn at least 20% less than workers in other economic sectors, a differentiation which is attributed to the higher proportion of unskilled workers and part-time or low-paid jobs. Up to half of workers in the industry are under 25 years old and up to 70% are women. Furthermore, migrant workers are another vulnerable group which tends to be overly represented in the industry, with migrants concentrated in lower-paid and less stable segments of the job market due to such factors as language and unfamiliarity with the host culture (ILO 2018).

The hotel, catering, and tourism industry is one of the fastest-growing sectors in the global economy. It is also among the top job-creating sectors because of its labor-intensive nature and its significant multiplier effect on employment in other related sectors. Yet, the sector's reputation for poor working conditions, the fragmentation of the industry with the majority of employers being small- and medium-sized enterprises, low union density, low wages, low levels of skill requirements, shift and night work, and seasonality are all negative factors (ILO 2018a).

In Europe, the hospitality industry is particularly significant in terms of employment. Hospitality businesses alone provide 11.1 million jobs directly, representing 4.7% of the total workforce. When considering direct and indirect labor, the industry supports 16.6 m jobs, 7.8% of the European workforce or 1 in every 13 jobs.

The hospitality industry is also especially significant in the employment of women. In the overall economy, 46.1% of people employed are women; in the hospitality sector, this figure rises to 53, 7%. Similarly, hospitality is also important in providing jobs to the young. In the overall economy, the unemployment rate of people older than 25 years was 8.3% in 2015, while for those under 25 years, unemployment was of 20.3%. Conversely, while in the overall economy only 8.2% of those employed were under 25 years, the figure in the hospitality industry was 19.6%.

In the USA, the situation is similar in that the restaurant industry in 2017, more than 9 in 10 restaurants, had fewer than 50 employees with more than 7 in 10 being single-unit operations. In total they employed in the order of 14.7 million people or about one in 10 of the working population. In addition, the restaurant industry is expected to add approximately 1.6 million jobs over the next decade, with employment reaching 16.3 million by 2027 (NRA 2017a).

Summary and Conclusions

The foodservice industry is truly heterogeneous, complex in its organizational structure with very little agreement either nationally or internationally, in areas such as definition and classification. As a result, it is often difficult to get reliable data on which to compare performance and gain a true understanding of the foodservice industry.

This chapter, as the first part of an introduction to the foodservice industry, has provided an overview of foodservice and the foodservice industry, firstly by clarifying semantics and suggesting one possible definition of foodservice, thus:

The serviced provision of prepared food and beverages, including meals that are either intended for immediate consumption on the premises or taken or delivered to another location, such as a home.

The size of the global industry is outlined, and organizational structures are considered where it is noted that worldwide the foodservice industry comprises primarily small independent units rather than chain operations as might be, and is often, assumed. Thereafter, two prevalent organizational structures, franchising and contracting out, are covered in outline.

Food production and the service of food can be undertaken in a number of ways, and the more popular ones are considered. No one system is “ideal” and much depends, not least of all, on the nature of the business being operated and the consumers patronizing the outlet. What is common, though, is that operators are resourceful and many hybrid systems have been developed.

The types and styles of menus are considered, and then the labor element is covered, where foodservice is often described as a “people industry.”

In order to fully understand the intricacies and nuances of foodservice, the chapter which follows continues the introduction and considers the “demand side,” that is, the consumer, in order not only to better understand the users of foodservice outlets but also to put the foodservice industry into context.

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48 Hospital Food Service

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Abstract

Hospital foodservice is complex and can be considered as one of the most complicated systems in the hospitality sector with many interrelated factors. Hospital menus should be based primarily on clinical needs as well as on patients' preferences and other important characteristics such as variety, quality, aesthetics, and taste of the food. However, if food is regarded as medicine, then necessary dietary modifications can make meals unappealing (e.g., low-sodium diet). Barriers to adequate food intakes are multifactorial and complex and require multi-level interventions, including a change in the awareness and attitude toward food among healthcare staff and older hospital patients. To be successful, the priority interventions need to be feasible in practice, in terms of the availability of human resources, budget, infrastructure, and time. Menus are an important tool for the foodservice as they are the first point of contact with the patient. A therapeutic diet is modified from a "normal" diet and is prescribed to meet a medical or special nutritional need. It can be part of a clinical treatment, and in some cases can be the main treatment of a condition. Furthermore, food safety is a critical part of this whole process, particularly when preparing and serving food for hospitalized patients who are likely to be more susceptible to foodborne illness due to their health status and decreased immunity. Still, in all foodservice settings there is an increasing demand for greater attention to the environmental impact of the food production. These are factors that are likely to have increasing prominence, with a demand for the use of more locally sourced foods, recycling, and improved energy efficiency.

Hospital Foodservice

Foodservice: An Overview

Around the world, more and more meals are being consumed away from the home. This phenomenon can be associated with the search for pleasure (e.g., in restaurants) or through necessity, in settings where individuals, given a choice, would perhaps choose not to be (e.g., hospital). There is a similar distinction between "domestic meal provision," where meals are provided to meet principally social goals and personal needs, tastes, and comforts, and "functional meal provision," where meals are provided in a context of rules governing work and especially time constraints (Williams 2009). This latter category encompasses a wide range of foodservices, which can be considered as institutional settings, of which in addition to hospitals also includes the following:

- Other healthcare settings (nursing homes)
- Prisons
- Schools and child care organizations
- Military settings (canteens and combat rations)

- Home-delivered meals
- Workplace canteens

Despite the growth in meals eaten away from the home, as a proportion of all foodservice, institutional meals in the USA have been progressively declining over the past 50 years, from 30.8% in 1955 to 14.6% in 2005. This pattern is likely to be broader than the USA because of the much higher growth in non-institutional meals from fast food outlets and the general trend to more out of home recreational dining (Williams 2009).

The meal experience is significantly shaped by the individual living arrangements in institutions and it has even been suggested that the word “meal” may be inappropriate to some experiences, where food is provided, but the social and emotional contexts of eating are missing (de Raeve 1994). Nonetheless, in all of these settings one can distinguish two goals that they have in common with all other meal service settings – (a) meeting customer expectations and needs (e.g., safety, taste, price, service) and (b) providing physical sustenance (e.g., satiation and nourishment) (Williams 2009).

Foodservice is a broad area that incorporates the provision of food and drink to individuals where this intake represents the majority of their daily requirements, or where populations are vulnerable and/or have special requirements. The role of the dietitian will vary depending on the service delivery model and the requirements set out by the consumer and relevant legislation (Dall’Oglio et al. 2015).

In institutions that provide all the daily meals for the clients, patients, or consumers (e.g., hospitals, boarding schools), it is most common to provide three main meals per day (breakfast, midday, evening), plus a number of mid-meal or snack options. The latter may be served on trays, or from a beverage and snack trolley wheeled around the ward areas. In other institutions, the mid-meals are less likely to be delivered, but supplies may be available for self-service in common dining areas. Among the different types of meals covered by food services, there are “food as medicine” meals, which implies a therapeutic provision. This type of meal can be seen in hospitals, nursing homes and to some extent in home-delivered meal services such as Meals on Wheels. From Hippocrates in the fourth century BC to Florence Nightingale in the nineteenth century, the provision of food suitable for sick patients has been recognized as an important part of their care (Williams 2009).

Foodservice in Hospitals

The importance of hospital foodservice and the use of food as medicine are not new concepts and can be traced back to one of the earliest medical works, the Hwang Ti Nei-chang Su Wen (The Yellow Emperor’s Classic of Internal Medicine, 722–721 BC). Concern with the role that food may play in the recovery of patients was also highlighted by Florence Nightingale who wrote in her Notes on Nursing in 1859 that “The most important office of the nurse, after she has taken care of the patients’ air, is to take care to observe the effects of his food”. Hospital foodservice can present especially complex features and is often considered the most complicated process in the hospitality sector with many interrelated factors impinging upon the whole. The layout of hospital wards, often at considerable distances from the kitchen, adds an additional logistics burden, and as a consequence, a long stream of possible delays between production, service, delivery and consumption. This stretched, continuous, and staggered food cycle can have potential negative effects on the safety and quality of food, and presents a challenge to any hospital foodservice manager (Williams 2009).

The goals of a hospital foodservice are to provide inpatients with nutritious meals that are beneficial for their recovery and health, and also to give them an example of healthy nutrition with menus tailored to patients' specific health conditions. When meals are carefully planned and customized to meet patients' specific needs, and when patients consume what they are served, these goals can be considered as achieved. Meal consumption by inpatients is related to nutritional status and satisfaction with the foodservice, along with other factors such as health status, medical conditions, appetite, the eating environment and dentition. Furthermore, foodservice quality is known to influence patient satisfaction with hospital stay. It is widely recognized that food and other aspects of foodservice delivery are important elements in patients' overall perception of their hospital experience and that healthcare teams have a daily commitment to deliver appropriate food to patients. Provision of a foodservice that not only meets but also exceeds the expectations of the patient is considered essential for a quality service (Dall'Oglio et al. 2015).

Defining quality for hospital foodservice requires a balance of many different features. Hospital menus should be based primarily on clinical needs, as well as on patients' preferences. Other important characteristics such as variety, quality, and taste of food should also be included. Moreover, the hospital environment and a pleasant helpful attitude from the nursing and food service staff are important elements that should be considered in a quality approach to the complex problem of inadequate dietary intakes by many hospital patients. Personal and sociocultural aspects have also been identified as a main factor in the acceptance of food and in predicting food consumption. Thus, customer satisfaction with hospital foodservice is multifactorial and can be difficult to assess (Dall'Oglio et al. 2015).

Foodservice professionals in hospitals can be compared with engineers in manufacturing factories. Engineers continuously research, plan, and manage production processes to improve the quality of products and the efficiency of processes. Once a dietitian set goals and standards by planning menus, they should manage and control the processes to a point where the goals are met. Foodservice staff should be trained and empowered as valued team members in hospital foodservice quality management. Communicating with patients should be bidirectional, which involve dietitians listening to patients' voices and helping patients understand their nutritional requirements (Kim et al. 2010).

In hospital the food provided to patients should not be viewed as just another hotel function (like cleaning and laundry), it is a key part of the treatment, and providing meals that are of high quality and which meet the individuals' specific nutritional needs is an essential goal. However necessary dietary modifications (e.g., liquid or pureed food, low-salt or low-protein diets) can make meals particularly unappealing. It is recognized that in these cases the medical requirements will outweigh the normal culinary expectations, but every effort needs to be made to maximize taste and appearance, in addition to nutrition. Parallel with concerns about malnutrition, consumer expectations of hospitals have been increasing, so the provision of food and the meal experiences are becoming increasingly important within the range of medical and support services offered by hospitals (Hartwell et al. 2016b).

Malnutrition Versus Nourishment in Hospitals

Who Are We Feeding in Hospitals?

Malnutrition is defined as a state in which deficiency, excess, or imbalance of energy, protein, and other nutrients causes adverse effects on body composition, function, and/or other clinical characteristics (Bernstein et al. 2012). The prevalence of malnutrition and poor dietary intakes have been evaluated by many studies in different countries. The Australasian Nutrition Care Day Survey (ANCDS) ascertained that malnutrition and poor food intake were independent risk factors for health-related outcomes in Australian and New Zealand hospital patients. Of 3122 participants from 56 hospitals, 32% were malnourished and 23% consumed $\leq$25% of the offered food. Malnourished patients had a greater median length of stay (15 days vs. 10 days) and readmission rates (36% vs. 30%). Median length of stay for patients consuming $\leq$25% of the food was higher than those consuming $\leq$50% (13 vs. 11 days). The odds of 90-day in-hospital mortality were two times greater for malnourished patients and those consuming $\leq$25% of the provided food (Agarwal et al. 2013). Furthermore, a study of 777 patients at Royal North Shore Hospital, in Sydney, found that 51% of patients had some level of malnutrition. The average length of stay for the malnourished patients was 30 days vs. 17 days for the well-nourished patients. Similarly to other studies, a large proportion of patients identified as being malnourished (43%) had not been referred on to a dietitian (Matthews et al. 2007). A further study reports that 30% of patients were malnourished on admission to hospital in Victoria, with a further 61% "at risk." Patients were often not referred on to dietitians, further highlighting issues related to the recognition of malnutrition by doctors and nurses. Symptoms such as reduced appetite and recent weight loss were not followed up as expected (Adams et al. 2008). Furthermore, a Canadian study found that 45% of patients admitted to a medical or surgical ward were malnourished (Allard et al. 2016).

The prevalence of hospital malnutrition is also high in other countries, with around 20–50% of patients in acute care being malnourished, depending on the population and criteria for determination. In the UK, Nutrition Screening Weeks reported that approximately one in three patients were at medium to high risk of malnutrition upon admission. Other work in this field suggests that referral processes are ad hoc, often missing malnourished patients(Russell and Elia 2014.). These studies demonstrated that nutrition care practices can vary and are inconsistent regarding screening, referral for diagnosis and treatment of patients who are malnourished (Allard et al. 2016).

Older patients have a higher prevalence of malnutrition, with patients above 80 years of age suggested to have five times the rate of malnutrition as those patients younger than 50 years. The frequency appears to increase with age, and those patients above 80 years have a higher odds risk of being malnourished compared with those between 61 and 80 years (Banks et al. 2007).

Aging Population and Increased Nutritional Risk

Several changes that occur in normal aging increase nutritional risk for older adults. Aging is followed by diminished organ system functions and weakened homeostatic controls. Nutritional requirements in this age range are determined by various factors, including specific disease conditions and related organ system compromise. The level of activity, energy expenditure, caloric requirements, ingestion, digestion, absorption, and other nutritional factors also pay a role (Bernstein et al. 2012). Some older adults living on their own may not achieve sufficient dietary intakes due to a lack of desire in preparing single portion meals. Loneliness is one of the key factors in decreased appetite and a major contributor to malnutrition. It is estimated that about 30% and 50% of adults over 65 and 85 years old live alone, respectively, which decreases food enjoyment and total energy and nutrient intake (Bernstein et al. 2012; Clegg and Williams 2018).

The prevalence of malnutrition in Europe and North America is 1–15% in community-living older adults, 25–60% in care facilities and 35–65% in in hospitals (Fávaro-Moreira et al. 2016). Malnutrition is associated with a decline in functional status, impaired muscle function and immune function, decreased bone mass, anemia, cognitive decline, poor wound healing, delayed recovering from surgery, higher hospital admission and readmission rates, and risk of mortality. The average daily dietary intake can decrease up to 30% between 20 and 80 years (Bernstein et al. 2012; Clegg and Williams 2018).

Insufficient dietary intake along with other metabolic changes present in order adults may lead to conditions such as cachexia and sarcopenia. Cachexia is an involuntary loss of fat-free mass (muscle, organ, tissue, skin, and bone) or body cell mass. It is caused by catabolism (breakdown of body mass to produce energy) and results in changes in body consumption. It is defined as a metabolic syndrome in which inflammation is the key feature and so cachexia can be an underlying condition of sarcopenia, a multifactorial geriatric syndrome consisting of skeletal muscle mass, quality, and strength (Ahmed and Haboubi 2010). Dietary intake in older adults may be impaired due to a reduction in the proper ritual of eating, reducing the quality and quantity of daily meals. Table 1 summarizes many factors involving impaired food intake and its respective determinants.

In addition to impaired intake, physiological changes in older adults may also impair digestion and absorption. Neurodegeneration of the enteric nervous system can lead to gastrointestinal manifestations such as dysphagia (difficulty swallowing),

Table 1 Factors involved in impaired dietary intakes by older adults

Factors	Determinants
Poor appetite	Illness, pain or nausea when eating, reduced sense of taste or smell, food aversion, beliefs regarding dietary restrictions, alcoholism, depression, anxiety
Inability to eat	Confusion, cognitive decline or dementia, weakness or arthritis in the arms or hands, dysphagia, vomiting, poor oral hygiene or dentition and painful mouth conditions
Lack of food	Insufficient resources, dependence to shop and cook
Polypharmacy	Anorexia, decreased or altered sense of taste, dry mouth, confusion, nausea, vomiting, diarrhea, constipation, dyspepsia. Incorrect use of medicines
Altered requirements	Altered metabolic demands due to illness, surgery, organ dysfunction, and/or treatments
Excess nutrient losses	Vomiting, diarrhea, fistulae, stomas, and colostomy
Illness-related malnutrition	Chronic kidney, respiratory, gastrointestinal and liver diseases, malignancies, HIV, AIDS, stroke, and surgeries
Eating environment	Social isolation, bereavement, or other significant life event

gastrointestinal reflux, and constipation. Reduced gastric acid secretions increases with aging, which influences digestion and absorption (Ahmed and Haboubi 2010).

Another dietary factor that is increased in the aging population is dehydration. Water is a coolant, lubricant, and transport agent. It is required to carry nutrients, regulate body temperature and remove waste products. Dehydration prevalence is higher in older adults and is a potential lethal problem among both institutionalized and community-dwelling older adults. In the USA, in 1991 more than 189,000 patients over 65 years were discharged from acute care hospitals with a primary diagnosis of dehydration. This translates into about 1.5% of community-living older persons being hospitalized with dehydration each year. In community-living older adults developing progressive disabilities, dehydration is one of the most common diagnoses on hospital admission and readmission (World Health Organization and Tufts University 2002).

Older adults are at risk of dehydration due to reduced fluid intake and increased fluid loss, consequently making them more susceptible to develop problems with fluid and electrolyte balance. Fluid deprivation and repletion studies comparing different age ranges have demonstrated that in spite of physiological needs, older adults consume inadequate amounts of fluids to maintain ideal plasma electrolyte concentrations (World Health Organization and Tufts University 2002). Many age-related diseases exacerbate the risk of dehydration, and at the same time dehydration is a common complication of acute illness in this population (Ahmed and Haboubi 2010).

Nutrition Requirements

There needs be some flexibility in the provision of hospital meals and the involvement of the patients in this process. Although adequate amounts may be provided, a substantial amount of patients consume less than half of their estimated daily requirements (Agarwal et al. 2013), due to a range of reasons as outlined in Table 1.

Using dietary reference values (DRVs) to plan the food provision in hospitals is needed alongside nutritional screening procedures that have clear nutritional management guidelines to support those individuals identified "at-risk." It is essential that a hospital menu is capable of meeting the nutrient standards (energy on a daily basis, protein on a daily basis and reference nutrient intake (RNI) for micronutrients on a weekly basis), as appropriate for the patient population it is foodservice for. This pragmatic approach allows menus to be planned with greater flexibility. It is unlikely that a free-living individual at home will meet the RNI for all nutrients on a daily basis, with most being met on average over a week (NHS 2016, p. 38).

Two sets of nutrient standards, based on the Scotland example for Food in Hospitals, have been specified in Table 2. This is acknowledgement of the extremes of the core nutritional requirements in the hospital setting. One set of standards is applicable to the needs of "nutritionally vulnerable" patients; those with poor appetites, poor food intakes, undernourished. The other set of nutrient standards is in line with the requirements of the healthy balanced diet and thus are applicable to the needs of those patients who are considered to be "nutritionally well." Provision of a menu that meets the nutritional requirements outlined for hospital patients, must also be a menu that provides choices of dishes that tempt patients to eat, and which they will enjoy (NHS 2016, p. 18).

Appropriate foodservice provision is essential for the nutritional support of hospitalized patients. This is particularly important for long stay older patients, who are increasing in number at a time when malnutrition is also a significant concern and consumer expectations of hospital patients are heightened (Williams 2009). The issue of addressing hospital malnutrition and being vigilant in continuously reviewing and improving foodservice systems and feeding assistance becomes even more relevant as the population ages (Clegg and Williams 2018).

The hospital mealtime situation and the provision of food is not planned by the patients and it is felt that more attention should be paid to the organization of food provision. Mealtime situations should respect individuality and preferences and consider the cognitive, social and environmental impacts on dietary intakes (Hartwell et al. 2016b).

Patients sometimes require complete feeding assistance, while others may require help positioning themselves for a meal, accessing the tray table and/or opening food and beverage items. This has traditionally been the role of nurses, however there are many reasons why they may not always be available to provide timely assistance to patients who require this, including competing duties such as medication rounds, a lack of skills and/or knowledge in screening and flagging patients at risk, meal breaks, and increased responsibilities and increased numbers of patients requiring support on some wards (Walton et al. 2012).

Aging is associated with a decreased total energy intake followed by a concomitant increased risk for low micronutrient consumption. In particular, despite all of the potential nutritional issues present in aging, recommended dietary allowances for older adults are similar (Maggini et al. 2018). In the healthy condition, the dietary

Table 2 Essential criteria for the provision of nutrients for hospitalized adults

Nutrient (per day)	"Nutritionally vulnerable" patients	"Nutritionally well" patients	Frequency of provision
Energy (kcal)	2250–2625	1800–2400	Daily
Protein (g)	60–75	56	Daily
Total fat (% food energy)	Not specified	≤35	Averaged over a week
Saturated fat (% food energy)	Not specified	≤11	Averaged over a week
Carbohydrate (% food energy)	Not specified	≥50	Averaged over a week
Non-milk extrinsic sugars (NMES) (% food energy)	Not specified	≤10	Averaged over a week
Fiber (g)	Not specified	30	Daily
Sodium (mg)	<2400	<2400	Daily
Vitamin A (μg)	700	700	Averaged over a week
Vitamin D (μg)	10	10	Averaged over a week
Calcium (mg)	≥700	≥700	Averaged over a week
Potassium (mg)	3500	3500	Averaged over a week
Magnesium (mg)	300	300	Averaged over a week
Iron (mg)	≥14.8	≥14.8	Averaged over a week
Vitamin B12 (μg)	≥1.5	≥1.5	Averaged over a week
Folate and folic acid (μg)	≥200	≥200	Averaged over a week
Vitamin C (mg)	≥40	≥40	Averaged over a week
Zinc (mg)	≥9.5	≥9.5	Averaged over a week
Fluid (liters) ≥1.5	Male 2,000 ml, female 1,600 ml	Male 2,000 ml, female 1,600 ml	Daily

energy requirements are diminished and although the recommended dietary allowance for protein is the same for older adults in many countries (0.8 g/kg), recent evidence points to a dietary intake of 1.0 to 1.3 g/kg appear to optimize physical function, particularly while undertaking resistance exercise recommendations (Bauer et al. 2013). Additionally, some micronutrients have their dietary intake requirements increased such as calcium, vitamins D and B6 (Table 3), while others, even presenting equal requirements, are crucial for healthy aging and are associated with lower intake in older adults such as vitamin B2 (riboflavin), B9 (folic acid) and B12 (Otten et al. 2006).

Table 3 Specific nutrient requirements for older adults >50 years

Nutrient	Recommendation (daily)
Protein	1.0–1.3 g/kg of ideal body weight
Calcium	1300 mg
Vitamin D	10.0 μg for >50 yr 15.0 μg for >70 yr
Vitamin B6	1.7 mg (male); 1.5 mg (female)

Length of Stay

Malnutrition on admission is an independent risk factor for complication-related readmissions, prolonged hospital stay, and hence increased healthcare costs. One study assessed whether protein intake relative to requirements at day one predicts complications and hospital length of stay. A post hoc analysis of a prospective cohort study was conducted in adult patients admitted to the wards of Orthopedics, Urology, Gynecology, and Gastroenterology ($n = 637$). Intake was determined at day one of full oral intake by subtracting the weight of each dish at the end of each mealtime from the weight at serving time. Protein requirements were calculated as 1.2 g/kg body weight. Data on complications and length of stay were reported using patients' medical records. In total, 92 patients (14.4%) had a complication and median length of stay was 5 days. A 10% increase of protein intake relative to requirements relatively reduced the complication risk by 9.4%. Also, each increase of 10% in protein intake relative to requirements predicted a shorter LOS by 0.25 days. These results show that protein intake relative to requirements at the first day of full oral intake is a predictor for the risk of complications and length of stay (Ijmker-Hemink et al. 2018).

A further study was conducted with 18 Canadian inpatients ≥18 years who were admitted for ≥2 days. One thousand and fifteen patients were enrolled and based on the Subjective Global Assessment (SGA), 45% were malnourished, and based on BMI (>30 kg/m^2), 32% were obese. The median (range) length of stay was 6 (1–117) days. After controlling for demographic, socioeconomic, and disease-related factors and treatment, malnutrition at admission was independently associated with prolonged length of stay. Other nutrition-related factors associated with prolonged length of stay were lower handgrip strength at admission, receiving nutrition support and food intake <50% (Allard et al. 2016).

Hospital Foodservice Systems

Meals may be chosen ahead of time and plated in a central kitchen, either hot (cook fresh) or cold (cook chill or cook freeze) for later retherm. Alternately hot food may be sent to the ward areas in a mobile trolley so that patients can select their choices at the point of service. This has numerous advantages including: selections can be made based on current appetite, different serving sizes are available, the aroma and appearance of the meal may assist appetite, more nursing staff may be involved in alerting patients to the arrival of the trolley and thus further socialization and encouragement of patients. Disadvantages may include: patients need to be mobile to access the trolley, therapeutic diets are difficult to manage this way as the foodservice staff are not trained in this area and there is often more food waste (from the bulk trolley, but not the individual patient meal plates) due to the number of options that need to be included in the trolley to cover the menu (Hartwell and Edwards 2003; Hartwell et al. 2016b).

Foodservice departments may utilize cook-fresh, cook-chill, cook-freeze, or a combination of several of those, and other systems.

Cook Fresh

In a cook fresh system, food is prepared close to the meal time and the hot food is plated hot after some time in "hot holding," which usually involves holding bulk gastronorm trays of food over a customized hot water bath (bain-marie style). To maximize nutrient retention, quality, color, and flavor the time in "hot holding" should be kept short (ideally <30mins, but certainly <90mins) (Williams 1996). For these reasons, it has been reported that hospital using cook-fresh systems are significantly more likely to offer choices of portion size and optional sauces and gravies with meat compared to cook-chill hospitals (Williams 2009).

Cook Chill

A cook-chill system involves food being cooked in advance and then rapidly chilled for retherming at a later stage. Advantages with this system may include: the availability of further main meal choices at the evening meal because the meals are prepared in advance, improved temperature control, cost savings due to bulk buying and because no cooks are required in the evening, or on the weekends when additional wage penalties would be in place. Disadvantages include that some items are not available as they do not retherm well (e.g., boiled eggs, crumbed items, steak); some foods dry out so sauces or gravies are usually required; and for this reason more wet dishes are often used (Spears and Gregoire 2007).

In pre-plated tray service systems that use the cook-chill system, a third disadvantage is the general requirement to standardize portion sizes and the amount of food on plates as much as possible; for example, baked potatoes may have to be cut into smaller pieces to facilitate even reheating. Menu choices can also be affected. To prevent drying out of meats, almost always they need to be served covered with a sauce or gravy. Wet entrée dishes that reheat well are usually favored when cook-chill systems are used over dishes such as grilled meats or eggs, which are more likely to dry out (Williams 2009).

Cook Freeze

Cook freeze is similar to cook chill, except that the meals that are cooked in advance are quickly frozen (rather than chilled) in a blast freezer for use at a later stage. Items may be frozen in bulk or as individual portions to provide greater menu flexibility, particularly for patients with special dietary requirements (i.e., gluten free). Each method of food preparation and delivery has their own advantages and disadvantages in terms of nutrient losses, flexibility, wastage, food safety, staff skills required, and food appearance and palatability (Spears and Gregoire 2007; Williams 2009).

Other Foodservice Systems

Food service systems throughout the second half of the twentieth century started to move away from patient meal services using bulk delivery trolleys in the ward areas (with food served by nursing staff) and toward centralized meal plating and distribution of individual trays by foodservice staff. Recently, there has been some reversal of this trend with several recent trials of a return to bulk food trolleys – particularly in nursing home situations. Such systems may result in less waste and greater patient satisfaction but it is unclear how they affect nutritional intake (Williams 2009).

Room service is a foodservice model that has been increasingly implemented across healthcare facilities in an effort to improve patient satisfaction and reduce food waste. As there is a paradigm shift to more personalized, patient-centered care, patient satisfaction has increasingly become a driver of high-quality care. In this type of service, patients are able to order meals of their choice from a menu that is suitable for them, according to their dietary recommendation and restrictions. Foodservice quality has been linked to patient satisfaction and, in the USA, room service is increasingly being seen as the foodservice model for hospitals to meet this outcome (Marcason 2012). Increased dietary intakes, improved patient satisfaction, and reduced plate waste and patient meal costs were reported for room service when compared to a traditional foodservice model.

Comparison of nutritional intake between a traditional foodservice model and room service showed increases with room service in both energy and protein intake, as well as energy and protein intake as a percentage of requirements. Total mean plate waste decreased from 29% (traditional foodservice model) to 12% (room service). Patient satisfaction ratings indicated improvements with room service for "quality of food" and for "flavor of food." The patient meal costs also decreased by 15% with room service (McCray et al. 2018). Another hospital study, conducted in the Netherlands, evaluated a meal service concept with a restaurant style menu and room service. There was improved patient satisfaction, nutritional status, and food intake compared to the traditional three meals per day service. There was a decrease in the risk of malnutrition followed by an increase in patient food service satisfaction among those who received this new foodservice (Doorduijn et al. 2016).

Menus

Food provision should be planned in order to be responsive to patients' needs, not those of medical, nursing, and other healthcare staff and should be managed as an integral component of clinical care rather than a "hotel" function. Before considering menu planning or the development of a recipe database, menu planning groups need to consider the wider issues that can affect patient food choice and hence food intakes. Gathering of information about the differing dietary needs of different hospital patient groups can help menu planners develop an appropriate foodservice that is in a form that is familiar to patients (The British Dietetic Association 2017, p. 70).

Menu Planning and Recipe Development

Different foods provide different nutrients; some nutrients are only found in sufficient quantities if specific foods or food groups are included in adequate amounts in the diet. Thus, in order to meet the nutrient standards specified in section two, patients will need to be provided with a diet that is made up of a combination and balance of foods from all of the five food groups (and additional protein, fats, and sugars where required), namely:

- Breads, other cereals, and potatoes
- Fruit
- Vegetables
- Milk and dairy foods
- Meat, fish, and alternatives

The balance of each of these food groups in the diets of hospital patients will vary depending on the dietary and nutritional needs of the different patient populations. The provision of different types of foods or choices of food items within each food group needs to recognize the differing dietary needs that are to be catered. Patients provided with foods that they are familiar with and enjoy will be more likely to consume it, ensuring that they receive the nutrition provided on the plate. Provision of greater choice is more likely to meet individual food preferences and individuals' dietary needs. The inclusion, preparation and cooking of a variety of foods specified in the five food groups needs to remain flexible if the diverse needs of the hospital population are to be met with "ordinary food" (NHS 2016, p. 32).

When developing a standardized recipe the following process should be followed (U. S. Department of Agriculture 2002, p. 9; Fig. 1):

There are several studies that have shown that many patients in hospital do not eat all the food they are served (Bannerman et al. 2016). Reducing portion size and increasing the energy and nutrient density of meals can encourage oral intake for patients with decreased appetite. This can ensure patients are not over-whelmed by a

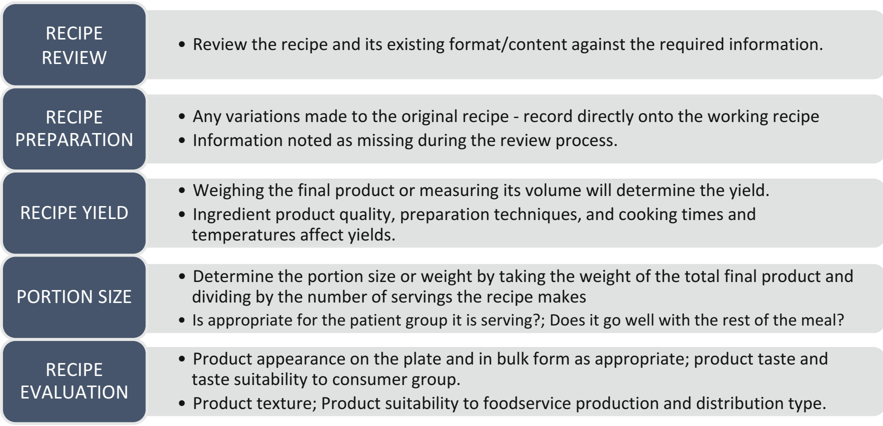

Fig. 1 Process to develop a standardized recipe

large meal and thus are more likely to eat what is provided, in turn increasing energy and nutrient intakes (Kim et al. 2010).

Types of Menus

In most institutional foodservices, the menus are either an a la carte type (offering a wide range of choices, but remaining the same each day), or a cycle menu (a series of daily menus on a weekly or longer cycle, after which the cycle is repeated). Cycle menus are commonly used in healthcare, prison, and school settings to offer variety with some degree of predictability for ordering, budgeting, and production scheduling. One or 2 week cycles are common in acute hospitals; 3–4 week cycles are more common in longer-care facilities (Williams 2009).

Menus are an important tool for the foodservice manager as they are the first point of contact with the patient and can be used both for communication and marketing purposes. However, a negative message can be portrayed if menus are not easy to read or interpret. Traditionally hospital menus have been implemented using a paper-based system where printed menus are manually distributed and meal orders collected and processed by foodservice staff. Advances in technology have seen the introduction of newer computerized systems where patients can view and order their meals using a bedside ordering system (Hartwell et al. 2016a; Ottrey and Porter 2016).

While the traditional paper menus are still available in many settings, food management systems are used in some settings to generate paper menus, or to facilitate a spoken menu via palm pilots that are operated by nutrition assistants. Meal choice at the point of service is also used occasionally (e.g., bulk hot meal trolleys in some wards). The method of offering options can subtly alter the variety that is offered, which has ramifications for resources, both human and otherwise. A patient sees all the available options allowed on a paper menu, while a spoken menu means that patients may just say yes to the first option, or alternately the last one offered, which they may remember.

A review found that modifications in menu design and menu ordering processes were associated with improvements in clinical and non-clinical outcomes in hospital. Outcomes such as intake, satisfaction, perception, cost and meal tray accuracy were analyzed. Standardized menu formatting and the spoken menu system were found to improve meal tray accuracy. The spoken menu and computerized interactive menu selector system enhanced aspects of patient satisfaction without cost increases. Descriptive menus may increase food consumption. Branding food items was not well supported by patients. Taken together, these findings show that the use of an electronic menu management system can create efficiencies in menu planning and meal production and provides a repository for standard recipes, menu, and allergen information. Many systems include nutrient catalogues, which can simplify the nutrition analysis of recipes (Ottrey and Porter 2016).

Therapeutic Diets

A therapeutic diet is modified from a "normal" diet and is prescribed to meet a medical or special nutritional need. It can be part or the principle clinical treatment of a condition, which comprises 17.22% of overall diets in hospitals (Thibault et al. 2011). Whenever a patient has a therapeutic diet prescribed by a dietitian or by medical staff, all hospitals and Health Boards must be able to provide this. In addition, when planning therapeutic diets it is essential to have accurate knowledge of the nutrient and ingredient composition of all dishes and individual menu items to determine their suitability. This makes the use of standardized, analyzed recipes crucial in the delivery of appropriate food.

Menus should reflect local population needs and healthcare organizations need to develop their own protocol for the requirement and provision of therapeutic diets for their population.

- There must be a hospital protocol for the provision of all therapeutic diets.
- Patients must be given choice for all food and fluid options suitable for their diets, including therapeutic and/or texture modified diets.
- Hospitals whose populations require certain therapeutic diets irregularly and in minimal numbers must include in their policy a formal contingency for the provision of these diets in the event they are required, for example an a la carte menu.
- Therapeutic diets must be capable of meeting the dietary requirements of patients using them.
- Where relevant, foodservice service contracts must be sufficiently detailed and cover the provision of both therapeutic and special diets (The British Dietetic Association 2017, p. 70).

Diets must not automatically be ordered for patients with the medical or surgical indications noted in the specifications, because a very restrictive diet may prevent good nutritional recovery for patients who are undernourished or eating poorly. Appropriate health professionals may alter the diets to meet individual patients' needs. For example, some patients on soft diets may not tolerate bread, and this would need to be noted at the time of ordering that diet. Combinations of diets can be ordered (e.g., low saturated fat and sodium restricted), but there is no need to specify a full diet where it is to be combined with other therapeutic diets (Agency for Clinical Innovation 2011, p. 7).

Types of Diets

Therapeutic diets is an umbrella term used for a wide range of diets for patients with specific requirements, such as texture-modified diets, allergy and intolerance diets, diabetic diets, diet–drug interaction diets, macronutrient modified diets (fat, protein, and carbohydrates), fiber-modified diets, fluid diets, and many others. The most commonly used therapeutic diets are described further (The British Dietetic Association 2017, p. 65).

Higher-Energy, High-Protein, and Nutrient-Dense Diet

Energy- and nutrient-dense diets are indicated for patients with a small or poor appetite who find it difficult to eat sufficient foods to meet their energy and nutrient requirements. These diets are also indicated for those patient groups with increased energy and protein requirements, including those who have had a major trauma such as a head injury; burns patients; cancer patients and undernourished patients. These individuals require additional energy and protein to meet their increased needs or to enable them to replace lost body weight and improve their nutritional status (The British Dietetic Association 2017, p. 65). The provision of substantial snacks three times a day is likely to be necessary to meet individual requirements.

A high-energy, high-protein, and nutrient-dense diet can be achieved by increasing the overall amount of food eaten by:

- Increasing portion sizes (larger amount of food in one meal is less effective in patients with poor appetite, prefer options below)
- Increasing the number of foods offered, for example increasing the number of times snacks are provided between meals
- Providing greater choice of energy- and nutrient-dense foods on the menu
- Increasing the energy and nutrient content of foods already consumed (fortification)

Texture-Modified Diets

The requirement for texture modified or modified consistency food and fluid, usually results from difficulties in chewing and/or swallowing food (also known as dysphagia). It is generally the result of a disease process and may be caused by either a mechanical, neurological or a psychological problem. An older person's ability to adapt and compensate for an inadequate swallow is further reduced by less saliva or chewing difficulties, and inadequate lip seal causing dribbling of liquids. A reduced ability to manipulate food in the mouth can cause loss of sensation and poor tongue control.

Providing food and fluid of an inappropriate consistency increases the risk of food or fluid going into the lungs, a major cause of chest infection, lung abscesses, and aspiration pneumonia in hospitalized patients; it can also cause asphyxiation. Aspiration can be silent, causing no outward signs of distress but still capable of causing pulmonary complications. The International Dysphagia Diet Standardisation Initiative (IDDSI) provides a practical framework to approach patients with dysphagia (International Dysphagia Diet Standardisation Initiative 2019).

Allergen-Free Diets

Food Allergy

True food allergy is an immune reaction to food that triggers the release of histamines and other substances into the tissues. Food allergy may be caused by numerous different foods or additives and symptoms can be triggered by minute amounts of these. Allergic reactions may range in severity from relatively short-lived discomfort through to anaphylactic shock, which may be fatal. Therefore, there are significant risks to patients if allergen-free diets are not provided when required.

Food Intolerance

Food intolerance differs from food allergy in that it does not involve the immune system. Food intolerances may arise in a number of ways (e.g., by dietary components acting as irritants or due to enzyme deficiencies which may result in an inability to digest or metabolize certain food components). Reactions due to food intolerance may be severe but they are not generally life-threatening. However, they can affect long-term health and do represent a health risk if not taken into account when required and thus these patients' dietary needs should be catered for in the hospital setting.

People who suffer from food allergies and food intolerances need to know the exact ingredients in the food that they eat as even a small amount of allergen can make them very ill or in some cases could be fatal. The use of food product labels is fundamental to identify foods appropriate for patients' diets when exclusion of specific foods is required due to an allergy or food intolerance.

Where an allergenic ingredient or its derivative is not clearly identified in the name of the food (e.g., malt vinegar), the allergenic ingredient should always be clearly identified in the labeling, for example "malt vinegar (from barley)." All added ingredients and components of added ingredients are covered by the new labeling regulations if they are present in the finished product, even in an altered form. This includes carryover additives, additives used as processing aids, solvents, and media for additives or flavoring and any other substance used as a processing aid.

Gluten-Free Diet

Celiac disease is caused by an autoimmune reaction to a component of gluten, which is a protein that is found in certain cereals, namely, wheat, barley, and rye. A gluten-free diet is used as the treatment for coeliac disease and the skin condition dermatitis herpetiformis (DH). Consumption of even a minute quantity of gluten by someone with coeliac disease can result in malabsorption, gastrointestinal symptoms, and fatigue. Patients with intolerance to gluten can also benefit from this type of diet by reducing symptoms such as bloating and low-grade inflammation.

Special and Personal Diets

Special diets refer to those meeting cultural or religious needs, while personal diets are those meeting personal preferences. Any organizational structures, policies, procedures, and practices are required to treat ethnic minorities fairly and equally. This applies to all public bodies and is therefore applicable to the hospital foodservice service. Although a standard hospital menu meets the majority of patients' cultural and religious food needs, there are some patient groups with alternative needs. A patient's personal dietary needs must be met when they also require a therapeutic diet.

Vegetarianism and Veganism

People from a variety of backgrounds adopt vegetarian dietary practices for a number of reasons including religion and culture, for example Hindus and Buddhists; moral or ethical beliefs, health, environment, ecological and economical concerns. Vegetarian dietary practices can vary quite considerably in terms of what foods will be eaten and what foods are excluded. The extent to which foods are excluded needs to be determined with the individual patient. Many of the principles of a vegetarian diet follow national targets for healthy eating, which is higher intakes of complex carbohydrates, fibers, and fruits and vegetables. If well planned, the vegetarian diet can be nutritionally adequate. However, exclusion of certain foods or food group items requires careful planning to ensure that alternative foods are included in the diet to prevent any nutritional inadequacies. A hospital menu has traditionally provided a lacto-ovo vegetarian option for patients. Any variants of this diet must be planned for the individual patient by the foodservice department in conjunction with a dietitian as per the local protocol.

Food Safety

Food safety is critical, particularly when preparing and serving food for hospitalized patients who are likely to be more susceptible to foodborne illness due to their ill health and decreased immunity. Anyone involved in handling food should receive appropriate food safety training. Depending on the level of risk this can be either at a local level or by a course accredited by an organization. All caterers are legally required to carry out a full risk assessment of their food production and service procedures and practices, and to put in place management systems and control measures to reduce the major risks in food manufacture. These set out what is, and what is not, permissible, and will take account of issues such as staffing and equipment availability in each individual unit (Abdullah Sani and Siow 2014; Food and Drugs Administration 2019).

The dietitian has a role to play in the assessment team, by providing specialized advice to the caterer about the vulnerability of specific patient groups. What is possible to do in one unit might not be safe to do in another, due to differing systems. The procedure manuals and staff training will all be based on the original hazard analysis, and the assumption that the control systems remain unchanged at ward level. The cooking process does not kill all food poisoning bacteria spores, and those that do survive are then controlled by the rigid time and temperature controls, so that their potential for growth is kept within safe limits (The British Dietetic Association 2017, p. 90).

Every year, more than one-third of the total population in developing countries is affected by foodborne illness. European Food Safety Authority (European Food Safety Authority 2010) reported that in year 2010 alone, approximately 48.7% of foodborne diseases are associated with the foodservice or foodservice establishments which prove the importance of basic food safety practices in these areas (ESFA 2010). Mishandling food may be implicated in 97% of all food-borne illness associated with foodservice outlets. In spite of food handlers having the skills and knowledge to handle food safely, yet human handling errors have been associated with most incidence of food poisoning. Hence, to reduce the risk of cross-contamination, serious attention should be given to train and supervise food handlers to ensure proper hand washing, adequate cleaning and good sanitation procedures (Abdullah Sani and Siow 2014; Food and Drugs Administration 2019).

The "Hazard Analysis and Critical Control Points" (HACCP) is a preventative food safety system in which every step in the manufacture, storage and distribution of a food product is scientifically analyzed for microbiological, physical and chemical hazards. Its principles and application guidelines can be found at https://www.fda.gov/food/hazard-analysis-critical-control-point-haccp/haccp-principles-application-guidelines

Food Quality and Foodservice Satisfaction

Consumer expectations of hospitals have been increasing, so that the provision of food and the meal experience are becoming increasingly important within the range of medical and support services offered by hospitals. One study explored the antecedents to patient satisfaction and experience, including the service element. Accordingly, focus groups were conducted with doctors, nurses, ward hostesses, and patients together with their visitors, while open-ended interviews were conducted with the foodservice manager, facilities manager, chief dietitian, orthopedic ward dietitian, and chief pharmacist. Themes centered on "patients," "foodservice," and "mealtimes," and results show that food qualities, particularly temperature and texture, are important factors impinging on patient satisfaction (Hartwell et al.

2006). A review also assessed which factor are more important for meal experience in Hospitals. Food quality, food temperature, taste of food, variability, time of food distribution, and staff service were among the most important factors for patients (Hartwell et al. 2016b).

Furthermore, Navarro et al. investigated if improved meal presentation, supported by gastronomy expertise, would have an effect on the food intake. This prospective open labeled, non-randomized controlled design study analyzed the meal experience satisfaction of 206 hospitalized patients, in two different periods lasting 3 weeks each. Patients who received the meal with the improved presentation showed significantly higher food intake than those who received the standard meal, despite reported loss in appetite. More participants from the experimental group reported their meal to be tasty in comparison to those in the control group. Length of stay was not different but readmission rate decreased significantly in the study group from 31.2% to 13.5% (Navarro et al. 2016).

Barriers and Opportunities

Barriers to Improve Dietary Intake

Barriers to adequate food intakes by hospital inpatients are multifactorial and complex, and require multilevel interventions, including a change in the awareness and attitude toward food among healthcare staff and older hospital patients (Hope et al. 2017). The main theme with regard to foodservice management is the fragmentary nature and difficulty of communication between the kitchen and wards. Foodservice managers have to rely on kitchen porters for the delivery of food to the ward; and ward staff may have difficulty in communicating with foodservice staff and dietitians. Financial constraints were a prominent part of the concern of the foodservice and facilities managers, with budgets continually being reduced and not "ring fenced" (protected) (Hartwell et al. 2006).

While nurses may view the nutritional care of patients as an important aspect of their job, increased time pressures and competing tasks may mean that they are not able to prioritize feeding above other duties, such as the distribution of medicines at. Most research in this area has reported common themes of time restraints and staff shortages. A further study investigated the most common barriers in food intake of long-stay, older adult patients in Australian hospitals. The key barriers identified were lack of choice due to special diet, boredom arising from the length of stay, a lack of feeding assistance, limited variety, and inadequate flexibility of food service (Walton et al. 2012).

Another factor that may be a crucial barrier to a proper dietary intake in older adults is the packaging. One study has demonstrated that "fiddly" packaging (i.e., packaging that appears to require dexterity to access the contents) and decreased hand strength are shown to influence the ability of hospitalized patients to open food and beverage packaging. Staff are aware of many problematic packages and acknowledge that many patients require assistance to open food and beverages, however a significant proportion of staff are also unable to open these packages.

This study also identified several key recommendations on the service delivery of packaged food and beverages at meal times (Bell et al. 2013). These are as follows:

- Offering alternative solutions such as decanting contents
- Identifying alternative package solutions, that is, that some packages are easier to access than others and those package forms could be encouraged
- Designating staff to assist in opening packages at mealtimes and training staff in understanding the difficulties users may have

Improving Nutrition in Hospital Foodservice

To be successful the priority interventions need to be feasible in practice, in terms of the availability of human resources, budget, infrastructure, and time. The need for additional feeding assistance (nursing and non-nursing), assistance in setting up with meals, assistance to open food and beverage packaging and socialization are issues to be considered. The same study aforementioned which highlighted the main barrier for food intake, also investigated feasible opportunities to enhance nutrition support of older, long-stay patients in Australian hospitals. Food fortification, assistance with packaging, additional feeding assistance by nurses, non-nursing feeding assistance and further nutrition assessment were key priorities in order to improve food intake (Walton et al. 2012).

Furthermore, a UK hospital study evaluated if the menu was able to meet energy and protein standards recommendations, as well as to determine the contribution of oral nutrition supplements and additional snacks. Energy and protein contents of food selected from the menu ("menu choice"), menu food consumed ("hospital intake") and total food consumed including snacks ("overall intake") were calculated. In total, 93 patients were included and were categorized as "nutritionally well" or "nutritionally vulnerable." For "nutritionally well" patients, energy and protein standards were met by 11.1% and 33.3% ("menu choice"); 7.4% and 22.2% ("hospital intake"); and 14.8% and 28.4% ("overall intake"). For "nutritionally vulnerable" patients, energy and protein standards were met by 0% and 8.3% ("menu choice"); 0% and 8.3% ("hospital intake"); and 8.3% and 16.7% ("overall intake"). Ten percent of patients consumed oral nutrition supplements. Patients who consumed hospital snacks (34%) were more likely to meet the nutrient standards (Pullen et al. 2018).

Several other studies investigated new strategies to improve nutrition in hospitals. A new concept comprising six protein-rich meals per day, provided directly at the bedside following proactive advice from a nutritional assistant, was evaluated as a strategy to optimize protein and energy intake and prevent or treat malnutrition during hospitalization. In a total of 311 patients in 4 different hospital wards, those receiving this dietary service had an improved mean daily protein intake relative to requirements and an improved mean daily energy intake when compared to patients on the regular 3 meals per day service. Additionally, the new strategy also increased patient's satisfaction with the appearance and smell of meals (Dijxhoorn et al. 2018). Another study followed a food quality control and improvement permanent process in a Hospital for 9 years. Among the 1291 patients included, the consumption of 1 oral nutritional supplements daily increased the protein needs coverage from 80% to 115% (Thibault et al. 2011).

Sustainability, Environment, and Costing

In all foodservice settings there is increasing consumer demand for greater attention to the nutritional quality and environmental impact of the food being offered. Recent trends to greater use of cook-chill foodservices, and more portion packaged food and disposable tray items (in order to reduce dishwashing) have not been made with much awareness of the consequences for energy consumption or environmental impact. These are factors that are likely to have increasing prominence, with a demand for the use of more locally sourced food, recycling and improved energy efficiency. Organic menus have started to appear in the hospital sector and environmental concerns may well have longer term impacts on the technologies employed for meal production and delivery (Williams 2009).

Hospital foodservice systems can be responsible for up to 50% of all hospital waste (Goonan et al. 2014). It has been suggested that some food waste is unavoidable to ensure patients' food and nutrition needs are met. However, foodservice systems can be more reactive and flexible to minimize wasted food. Increasing resource restrictions within the healthcare system are driving facilities to scrutinize the costs of service delivery and investigate avenues for saving. The provision of food to patients and associated levels of waste are often a priority focus in cost-management strategies. Sources of food waste are varied and can include foodservice model design (bulk cooking and rethermalizing, long lead time forecasting, and in-advance meal ordering), missed meals due to environmental factors (hospital procedure and test scheduling), and individual patient factors (reduced appetite and other impacts of clinical symptoms and treatments, such as nausea or pain). Foodservice models that can reduce or eliminate these sources of waste are considered optimal from this cost-management perspective (McCray et al. 2018; Williams and Walton 2011).

Plate waste in hospitals refers to the served food that remains uneaten by patients. High levels of plate waste contribute to malnutrition-related complications in hospital, and there are also financial and environmental costs. Plate waste is typically measured by weighing food or by visual estimation of the amount of food remaining on the plate, with results presented as the percentage by weight of the served food, or by calculating the protein, energy or monetary value of the waste. Results from 32 studies in hospitals show a median plate waste of 30% by weight (range: 6–65%), much higher than in other foodservice settings. Levels are lower in hospitals using a bulk food delivery system compared to plated meal delivery. Reasons for these high levels can relate to the clinical condition of patients, food and menu issues (such as poor food quality, inappropriate portion sizes, and limited menu choice), service issues (including difficulty accessing food and complex ordering systems), and environmental factors (such as inappropriate meal times, interruptions, and unpleasant ward surroundings). Strategies to minimize waste include reduced portion sizes with food fortification, bulk meal delivery system, feeding assistance, provision of dining rooms, and protected meal times (Williams and Walton 2011).

Recommendations

A study reported that a multi-level approach is required to address the complex issue of improved care processes and strategies to promote the nutrition care culture in hospitals. Examples of strategies and processes at the organizational, staff and patient levels have been provided to demonstrate that a change in culture to improve patient-centered nutrition care is within reach. A structured implementation program using implementation frameworks is needed to change organizational policies and procedures, provide staff role delineation and training, as well as **s**trategies to reinforce this training and to empower patients and families. The framework suggested by this study is presented below (Laur et al. 2015).

Suggested Practices to Change the Culture of Nutrition Care

Organizational Level

- Hospital management aware of the effect that nutritional status has on length of stay, risk of readmission, and cost to the hospital, should make nutrition a priority
- Use of knowledge translation/implementation frameworks to develop and implement policies/protocols for enhanced nutrition care
- Frameworks in place to support changes in nutrition practices/culture
- Hospital benchmarking and progress tracking for nutrition related goals
- Effective communication systems (i.e., between wards and foodservices, and between healthcare professionals)
- Focus on all aspects of the nutrition care process including screening, referral, assessment, intervention, and monitoring
- Interventions to promote intake (i.e., use of color-coded trays for patients requiring feeding assistance or protected mealtimes)
- Foodservices is able to respond quickly to diet changes and allow food access outside of meal times (i.e., snack carts)

Staff Level

- Clarification of staff roles and responsibilities in nutrition care
- Staff education and training on how to perform these roles (i.e., nutrition screening)
- Auditing and feedback of nutrition care practices
- Individual actions to promote nutrition (i.e., avoiding interruptions at mealtimes, providing feeding assistance if needed)
- Ensuring nutrition is considered in transitions in care (i.e., handovers, discharge or transfer to other wards/areas)

- Training of hospital volunteers to assist with specific tasks, when appropriate
- Reminders in place for staff to ensure training is carried over into practice and changes are sustained

Patient-Family Level

- Encouraging patient and family participation in nutrition care (i.e., intake monitoring, advocating for nutrition needs, making the dining area as pleasant as possible)
- Educating patients and families on the importance of nutrition during and post hospitalization
- Training families on meal setup and assistance for patients
- Allow social interaction (i.e., opportunities for patients to eat while family is present)

Conclusion

Hospital foodservices present a challenging system, comprising a myriad of factors ranging from administrative functions to high complex medical decisions. The balance between costs, sustainability and foodservices provided should always be centered in the improvement of patients' health, recovery, and support. This chapter addressed several topics in this field, gathering practicable knowledge from different parts of the world with diverse resources and populations' characteristics. This chapter serves as guide to the development, restructuring, and promotion of a systematic approach to hospital foodservice.

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An Overview of the Foodservice Consumer 49

John S. A. Edwards

Contents

Abstract

This chapter provides the second part of the introduction to foodservice and focuses on the "demand side," that is the consumer, in order to offer a better understanding, thereby putting the foodservice industry into context.

The number of people eating out of the home has increased worldwide although the rate of increase varies with the Asia-Pacific region increasing at the fastest rate. Although there are little reliable international comparative data, it

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would seem that in many countries, the amount of money spent on eating out is similar to that spent on eating at home.

The possible reasons for people eating out are identified, and approaches to meet this demand center either on putting the focus on the consumer and building the product (and service) around those reasons or putting the emphasis on the product then identifying consumers for those products and services. In most cases, though, consumers, when dining out, are not only looking for food, drink, and service that meet and satisfy their expectations but they are also looking for other factors, which here and elsewhere are often referred to as experiences. A number of factors synergistically, create that experience. More recently, these ideas have been developed and brought together describing the situation as the experience economy.

This chapter in looking at the consumer when eating out considers factors such as the growth and size of the eating out market, along with current patterns of eating out; the frequency of eating out and what establishments are chosen; the most important factors driving decisions; and the time taken to eat out.

However, a note of caution is offered, principally the fact that meals eaten out of the home may be less healthy than those cooked at home, and foodservice operators will need to consider all of the issues involved as they move forward.

Introduction

This chapter provided an overview, an introduction to foodservice and the foodservice industry. This chapter of the introduction considers the demand side, that is the customer and consumer aspects of foodservice, in order to provide a better understanding and put the foodservice industry into context.

Background, History, and Development

Eating out is not new. It is something that has taken place for centuries although until the latter part of the nineteenth century, it would probably have been confined to a small proportion of the population. Throughout the world, the main type of eating establishment has always been the street kitchen (vendor), where a busy person could buy a precooked dish for a modest sum (Pitte 1999). In Roman times, cooking equipment for the poor was primitive, fuel was in short supply, and the ever-present danger of fire in houses ensured that little cooking was undertaken at home. Instead, individuals used the numerous cookshops where they could purchase dishes that included slices of roast pork, salt fish, goat's milk cheese, or more often, a handful of olives, raw beans or figs (Tannahill 1988).

This situation prevailed for many centuries, but it was not necessarily the lack of time that was the issue but often the lack of facilities. In the middle ages, in Europe, for example, few houses, particularly in cities, had adequate kitchens or cooking facilities, hence much of the food consumed at home was purchased from public cookshops where customers could either buy hot ready-prepared dishes or they could send their own joints to be cooked (Hammond 1993).

The first mention of cookshops in the UK was in London in 1183 (Curtis-Bennett 1949), and many were grouped together, often according to what they sold, hence in London, for example, streets were given the appropriate name (Pudding Lane, Pye (Pie) Corner). During the middle ages, most countries had cookshops and by comparison, those of China's were well advanced. As well as the more traditional eating houses, China also had fast food operations, hotels, taverns, teahouses, noodle shops, and wine shops (Tannahill 1988).

Various estimates have been made as to the size of this early eating out population and one consideration is that up to the middle of the nineteenth century and the spread of the railways, something like 90% of the population would never have travelled further than 5 or 10 miles from their home (Tannahill 1988). Hence, with the exception of people such as merchants and pilgrims, most of those who were able and could afford to eat out would have done so within the geographical limits of their own town. What has changed and what is new is that in the last hundred years, eating out in its various guises, and for a variety of different reasons, has become increasingly popular and is now very much part of everyday life.

Global data on the changes in eating out are difficult to find, but one example, illustrative of the changes and growth in eating out, compared with food eaten at home, can be taken from data collected by the US Department of Agriculture and shown in Fig. 1.

As can be seen, more and more people are eating out of the home, caused by a number of factors; these include:

- A growing population which is also aging
- More women in the workforce, hence not at home and able to shop, prepare, and cook meals
- Greater urbanization;
- Higher disposable incomes
- A more hectic lifestyle, often with long working hours, competing with demands for a limited amount of time
- Increasing availability of foodservice outlets, at work and elsewhere, offering a variety of cuisines at prices people are able to afford and willing to pay

In many countries, eating out has become a way of life, often considered as being "circular." As more people eat out, eating out places and meals become more readily available and cheaper, and therefore, more people eat out, and they do so for a myriad of reasons.

Reasons for Eating Out

The reasons for an increase in the number of people eating out are not merely a matter of the ability to pay or the degree of convenience, important though they are, but also the matter of social relationships in the home, perceptions of treats and

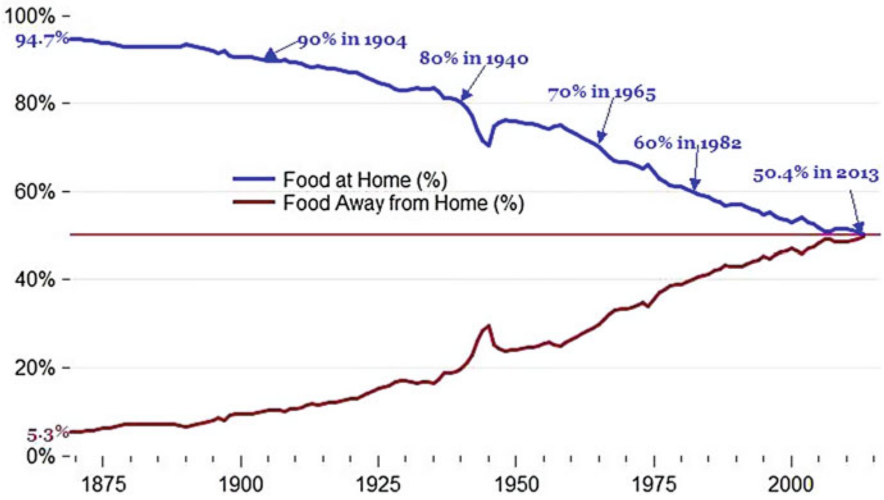

Fig. 1 Percentage changes in spending on eating at home and eating out. (Source: Adapted from Perry (2015) using data from United States Department of Agriculture Economic Research Service)

luxuries, and sets of values and judgements about food and eating in public which are differently distributed across the population (Warde and Martens 1998).

Historically, it was considered (Murcott 1997) that eating out was most likely to be associated with a series of socioeconomic characteristics, outlined below, although it is doubtful whether these hold good today. They may, perhaps, be relevant to "fine-dining," not so with fast food and other quick-service restaurants.

- High income
- Being of a higher social class
- In full-time employment
- Highly educated
- Being younger
- Being unmarried
- Having no children in the household

In Europe, it was not until the mid-1960s that authors really attempted to analyze, understand, and explain the phenomenon of eating out, identify what diners might be looking for, and what influenced their decisions both to eat out and affect their "enjoyment." The work generally credited with starting the process, *The Marketing of the Meal Experience* (Campbell-Smith 1967) which, in addition to approaching and evaluating eating out in marketing terms, also established the term, *the meal experience,* a term to broadly describe the factors associated with eating a meal.

In his deliberations, Campbell-Smith (1967, p. 75) identified 43 separate reasons why people eat out and categorized them into four broad areas, namely:

- Functional eating at home or in “digs” lodgings)
- Pleasurable eating at home
- Eating at work, school, or university
- Eating in other situations

Since then, a number of authors have developed their own characterizations of eating out.

Cullen (1994) provides a much simpler distinction and gives two categorizations: social eating and convenience eating. The former a means to an end, which must also fulfil a social function if they are to be successful; the latter consisting of meals and snacks which enable more time and effort to be devoted to other activities. In practice, social eating is further divided into two categories: the formal social event which is part of a planned routine and entails activities such as dressing-up. These meals only adjust slowly to changing circumstances, such as income, and are probably associated with an older age group. Informal social functions are not connected to any specific activity and dressing-up is not involved.

Johns et al. (1996), drawing on other work, have suggested that the “product” of any foodservice operation is “an amalgam of tangible and intangible components.” The quality of the *meal experience* they consider as being equivalent to the overall service quality which they divide into three broad categories or factors:

- Those concerned with customer traits and preferences
- Those which are directly important in terms of managing the foodservice outlet (although it is not clear why these should be of any consequence to the consumer)
- Those which seem intuitively to be attributes or benefits of eating outside the home

O’Conner (2000) considers four basic reasons for eating out on a continuum ranging from “pure pleasure” to “pure necessity,” although he acknowledges that there is considerable overlap. The categories suggested are:

- ***Necessity*** – for example, travel, work, or study
- ***Contingency*** – for example, association with other activities such as shopping and leisure
- ***Time-saving*** – for example, association with female employment
- ***Pleasure*** – for example, social, family and friends meeting, celebrations, gastronomy

What these all have in common is that they present a very mechanistic categorization of eating out. The assumption perhaps is that each occasion fits neatly into a box, and once this initial sort has been completed, there is little else that can be done other than to measure the effectiveness of this categorization. But is that the case?

Social scientists take a somewhat different stance and often classify the circumstances of eating out into enabling and constraining factors. These include aspects such as the economic ability to be able to afford to eat out (economic access), appropriate social skills (social access), and the levels of provision (Wood 1990).

Gillespie and Cousins (2001) suggest that the reasons for eating out can be summarized under seven headings:

- **Convenience**, for example, being unable to return home as in the case of shoppers or people at work or involved in some leisure activity
- **Variety**, for example, trying new experiences or as a break from home cooking
- **Labor**, for example, getting someone else to prepare, serve food, and wash up or simply the physical impossibilities to house special events at home
- **Status**, for example, business lunches or people eating out because others of their socioeconomic group do so
- **Culture/tradition**, for example, special events or simply because it is a way of getting to know people
- **Impulse**, for example, simply spur-of-the-moment buying
- **No choice**, for example, those in welfare, hospitals, or other forms of semi or captive markets

To which we might also add:

- **Pleasure** – social occasions, both formal and informal, special occasions, or celebrations
- **Purely as an experience** – to experience and enjoy different cuisines, as part of another event, as a change, mood.

Clearly, the rationale and reasons for eating out will vary enormously, although in one study of fast food restaurants, the most frequently reported reasons for eating out were that fast food is quick (92%); restaurants are easy to get to (80%); and food tastes good (69%). The least frequently reported reasons were: eating fast food is a way of socializing with family and friends (33%), restaurants have nutritious foods to offer (21%), and restaurants are fun and entertaining (12%) (Rydell et al. 2008).

Approaches to Addressing Consumer Demand

Identifying and satisfying consumers' and potential consumers' demands can be approached in a number of ways but in essence all focus on whether the product and service should be put first, then consumers identified or encouraged to consume that product and service; or whether consumers are put first, their needs, wants, and aspirations identified, then the product and service adapted to satisfy those aspects.

Kotler and Armstrong (2018) have identified and explained this situation in each of these concepts:

The production concept: This suggests that consumers will favor and prefer products (and services) which are expensive and, as a result, seek these out. It could be argued that "Michelin Star" restaurants might fall into this category.

The product concept: This suggests that consumers will favor those products and services which are perfect in terms of quality, innovation, and provide the best value for money. The product and service are the most important issues and every attempt should be made to improve these. It suggests that when applied to foodservice outlet must use the finest ingredients and so on, produce the best possible food and meals along with an exceptional standard of service. In that way, consumers will recognize the quality of the offering and seek to buy it. This might manifest itself in a number of ways in "up-market" restaurants, but perhaps in many cases, it is an approach which satisfies the foodservice operators' own interpretation of what is required and to meet his or hers ego, rather than providing products and services that the consumer actually wants.

The selling concept: This assumes that the consumer does not really know what he or she wants, and that the only way of achieving sales is to promote the product in some way. It might be argued that some approaches to healthy eating follow this idea and place a greater emphasis on, and seek to sell, the idea of "healthy" products rather than to explain their benefits and provide dishes which meet the desired criteria and which the consumer actually enjoys and therefore wants.

The marketing concept: This concept turns the focus on to the consumer and attempts to identify exactly what the consumer would like, where, when, and how he/she would like it and at what price he might be prepared to pay. The product and service are then developed accordingly. It could be argued that fast food exemplifies this concept.

A development on from this is the Societal Marketing Concept which addresses some of the concerns of consumers with regard to shared values and environmental issues. Can the needs, wants, and aspirations of the consumer be satisfied but with due regard to areas such as the environment? For example, is the packaging minimalistic, recyclable; is the food sourcing sustainable; and is waste avoided?

As in so many instances, none of these approaches on their own might be entirely suitable and a combination could be used in order to bring the foodservice provider and consumer together.

The Meal Experience and the Experience Economy

The theme running through a lot of the reasons for eating out center on the fact that in many instances, people who eat out are not necessarily looking solely at the food and may well be influenced by many other aspects (Edwards 2013). In addition, they may, perhaps unbeknown to themselves, be looking for an experience.

The meal experience identified a number of issues, but the concept was taken to another level with "the experience economy," articulated and popularized by Pine II and Gilmore in 1998/1999 (Pine II and Gilmore 2011). Here the authors argue that we have moved on from our original roots, based on agriculture, extractive, and mining, through production and services and what people now demand is much more subtle. They are not looking, necessarily for goods and services, although these are or maybe important, if not essential. In many instances, consumers are looking for more, they are looking for experiences, which are not delivered but staged! Fig. 2.

Hence, in many foodservice operations, the emphasis is not necessarily on providing meals and service, although these are important, the emphasis is on providing an experience; not on delivering a service but of staging a "production" throughout the meal; not necessarily on providing a service which is not only intangible but also something which is completely different from other outlets and is, therefore, memorable; the meal is not simply delivered to the table but revealed over time, over the course of the complete meal; not something provided by the restauranteur but staged by the staff, waiters, or waitresses who in reality are actors within the "show"; no longer customers but as so often referred to in hospitality as guests; and the outcomes are not benefits, both tangible and intangible, but on sensations. The relevance and application to the foodservice industry are summarized in Table 1.

Clearly though, while many foodservice outlets might now be perceived as belonging to and benefiting from an understanding of the experience economy, a number, for example, prisons and hospitals, might not fit into this category but in the latter category, hospitals, where food is generally regarded as part of the treatment, there may be some merit to this approach. Similarly, consumers may not be looking for an experience but simply be hungry and looking for something to eat.

A more recent construct (Collier et al. 2018) that represents unique service experiences is the Idiosyncratic Service Experience (ISE). This is made up of perceived employee effort, surprise, and perceived employee empathy. These, it is said, promote feelings of delight which lead to a higher tolerance to future failures,

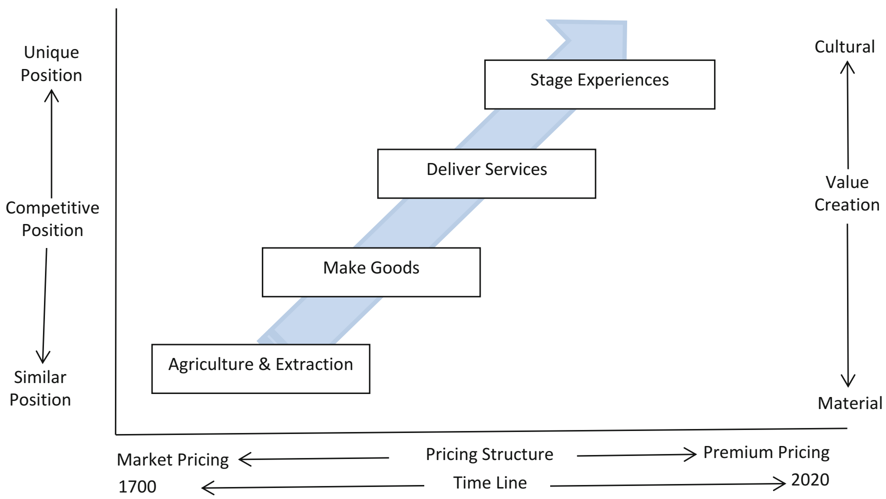

Fig. 2 The progression and development of economic value. (Source: Adapted from Pine II and Gilmore 1998)

Table 1 The application of the experience economy to the foodservice industry

Traditional dimension	Traditional foodservice approach	Transforming eating out to an experience
Management	Manager	Host or mine host
Staffing	Waiting staff	Cast, crew, actors
Production/ manufacturing	Food preparation	Food theatre
End users	Customers or clients	Guests
Delivery/sales	Food is served	Meals are staged
Customers	Customer interaction	Guest engagement
Timeline	Meals served as courses	Meals revealed over time
Customer relations	Customer service	Complete performance
Customer requirements	Functional operation	Experiential
Delivered	Customer led	Host led
Offering	Intangible operation	Memorable event
Characteristics explained	Benefits emphasized	Sensations realized
Characteristics static	Measured interaction	Generosity throughout

Sources: Adapted from Pine II and Gilmore (1998, 1999)

decreased price consciousness, and stimulated self-enhancing word-of-mouth. Exception making or the willingness of an employee to break a service norm influences ISEs and evaluations of delight. It will be interesting to see if and how these might be applied to the foodservice industry.

Current Patterns of Eating Out

Worldwide, food consumed out of the home now represents an increasing proportion of total food consumption as previously shown in Fig. 1, and a myriad of statistics are available. Caution needs to be exercised with many of these figures, not only for reasons of definition and categorization identified in this chapter, but also partly because some data are contradictory and in a number of global household surveys, only 42% actually met the minimum criteria deemed reliability (Smith et al. 2014). In addition, many of the reports available show changes, for example, in consumption patterns without really explaining why, leaving the reader to surmise. Despite these limitations, most of the available data provide a broad indication of trends and developments.

Growth and Size of the Eating Out Market

Notwithstanding, from the data available, and as noted earlier, the global foodservice industry had a compound annual growth rate of 4.5% between 2012 and 2016 with total revenues of US$3628.6bn (Business Wire 2018). This global breakdown of this is given in Fig. 3.

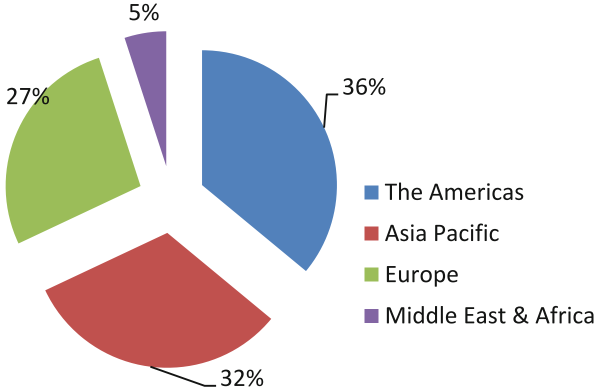

Fig. 3 Global breakdown of all consumers spending on eating out (2016). (Source: Cushman and Wakefield 2017)

The number of people eating out is increasing and the Asia-Pacific region has been the fastest growing region with spending on eating out averaging an annual growth of 9.8% in the years 2006–2016. In the period 2017–2026, the annual average growth is forecast to be of 7.5%.

In the Middle East and Africa, the annual average growth rate was 7.4% between the years 2006 and 2016. The annual average growth for the years 2017–2026 is forecast to be at 7.3%.

North America and Europe are generally regarded as being the most mature markets, hence growth between 2006 and 2016 has been lower at 6.1% and 4.2%, respectively. The annual average growth forecasts for 2017–2026, however, remain positive but are lower with North America forecast to grow by 5.5% over the period and Europe by 4.9% (Cushman and Wakefield 2017).

Despite the fast growth in the Asia-Pacific region, the USA is currently the world's largest foodservice market and which is estimated will continue to be so up to 2026 with China retaining its second place, as seen in Table 2. It is interesting to note from this table the rapid growth of India and to a lesser extent Venezuela and Indonesia with the decline of Canada. It is far from clear why this growth might be happening although one explanation advanced in the reports centers on increases and changes in ages of the populations together with higher incomes and opportunities in outlets located in places such as shopping malls (Cushman and Wakefield 2017).

Meals Eaten Out

Eating out, with the exception of Latin America, is primarily associated with the evening meal, followed by lunch then breakfast, as shown in Fig. 4. However, this trend may be changing in some markets. In the USA, for example, respondents are more likely than average to report that they eat breakfast at a restaurant (21% versus 16% globally). Many establishments are capitalizing on this by expanding their menus with items suitable for consumers who have little time for a formal meal. Coffee shops, for example, are enlarging their menus to include more breakfast

Table 2 Rankings of the largest foodservice markets 2006–2026

Country	2006	2016	2026
The USA	1	1	1
China	3	2	2
India	14	3	3
Spain	2	4	5
Japan	4	5	7
UK	5	6	4
Brazil	6	7	8
Italy	7	8	9
Thailand	12	9	6
Germany	8	10	11
France	9	11	12
South Korea	11	12	13
Venezuela	27	13	10
Hong Kong	15	14	16
Russia	13	15	17
Turkey	17	16	19
Canada	10	17	23
Taiwan	20	18	18
Colombia	21	19	20
Indonesia	23	20	14

Source: Cushman and Wakefield (2017)

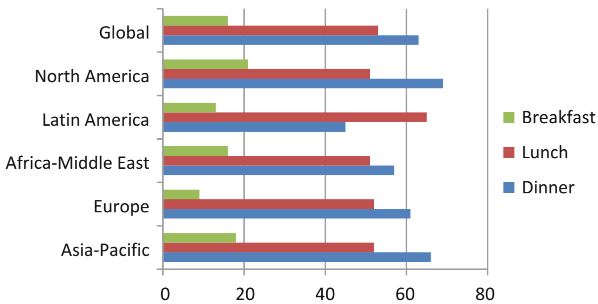

Fig. 4 Percentage of diners eating meals out of the home. (Source: Nielsen 2018)

options, while some quick-service restaurants have introduced breakfast service or made "breakfast" available all day (Nielsen 2018). The Asia-Pacific and North America are particularly avid out-of-home diners.

Frequency of Eating Out

Eating out has not only become more prevalent with people reporting that they are eating out on multiple occasions as shown in Fig. 5. Nearly half of global respondents (48%) eat out of the home weekly or more often, with more respondents in Europe reporting that they only eat out once per week (Nielsen 2018).

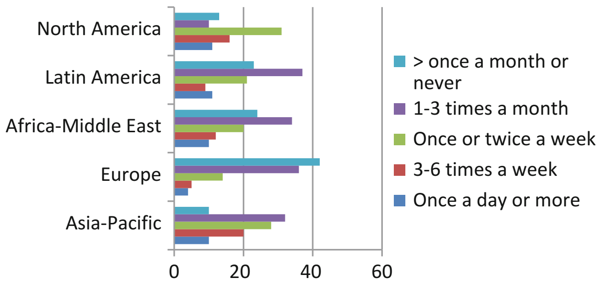

Fig. 5 Frequency of eating out of the home. Note: Figures do not sum due to rounding. (Source: Nielsen 2018)

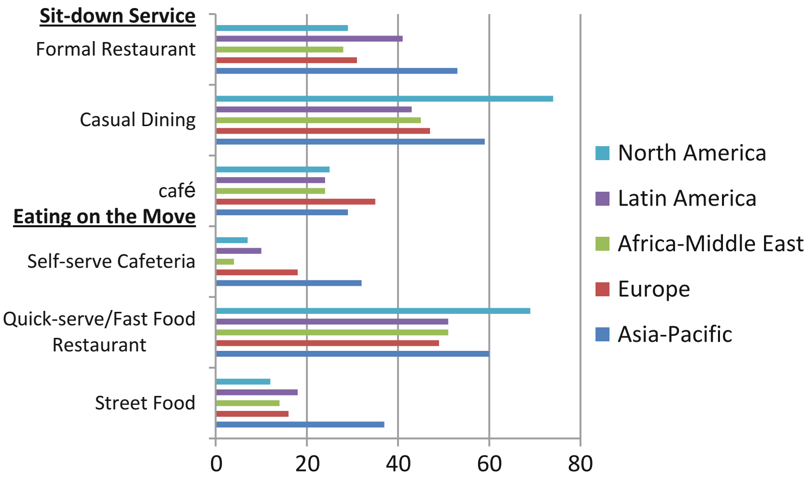

Fig. 6 Establishments frequented when eating out of the home. (Source: Nielsen 2018)

Establishments Frequented When Eating Out

Globally, 57% of diners who say they eat out do so at fast food restaurants, whereas the figure for North America is 69%. Malaysia (51%), Taiwan (50%), and Vietnam (48%) are the most likely to say they eat food from street food vendors, Fig. 6.

Most Important Factors When Eating Out

In terms of what drives the decision as to where to eat out, reasonably food prices and food quality are the two most important attributes in all continents, Fig. 7. Price is of far more importance in Europe, by 10%. Interestingly, perhaps, is that service is of least important in North America, and good hygiene is most important in the Asia-Pacific region, least important in Europe and North America. Could it be that when considering

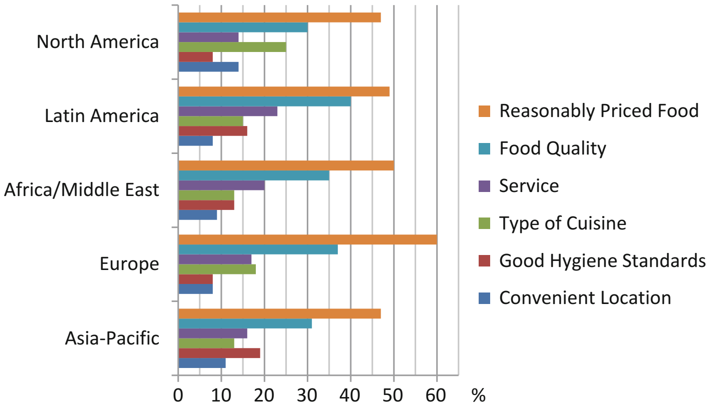

Fig. 7 Top six factors in importance when eating out. Note: Percentage stating which is the most or the second-most important factor when choosing where to eat out. (Source: Nielsen 2018)

where to eat out, these two aspects are taken as given and should be expected? Type of cuisine and convenient location are most important in North America.

Time Spent Eating and Drinking

Eating, both in and out of the home, is an important leisure activity, although unfortunately no internationally comparative data are readily available to separate the two issues. The available data show the total amount of time people spend eating and drinking varies by country, Fig. 8. Here it can be seen that European countries occupy the top three positions spending over 2 h, with the USA at the bottom, taking less than half the time as the top country, France. These data, as interesting as they might be, also provide an indication as to what type of foodservice operation might be most suitable for each country and what operators might need to consider when they expand internationally.

Caution When Eating Out

The continued expansion of the eating out market is not without its negative aspects, some of which were considered in this chapter, and which the foodservice industry needs to take into consideration. It has been suggested, for example, that eating out might be less healthy than meals consumed at home, and while data are available for a few countries, primarily the USA and UK, very little comparative data are available globally.

The rapid growth of the fast food in China has become a public health concern. Data collected from multiple sources and analyzed identified over two million fast food facilities where the total revenue had increased from US$10,464 m in 1999 to

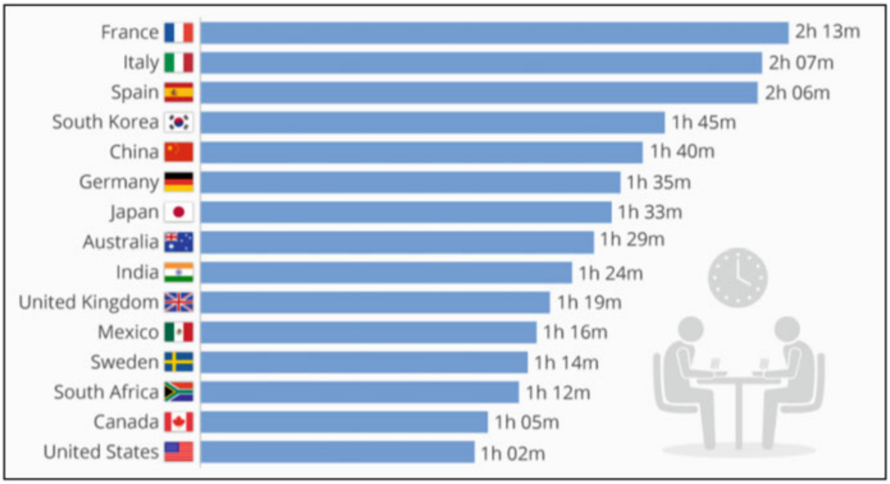

Fig. 8 Time spent daily eating and drinking – hours (h) and minutes (m). (Source: Statista 2018a)

US$94,218 m in 2013. This was attributed to increased income, greater urbanization, busier lifestyle, fast service, assurance of food safety, and new brands and foods. However, the rapid increase in consumption had negative health consequences including obesity-related risks (Wang et al. 2016).

Certainly it has been suggested that taste preferences or other factors, independent of demographic characteristics, might explain the decision to eat at fast food or sit-down restaurants. In the USA, greater frequency of eating at fast food restaurants has been associated with less healthful eating habits, but no associations were found between frequency of sit-down restaurants (Close et al. 2016).

In the most recent study (Robinson et al. 2018), the energy content of meals served in "full-service" restaurants' in the UK were shown to be higher than fast-food chains. In a study of more than 13,500 meals served in 21 full-service restaurants and 6 fast-food chains, the mean energy content of main meals was 977 kcal. It was shown that the average energy content of main meals served in full-service restaurants was 268 kcal higher than that of main meals served by fast food restaurants. Full-service restaurants also tended to serve more high calorie main meals and provide fewer main meals meeting public health recommendations for energy consumption.

Interestingly, though, irrespective of whether or not a person is trying to lose weight, cooking dinner frequently at home is associated with the consumption of a healthier diet which may also assist when eating out of the home. Strategies are needed to encourage more cooking among the general population and help infrequent cookers better navigate the food environment outside the home (Wolfson and Bleich 2015).

It has been suggested, therefore, that if foodservice operators are to address these issues and increase their businesses, they should focus on health and convenience, particularly at breakfast. Consumers often have less time for meal planning and preparation, but quality, taste, and freshness remain critical. Hence, menus which include and emphasis healthy benefits are even better positioned to succeed (Nielsen 2018).

Summary and Conclusions

This chapter, being the second part of the introduction to foodservice, considers the "demand side," that is the consumer, in order to offer a better understanding, thereby putting the foodservice industry into context.

The demand for eating out has increased, and although there are little reliable, readily available, and comparative international data, it would seem that in in many countries, the amount of money spent on eating in the home is similar to that spent on eating out of the home.

People eat out for a number of reasons which are identified, and approaches to meet that demand center on either putting the focus on the consumer and building the product and service that satisfies those demands or putting the emphasis on the product then and identifying consumers for those products (and services). In most cases, though, consumers, when dining out are not only looking for food, drink, and service that meet and satisfy their expectations, but they are also looking for other factors, which here and elsewhere are often referred to as experiences. A number of factors, synergistically, create that experience. More recently, these ideas have been developed and brought together, describing the situation as the experience economy.

This chapter, in looking at the consumer when eating out, considers factors such as the growth and size of the eating out market, along with current patterns of eating out; the frequency of eating out and what establishments are chosen; the most important factors driving decisions when eating out; and the time taken to eat out.

However, a note of caution is offered, principally the fact that meals eaten out of the home may be less healthy than those cooked at home, and foodservice operators will need to consider all of the issues involved as they move forward.

And Beyond

What then is the future for the foodservice industry and eating out of the home, and where are they heading? What will people be eating in the next 5, 10 years, or even beyond? How will the foodservice industry adapt to meet changing trends and demands, or will the foodservice industry lead, grow the market, and provide an offering that consumers will react to? These are but some of the questions often posed by many trying to keep abreast, or more importantly, ahead in the market place.

However, forecasting the future is not easy:

> *The only thing we know about the future is that it is going to be different.* (Drucker 1986)

> *Predictions are difficult, especially when they involve the future.* (Usually attributed to Mark Twain)

But some effort to provide a forecast is needed for businesses to develop and survive.

Clearly, and as already alluded in this chapter and ► Chap. 49, "An Overview of the Foodservice Consumer," the foodservice industry does not operate in a vacuum and needs to be aware of what is happening, locally, nationally, and globally. Population trends – the growth, aging and movement of populations, sustainability, availability, and growing scarcity of resources including energy and water – are just some of the issues that need to be considered. In other words, it is important for the foodservice industry to remember and consider the "bigger picture" in order to fully appreciate where it might be heading and how, therefore, to react to it.

Many foodservice companies have part of their organization specifically devoted to keeping up-to-date with trends and have budgets allocated accordingly. Other market research-based companies also provide such a service but these tend to be expensive, especially for an individual.

There are a number of websites which provide "snippets" of information, summaries if not full reports which are useful for anyone to help keep abreast. A sample of such sites is given below:

Information snippets from full reports

> Foodservice Market – Global Industry Analysis, Size, Share, Growth, Trends, and Forecast, 2016–2024. (TMR 2018)

> The global contract catering market is anticipated to reach revenues of around US$264 billion by 2023. (Cision 2018)

Full reports

> The global food and beverage market. What's on the menu? (Cushman and Wakefield 2017)

> What's in our food and on our mind. Ingredient and dining out trends around the world. (Nielson 2018)

One very useful source of information is Statista (2018b) who provide a free service with a lot of information, much of which covered is relevant to the foodservice industry and which has been used in these introductory chapters. Pieced together, these can provide information thereby enabling foodservice outlets to keep abreast of changes, so as to position themselves to react to, reflect, or influence changes in supply and demand.

And Finally

In a perverse way, the influence of the foodservice industry can be illustrated by the "Big Mac Index." This index, developed by "The Economist" and published annually since 1986, compares the purchasing power of a McDonald's "Big Mac" in each country

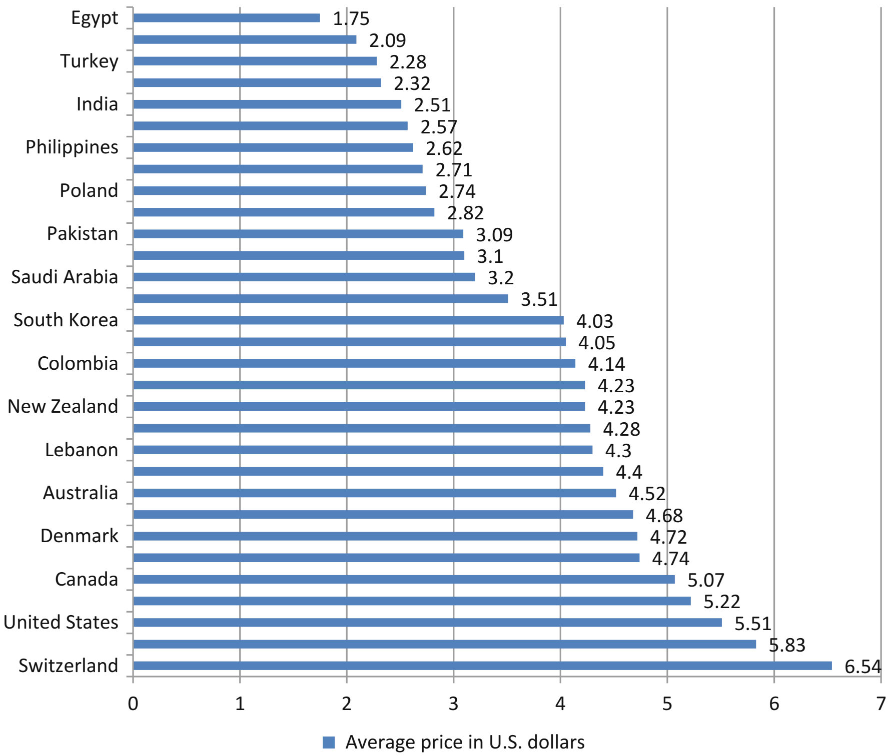

Fig. 9 Big Mac index – global prices (US$) for a Big Mac in July 2018. (Source: Adapted from Statista 2018c)

measured in US$, thus providing a measure of the purchasing power parity (PPP) between different countries. An extract from the most recent index is given in Fig. 9.

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Feeding the US Military: The Development of Military Rations

50

Stephen M. Moody

Contents

Abstract

For millennia, societies have organized and maintained armies to defend their sovereignty, extend their power, or obtain additional resources. Often the greatness of a nation was measured by the size of its army. With the establishment of a large military force comes the burden of equipping and sustaining them in a way that will maximize their effectiveness. This gets even more challenging when an army is expeditionary, that is, when they are asked to move over long distances far from their home. One of the most difficult of these logistical burdens is providing the quantity and quality of food required to sustain an army.

Feeding an army is a daunting task. So much so, that for centuries the emphasis was on simply providing enough food to keep soldiers alive. Eventually, nutrition science provided information on how food could be used to prevent disease, improve performance, and promote well-being. The most

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modern military forces are no longer satisfied with providing enough food to feed an army, but are endeavoring to provide the right food to optimize their physical, cognitive, and emotional condition.

For the US Armed Forces, military feeding has evolved greatly in the last century. Changes have been driven by new discoveries in nutritional biochemistry and behavioral science, innovative food processing technologies, diverse operating environments, and revised military strategies. Each of those factors has played a significant role in how the US military sustains its forces both at home and abroad.

Introduction to US Military Feeding

Eating and drinking are very personal and often emotional life experiences. Their inextricable ties to familial relationships and their life sustaining nature invoke powerful sentiments and almost instinctual appetites. From the first drink of the mother's milk, strong bonds are developed in association with feeding, and those bonds continue to develop throughout childhood and beyond. Our likes, dislikes, cravings, and aversions are formed as we eat and drink, beginning in family units and eventually with broader social groups (Capaldi 1996).

Often, the first experience with institutional feeding is in a school setting. This serves to expand our dining experiences beyond the familiarity of the home and introduces what is usually a more regimented and methodical aspect to eating, at least for the midday meal. The introduction of this systematic approach to feeding with school lunches is likely the only comparative experience to prepare new recruits for their introduction to military feeding (Baines and Blatchford 2012).

For most members of the US Armed Forces, their experience with military feeding begins with basic training. Upon induction, the recruits are thrust into an entirely new routine of marching, running, and classroom instruction. Every minute of their day is carefully planned and strictly controlled. Meals are taken at a military dining facility to which they are marched three times a day. The quantity and variety of foods are sufficient but certainly not sumptuous, and recruits rarely have time to experience the communal aspects of eating. Eating is relegated to a disciplined and perfunctory event with little time for socializing; from arrival to departure is about 30 min including the wait in a very long serving line.

After several weeks of basic instruction, training evolves into more practical training and repetition of actual battlefield tasks. The recruits spend less time in the classroom and barracks setting and more time at various weapon ranges and field training areas. These are often quite far away from the main garrison with no nearby dining facility, which introduces a new military feeding experience: military rations.

Rations in the field are provided in one of two ways. Individual, prepackaged foods may be given out on a one-per-soldier basis, or group meals can be served from mobile or temporary serving lines. Both of these are quite different from the typical garrison military dining facility with regard to the types and variety of food provided.

Individual rations are used in austere environments when kitchens and cooks are not available. They are composite rations, that is, a group of several different components provided in one package. The mix and type of foods may vary, but all are designed with certain requirements in mind. Rations are shelf-stable with a relatively long shelf life and are packaged in a way that allows them to remain safe and intact throughout a very rough supply chain under sometimes harsh storage conditions. They must be nutritionally complete and palatable enough to ensure consumption under field conditions.

The shelf life required by most current US military rations is 3 years at 80 °F (37 °C). This is much longer than most commercially available, shelf-stable products. The extended shelf life is driven by the need to maintain large stockpiles of rations in prepositioned storage locations to be used in the event of a major military deployment. Because much smaller quantities of rations are consumed in peacetime than in wartime, that long shelf life is required to rotate through the stocks and consume the stored rations before their expiration.

Packaging of rations also must be more robust than that of their commercial counterparts. Military rations need to be able to survive the harshest environmental conditions, from desert heat to arctic cold, and must survive and remain edible even when dropped from planes and helicopters. It's not unusual for rations to be exposed to rain, mud, and all sorts of adverse conditions. The military supply chain is extremely demanding. It requires very durable packaging, from primary containers to shipping cases, to maintain the quality of the food.

Group rations are used when field kitchens and cooks are available or at least when they are close enough for hot food to be transported to a military unit. The variety of food available at any given meal is much more limited, with often only one choice of main dish, starch, and vegetable. Meals are served onto disposable compartmentalized trays from either a field kitchen or temporary serving line of insulated food containers. There is usually no dining area. Meals are taken to the most comfortable place available (Fig. 1).

Although lacking in variety and fixed facilities, field feeding does have its advantages. At least in a training setting, there is usually a longer time available to eat which allows a bit more socialization than the rushed regimen in a basic training military dining facility.

Toward the end of basic training and as soldiers move on to advanced training or their first units, the dining experience becomes much more relaxed and provides something of an escape from the rigors of military discipline. There is more opportunity to socialize, and feeding becomes a type of refuge which builds both morale and camaraderie, even if the quality and variety of food are constrained by the operational requirements such as extended shelf life (Fig. 2).

Fig. 1 US Air Force group meal during field training at Ft. Leonard Wood, MO (US Army photo 2016)

Recognizing the Physical, Cognitive, and Emotional Importance of Military Feeding

Military leaders have continually recognized the need to sustain their troops and the importance of food to the success of their mission. Historically, their interest had been focused simply on providing enough energy by way of calories from food to make up for those expended in battle. As the science of nutrition matured, food was increasingly seen as not just a way to maintain life, but to optimize health and performance (Smith and Psychological Research Associates 1961). Advancements in food technology as well as changes to the tactics and strategy of warfighting have led to an ever changing evolution of military feeding.

Fig. 2 Two soldiers share a meal of Meal Ready-to-Eat in Afghanistan (US Army photo 2016)

Technology-Driven Changes to Military Feeding

Military food has almost always, usually for good reasons, been disparaged and maligned by soldiers. At the same time, there are few things that boost a soldier's morale as much as the gratification and satisfaction of eating, especially on the battlefield. That intangible morale factor seems to be even more pronounced when soldiers eat together as a group, even when simultaneously commiserating about the quality of their fare. It's a love-hate relationship that has spanned millennia.

The saying, "An Army marches on its stomach," does not make a distinction between the physiological or psychosocial aspects of military feeding. Indeed, the former is absolutely necessary. How far and how fast a soldier can go is undeniably related to the amount and type of his food. But the latter cannot be ignored. When seeking to improve military food, it would be prudent to focus on both. In fact, that's what the US Army has been doing for quite some time (Samuels 1947).

When hunter-gatherers shifted to agrarian societies and city-states, wealth and power began to be concentrated in river basins and watersheds throughout the world. The resources over which tribes and societies fought were now tied inextricably to real estate. The more fertile the land, the more desirable the real estate. That called for large, well-fed armies to defend that territory. Fortunately, there was plenty of food in these fertile flood plains (Jacob 1944). There were no worries when armies were garrisoned close to home. The challenge came as regional powers sought to expand their regime.

The perishable nature of food has been the bane of military logisticians since the first expeditionary force set out on a long campaign, and it continues to this day. In the past, this severely limited the types of foods that could be included in military rations. Early rations were replete with flours and grains that could be eaten as porridges or flatbreads with a bit of preparation. Meats or fish could only be included if preserved by rudimentary preservation techniques such as salting, drying, pickling, fermenting, and smoking. Long before anybody understood the scientific relationship between water activity, pH, and food spoilage, the empirical evidence spoke for itself (Darsch and Moody 2009).

Military rations during the American Revolutionary War contained products like dried fish, salt pork, flour, and corn meal (US Armed Forces Food & Container Institute 1963). For over a hundred years, not much changed. Even after connections were made between illness and a deficiency of certain types of food, limitations in food preservation technology significantly hindered the variety of foods that could be provided to soldiers. During the American Civil War, although the necessity of including fruits, vegetables, and dairy products was acknowledged, the diet of an army on the march rarely included them. “No doubt the diet was often deficient. The ration most commonly issued in the field consisted of salt meat (bacon, “sow belley”), hard bread (hardtack), coffee, sugar, and occasionally beans” (Steiner 1968).

One specific food preservation technology that developed throughout the nineteenth century was responsible for solving this problem: canning. The idea of placing perishable foods in a sealed container and then heating those containers to preserve the shelf stability of the food can be directly attributed to the military (Mrak 1970). Invented by Nicolas Appert in 1810 as a way to help feed Napoleon’s expeditionary army and navy, canning helped transform the way armies are fed even to this day. By the turn of the twentieth century, that ushered in a significant expansion of the types and diversity of foods finding their way into US military rations (National Provisioner 1981). This new type of processing allowed the delivery of meats, vegetables, and dairy products through extremely long and austere supply chains without the need for refrigeration or the threat of spoilage. The canning process became one of the most prevalent preservation methods for shelf-stable foods in both the military and the commercial sectors. In fact, the canned rations of the Spanish-American War in 1898 were the distant cousins of the canned rations of the Vietnam Conflict over 70 years later.

It was during World War II that the US military relied most heavily on canned products to feed their deployed soldiers and marines. It was also during that time that there began to be a recognition of that intangible morale factor associated with food in addition to its benefit to health and performance. Once the domain of nutritional biochemists and microbiologists, military research turned to behavioral scientists and psychologists to understand the relationships of concepts such as satiety, food preferences, and appetite to consumption of military rations (Cardello 2012).

The preferred ration of the soldier was a hot, cooked meal. This was, and still is, well recognized throughout the chain-of-command and provided whenever possible. In those instances when it is not possible, however, every attempt is made to provide food that will meet the physical and psychosocial demands of the warfighter, commensurate with the constraints of the military supply chain.

It was in the mid-twentieth century that military leaders decided to focus on what a soldier wants, not just what he needs. “The regular serving of palatable food is the greatest single factor in building and maintaining high spirit and morale” (Risch 1953). In addressing a group of quartermaster officers, Brigadier General C.O. Thrasher likewise stated, “No single factor so influences morale of troops as their messes” (Thrasher 1943). This increased emphasis on palatability spurred a large number of research projects during the later years of World War II. The research program approved for 1945–1946 by the newly formed Committee on Food Research included 21 projects related to food acceptance research (US, Office of the Quartermaster General 1946).

That led to a variety of US military rations and field feeding systems that have evolved over the last 70 years. As new food preservation and packaging technologies were developed, they often made their way into military rations. Shelf-stable combat rations, such as the Vietnam era Meal Combat Individual (MCI) and the current Meal, Ready-to-Eat (MRE), are a direct result of the work started in World War II.

The first iteration of the MRE, fielded in the early 1980s, contained some unique components. Freeze-drying of foods is an expensive process that consumes much time and energy, but the benefits, significant weight reduction, extremely long shelf life, and high quality of products, made it a desirable technology for ration production. Early MREs included freeze-dried fruits, potatoes, and cooked meats. When properly rehydrated, those components yielded fresh-like products. Unfortunately, the preparation process was challenging. Add too much water, and the product was bland and soggy. Too little, and it was still crunchy. Not to mention that the process itself conflicted with the premise that the meal was “ready-to-eat.” By the end of the decade, the freeze-dried components were replaced with canned products in flexible pouches; the increased weight was accepted to achieve higher acceptability (US Army, NRDEC 1992).

Consumer-Driven Changes to Military Feeding

While the packaging of the MRE was much different than its predecessor, the menus provided were strikingly similar. Traditional stews and pasta casseroles were predominant, and both the MRE and MCI delivered 12 menus composed of several components similar to those in Fig. 3. Products such as beef stew, chicken à la king, frankfurters, and ham slices were some of the enduring dishes. Changing demographics in the United States in the latter part of the twentieth century, however, began to erode the acceptability of those customary foods. As the general and military population diversified, so did their tastes for a variety of ethnic and cultural foods. Added to that was a large-scale deployment to the Persian Gulf for Operation Desert Storm. According to doctrine established by the US Army Surgeon General, the MRE is only supposed to be consumed as the sole source of food for up to 21 days. Studies showed that over time consumption declined resulting in a significant loss of body weight (Thomas 1985). Because of challenges with the supply chain, many of the troops initially deployed to Operation Desert Storm subsisted

Typical Components of a Meal, Ready-to-Eat

Beef Brisket
Garlic Mashed Potatoes
Cookie
Peanut Butter
Snack Bread
Jelly/Jam
Irish Cream Cappuccino
Sugar Free Beverage Base
Sugar Free Chewing Gum
Towelette
Salt
Toilet Tissue

Fig. 3 Meal, Ready-to-Eat composite ration (US Army photo 2015)

on MREs for several weeks, and the 12 menus quickly grew monotonous. Both acceptability and consumption of the MRE declined badly due to its lack of variety and diversity.

Accordingly, during the 1990s the MRE menu variety was expanded from 12 to 24 different menus. Many of those new menus contained regional and ethnic flavors that were beginning to be commonplace in casual restaurants and mall food courts. Once again, consumer acceptance was the catalyst for substantial changes to US military rations.

It's typically times of war that have spurred the greatest innovation. This is partly due to unique needs specific to each conflict and partly due to the increased funding available to conduct military research in wartime defense budgets. Because of this, in the beginning stages of military combat, soldiers are often fed with rations that are the result of older technologies and designed for previous conflicts. In effect, each conflict begins with the perfect ration for the last war.

Operationally Driven Changes to Military Feeding

Throughout the deployment of US Armed Forces to Afghanistan and Iraq in the early twenty-first century, they have had the luxury of total air superiority, allowing them to build huge base camps with relatively little risk. The infrastructure of those bases established a home away from home for deployed troops, with large, contractor-run dining facilities that provided near restaurant quality meals up to four times each day. It was on the outreaches of these deployments when the first effects of inadequate rations were felt. Soldiers and marines at some of the more remote outposts were conducting regular dismounted missions outside the wire for up to 3 days, and sometimes longer.

Reports of US marines in Afghanistan losing up to 35 pounds of body weight during deployment raised significant concern. This was significantly more than that reported in earlier studies (Thomas 1985). Upon examination of the eating patterns of those marines, it was found that they regularly used a process called "field-stripping" to lighten their load as they conducted dismounted operations marching up and down the mountains at moderate to high altitudes. They would be issued an appropriate number of MREs for the mission but would open the packages and take only those components that were easiest to carry and consume such as jerky and trail mix. This caused enormous caloric deficits that resulted in weight loss.

Upon hearing this, the scientists and engineers responsible for developing and improving US military rations began to develop a ration specifically designed for a 3-day dismounted mission. The result was the First Strike Ration. One packet of several eat-out-of-hand, highly acceptable components contained 3000 calories but was half the weight of the 3 MREs it was meant to replace. A drawback was the limited variety of only three menus. That was later expanded to 9 menus but was still dwarfed by the 24 menus of the MRE. Variety had been traded for functionality.

The ration worked well for its intended purpose, perhaps because of a simultaneous shift in eating patterns. The traditional breakfast, lunch, and dinner pattern had been prevalent for decades but more recently leaned toward what came to be called grazing: Eating many smaller meals or snacks throughout the day. Some thought the reason for this societal shift was that eating regular meals together as a family unit was beginning to diminish. The prevalence of both parents being employed resulted in eating becoming more of an individual event than a social event (Mäkelä 2009). It remains to be seen how this shift may impact the morale-related aspects of military feeding (Fig. 4).

Another need arose about that same time, this one in conjunction with a military surge in Iraq. The new surge in troops was deployed in small units at or near

Typical First Strike Ration Menu Items

Bacon-Cheddar Pocket Sandwich
Filled French Toast
Pepperoni Pocket Sandwich
Cholate Energy Bar
Mocha Energy Bar
Snack Bread
Jalapeno Cheese Spread
Peanut Butter
Applesauce Spout Pouch
Protein Shake Mix Drink Pouch
Caffeinated Chewing Gum
Moist Towelettes
Toilet Tissue
Matches
Spoon

Fig. 4 First Strike Ration (US Army photo 2015) population centers that were threatened by violent insurgents. Depending on their proximity to larger bases, those small units were typically provided one or two MREs per day along with one hot group meal. The hot meals were prepared in on-base kitchens and sent to the units in insulated food containers. This meant that convoys were on the road once or twice each day delivering food to the outposts, putting those in the convoy at risk of attack by improvised explosive devices. Commanders wanted to mitigate this risk but did not want the deployed soldiers to get nothing but MREs.

Once again, scientists and engineers analyzed the problem and developed a field feeding solution. The new design was for a self-heating group ration. One box contained four half-steam-table trays of canned foods: one main dish, one starch, one vegetable, and one dessert, each with an integrated chemical heater under the tray and each with a pouch of saltwater positioned to activate the heaters. The box also included serving trays, utensils, snacks, and everything else necessary to serve a hot group meal to 18 soldiers. Several boxes could be delivered to each outpost. A pull on a plastic handle flooded the magnesium-iron heaters with activating fluid, and in about 40 min, the hot meal could be served. This kitchen-in-a-carton reduced the number of convoys on the roads of Iraq and still allowed the small units to enjoy a group meal experience.

The year 2016 marked 15 years since the initial deployment of US troops in response to the 9/11 attacks on the World Trade Center and the Pentagon. In more than a dozen years of military operations against enemies who were exceedingly overmatched in military technology and firepower, the US military in general, and the army in particular, had shifted its focus from modernization to maintenance. Significant cuts to military budgets had also taken their toll on both research and procurement devoted to modernization. The strategic readiness of military units began to be questioned by army leadership (Lyle 2015).

Strategy-Driven Changes to Military Feeding

Military planners finally realized that the ability of the United States to fight and win a war with a peer or near-peer adversary was significantly degraded. A renewed emphasis on highly mobile expeditionary operations identified several capability gaps that served to inform military researchers, including those responsible for combat feeding research and development.

The new strategic guidance steered field feeding research in three distinct areas: reducing the logistics burden and individual soldier load by reducing ration weight and volume; seeking to use nutritional interventions to improve physical and cognitive performance; and making rations operationally relevant by tailoring them for specific operations or environments. A research portfolio spanning these areas was endorsed by military leaders.

Military leaders began discussing scenarios in which small units might have to operate semi-independently with little or no resupply for up to 7 days. This substantially underscored the need to reduce the weight of individual rations. A soldier would have to carry 21 MREs weighing 32 pounds to sustain them on a 7-day mission. Even the First Strike Ration, with its limited menu selection, would add 16 pounds to the soldier's load. Efforts have been initiated to take advantage of innovative dehydration and nutrient densification technologies to provide high-quality, lightweight ration components.

Energy- and nutrient-dense ration components will be developed leveraging emerging and innovative technologies in food preservation and processing. Vacuum microwave drying is a very promising technology that has the potential to adjust the water activity of food products just enough to provide shelf-stable product with significantly lower weight but not dry and crumbly like most conventionally dried products. The technology was evaluated and matured under a foreign comparative test project, which resulted in the installation of pilot scale equipment. Initially targeted for the production of compact food products for NASA to support a mission to Mars, the technology was soon recognized for its potential application to lightweight military ration components. Combining this with a novel technology that uses sonic waves to assist in the compression of heterogeneous food bars appears to be a promising approach to reduce weight and cube while increasing nutrient density.

This equipment will be used to produce prototype components for characterization, optimization, and validation of footprint reduction metrics. Prototype components will then be tested in a relevant environment to ensure they can meet other military operational requirements such as shelf life and rough handling. These technologies will likely be able to produce a combat ration significantly lighter and smaller than the First Strike Ration, but that ration will likely have to further sacrifice variety and potentially soldier acceptance in order to achieve the necessary reduction in logistical burden.

Much work remains to be done to identify specific nutritional interventions that could provide measureable impacts on physical or cognitive performance. Previous research in this area provided the foundation for the targeted use of caffeine for alertness and the combination of calcium and vitamin D for increasing bone density. Other efforts are underway to identify the effect of phenolic compounds on muscle recovery and inflammation. In vivo and ex vivo experimentation will have to be followed by human subject research before the efficacy of those food constituents can be quantified. Another area of emphasis seeks to understand the relationship between the gut microbiome and neurological outcomes.

> The composition and activity of gut microbes are modulated by changes in host diet and physiology while, in turn, gut microbes support immune health, deter pathogen invasion, regulate central and enteric nervous system activity, and generate beneficial nutrients and metabolites [4–6]. These beneficial relationships, however, can be perturbed by environmental stressors that directly or indirectly modulate the gut microbiome, thereby resulting in a state of dysbiosis that has been implicated in the development of acute health decrements, such as systemic inflammation [7], increased susceptibility to illness and infection [8], cognitive decrements [9, 10] and the development and/or persistence of multiple chronic diseases [8]. (Arcidiacono et al. 2018)

The Most Important Nutrient

If eating can be characterized as life support because of its inherent ties to health, drinking is even more critical to survival. According to the National Academies, "Water is the largest single constituent of the human body and is essential for cellular homeostasis and life" (Institute of Medicine 2005). From the very beginning of basic training, a new recruit is instructed on the importance of hydration. They are taught that drinking adequate amounts of water will help to prevent heat injuries such as cramping, heat exhaustion, and heat stroke, and their noncommissioned officers insist on regularly scheduled consumption of water, especially during times of heavy exercise and hot weather (Fig. 5).

In a training environment, the provision of potable drinking water is relatively easy. Like food, however, the supply of water in a combat environment can be quite challenging. Not only does the weight and volume of water create logistical concerns, but additional risks are assumed because of the fact that contaminated water can be a major source of non-battle disease and injury. As such, soldiers are instructed to consider every source of water to be unpotable unless specifically authorized by their leaders to drink it and are instructed to disinfect water through either chemical disinfection or boiling (US Army TC 4-02.3 2015).

This poses significant challenges to achieving the proper fluid intake, which can range from 3 l to 11.4 l depending on the air temperature and level of activity (US Army TB MED 507 2003). Chemical disinfection using either chlorine or iodine renders the water potable, but unpalatable. Boiling is often precluded due to constraints on time and resources.

One way to mitigate the adverse effects of chemical disinfection is the provision of water flavoring packets to US military rations. Since the rations themselves provide less than 20% of the water necessary for proper hydration, most rations

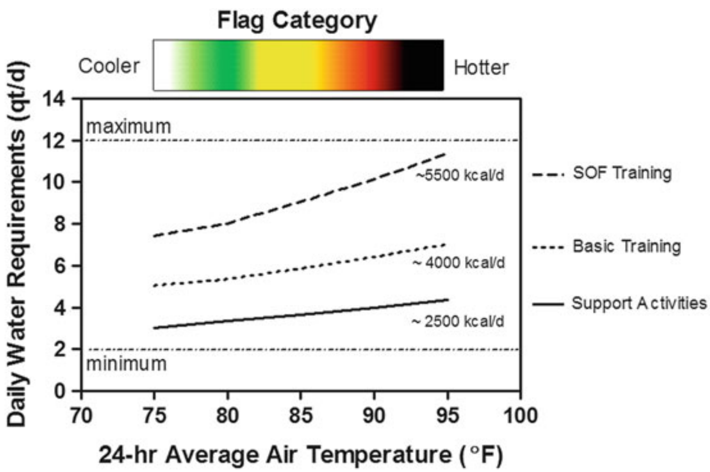

Fig. 5 Daily water requirements (US Army Research Institute of Environmental Medicine)

contain one or more packets of beverage bases (Institute of Medicine 2005). Some of those are also used to provide additional carbohydrates and in some instances supplementary electrolytes. As is often the case with military rations, the beverage bases are often disparaged with epithets such as “bug juice.” When needed, however, they provide an indispensable masking of the objectionable flavors associated with chemical disinfection.

Conclusion

All of these scientific developments in food and nutrition may impact the types of foods provided on the future battlefield; however, as amazing as some of these scientific breakthroughs may be, the most impressive fact may be that the US military continues to recognize the importance of military food on the health, readiness, and lethality of its warfighters. While many of the non-battle disease and injuries related to nutritional deficiencies may be relegated to the past, there is still widespread recognition that food plays a huge role in the physical and psychosocial well-being of men and women in uniform.

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Contextual Considerations in Experimental Food Research and Policy

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Abstract

A food or beverage, depending on the situation, may be judged in a different way, even by the same individual. The impacts of these context effects on food judgments and decision making, and how to take them into account in the collection and interpretation of consumer data, are key topics in sensory and consumer sciences. This chapter aims to provide an overview of the debate and current scientific advances on context effects in the case of research related to the perception, the selection, and the consumption of food. We discuss the empirical evidence of these effects and present a theoretical framework to explain them. Then, we draw implications, questions, and current directions from the angles of research methodologies. Finally, we discuss the context issues from the angle of policy-making and new product design.

Introduction

A food or beverage, depending on the situation, may be judged in a different way, even by the same individual. This observation that context affects judgment and decision-making has been the starting point of a long line of research and debate among sensory scientists, new product developers, and more generally all scientists concerned with behaviors related to food consumption for several years. Meiselman, in 1992, argued that eating behavior cannot be studied without the consideration of "real food" in "real" contexts (Meiselman 1992). In his own words, "consumers' eating decisions in real contexts may be influenced by 'situational, economic and social constraints' that studies in controlled conditions such as laboratories may not include" (Meiselman 1992, p. 50). Almost 30 years later, the topic is still more than ever a key issue for the future of the sensory and consumer sciences in the food domain (Jaeger et al. 2016).

In sensory science, context is a particularly important topic of concern, as its influence on judgment may endanger the reliability of the data obtained in experimental conditions, on which many research studies are based.

In the industry, new product developers are concerned with context-related effects that can be a source of costly errors in the prediction of market success of a new product.

For social scientists, the fact that consumers respond to food differently depending on the conditions in which it is evaluated questions the very way in which consumer choice behavior is described, tested, and predicted by theories of consumer behavior.

Overall, the problem of context effects is a problem of generalizability of results of consumer studies.

This chapter aims to provide an overview of the debate and current advances on context effects in the case of research related to the perception, the selection, and the consumption of food. We first present a theoretical framework to analyze context effects. Then, we draw implications, questions, and current directions from the angles of research and development methodologies. Finally, we discuss the context issues from the angle of policy and new product design.

Can Context Effects Be Explained and Predicted? A Theoretical Perspective

What Is Context and How Does It Affect Food Consumption?

It is a widely recognized fact that the perception, evaluation, and intake of food depend on the context. But how, precisely, is context defined?

The context of a food decision is defined broadly as the set of physical, social, and situational parameters, called contextual variables, in which food consumption occurs (Meiselman 2006). But how, precisely, can we define the perimeter of what is part of the context and what is not? If a food decision is the observable action of an individual over food, then the context of this decision refers to all the elements that appear to be independent of this action, and what is not part of the context refers to the elements of the decision that would remain identical in another situation. In a first, simplified approach, one might consider that all variables that are not characteristics of either the object of the decision itself (the food) or of the subject (the decision-maker) are contextual variables. Typically, if we consider a choice between two apples, a large one and a small one, the size of the apple would be part of the decision, as it is a characteristic of the object, and so would the preferences of the decision-maker for certain sizes of apples. However, the music in the shop where the apples are presented would be part of the contextual variables.

The core principles of standardized laboratory experiments are derived from this rationale: all the factors that are identified as contextual variables of the behavior of interest are controlled through the use of a common set of rules, creating a testing environment that is expected to be as unevocative as possible (controlled temperature, controlled light, etc.). The rules of standardization are set to guarantee that the results obtained in an experiment can be reproduced elsewhere, in the same conditions, to assess the replicability and robustness of the experimental results, as it is the case, for instance, in the European standard NF EN ISO 11136 (2017) that sets general guidelines for conducting hedonic tests in controlled conditions.

While standardization is set to assess reproducibility in a given, controlled context, it does not, however, say anything about the *generalizability* of results outside this given set of contextual variables. In order to answer this, the contextual variables that change the results obtained under standardized conditions, and how they change the results, need to be identified. For some contextual variables, this question has been, or could be, investigated. For instance, research has investigated how room temperature or musical ambience affects food perception and intake (Stroebele and de Castro 2006). Several research works have attempted to identify and classify influential contextual variables, using different categorization approaches (see, for instance, Rozin and Tuorila 1993; Sester et al. 2013; Stroebele and De Castro 2004).

These works highlight some limitations of defining contextual variables as all variables that neither characterize the subject nor the object of a decision. One of the issues that arises is that some characteristics of the object or of the subject may be difficult to disentangle from the context in which the decision occurs, therefore also resulting in context effects. For instance, the color of an apple may seem like a characteristic of the object, but the fact that color is perceived differently depending on the light of the room makes it difficult to consider color as a characteristic of the object of decision that is independent of the context and transferable to another context. Likewise, context shapes the way individuals appeal to their personal values and preferences to make their judgment and decisions: in other words, the way we judge products is framed by the economic, social, and cultural environments, which make some aspects of the decision more salient than others in a given context. In that case, it may not always be clear whether the characteristics of a decision-maker are independent of the situation, or not.

A broader definition of context is therefore necessary, to include the characteristics of the object, of the subject, and of the decision action itself that are defined in interaction with the situation (Galiñanes Plaza et al. 2019). In that framework, four types of contextual variables can be identified, as represented in Fig. 1:

1. Contextual variables describing the situation, which include the physical context of evaluation (e.g., furniture, lighting, etc.) but also the social context (e.g., the same individual could evaluate the same product with or without any social interaction) and the temporal context (e.g., the same individual can evaluate the same food in the same place but at different times in the year or in the week).
2. Contextual variables that are directly linked to the object of decision: for instance, the same product can be presented in different quantities or containers. Likewise, the consumption of the same product can be preceded or followed by different consumptions depending on the context.

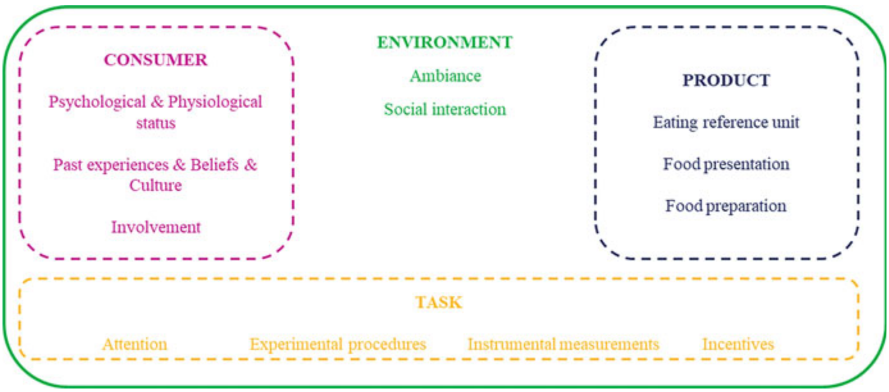

Fig. 1 A representation of contextual variables. (Adapted from Galiñanes-Plaza 2019)

3. Contextual variables linked to the individual: such as emotions, representations, or context-related beliefs which may put the same individual in a different mindset to evaluate the same product in different contexts.
4. Contextual variables linked to the evaluation task itself, which include the type of question asked for the evaluation, the way it is phrased, how many questions were asked, in which order, etc. While the first three categories are related to the perception and judgment in themselves, the latter is due to the way consumers respond to the methodology of measure and questions the conditions and feasibility of its standardization.

A Model of Context Effects: Prospect Theory

A context effect can be defined as a change in behavior that occurs when there is a change in the context in which a decision takes place. Appendix 1 presents a synthesis of the literature identifying such effects for food decisions and perception. While many contextual variables change across evaluations, the ones that are relevant when assessing the transferability of results are those that interact with the decision. Within the four categories of contextual variables presented above, it is very likely that those in the last three will influence judgments and decisions. Conversely, not all variables in the first category may have a relevance when it comes to the validity of results obtained in a given context: for instance, the hair color of the person who serves the food is a contextual variable; however, we have very little reason to think that not reproducing this particular variable in another situation will affect the consumer's perception of a product.

In order to properly identify which variables are indeed relevant, a theoretical framework is needed to formulate hypotheses about the possible occurrence of context effects. Psychology and economics, which use experimental approaches to study human behaviors, have developed and tested theories of context. The dominant theory is most certainly *Prospect theory*, introduced by Daniel Kahneman and Amos Tversky as early as the 1970s (Kahneman and Tversky 1979). Three main points of this theory seem particularly relevant for food evaluation:

(i) *Bounded rationality and heuristics* – Originally a theory of economic decision-making under risk and uncertainty, prospect theory seeks to incorporate principles from psychology in economic theories. It builds on the notion of bounded rationality, introduced by Simon in the 1950s, which refers to the fact that decision-makers use a limited number of cognitive, informational, and time resources. In order to spare these resources, decision-makers resort to heuristics – shortcuts which rely partly on cues from the context to shape the decision.
For food studies, taking heuristics in consideration significantly modifies the view of how context may affect food decisions. For example, a standard approach would consider consumer's food intake in a restaurant as the result of a decision to consume the quantity of food that will best satisfy the consumer's appetite and desires with respect to her/his constraints. However,

several studies indicate that the quantity of food consumed may depend, among other things, on the size of the portion proposed (Diliberti et al. 2004; Kral and Rolls 2004). Behavioral economics explains these "biases" (in the sense of deviations from the standard approach), by bounded rationality and the mobilization of heuristics. In other words, the consumer relies on standards provided by the environment (here, the standard portion) to make her/his decision. Behavioral economists have identified several heuristics and biases to integrate into theoretical models in order to better understand consumers. The systematic mobilization of these heuristics in certain contexts would result in deviations from the predictions of models that do not account for context. Some works have attempted to identify and characterize more specifically the heuristics associated with certain dietary decisions or certain "anomalies" with respect to the standard model such as staffing effects (Antonides and Cramer 2013; Cramer and Antonides 2011; Scheibehenne et al. 2007; Schulte-Mecklenbeck et al. 2013).

(ii) *Dual-processing* – Kahneman also introduces the idea of a dual system of thought on which judgment and decision-making rely. System 1 corresponds to rapid, automatic, and intuitive decisions that rely heavily on the elements directly accessible and perceptible to the individual at the time of decision. System 2 relies on reflection and control and mobilizes more complex resources. Depending on the situation, either system is predominant in the decision-making process (Kahneman 2003).

In the case of food studies, the context of decision may impact the thought processes that would predominate in judgment and decision-making depending on the situation. For instance, it is very likely that system 1 will predominate in situations where the emotional value of food is high (for instance, after exams week) or attention is low (for instance, if a lot of social interactions are taking place during consumption). Conversely, a more reflexive process may be mobilized if more emphasis is put on the consumption, which is often the case in a specific hedonic evaluation task in a laboratory. This invites us to give more importance to the design of the evaluation task itself and to reflect on which of the two thought systems may have been predominant in the measure.

(iii) *Reference-dependence* – Lastly, according to prospect theory, two core principles guide judgments and choices (Kahneman 2003). The first principle is loss aversion: individuals have a "myopic" focus on changes rather than final states, with a more pronounced dislike of loss and greater aversion to change. The second principle is reference-dependence: judgments are not absolute, but relative to a reference point that may vary depending on the context.

In food studies, the reference point from which judgments and decisions are made is linked with the context. Food has multiple values, such as hedonic, social, emotional, and cultural values, and some may be predominant in one decision context and not in another, modifying the reference frame of evaluation. In particular, depending on the context, consumers' expectations for a product may be higher or lower, affecting the way this product will be perceived with reference to those expectations (as a gain or as a loss) (Bergeron et al. 2019).

This new perspective on context effects has at least two consequences when it comes to food perception and choices: (1) implications for the methodological approaches used for the interpretation and prediction of food judgments and decisions and (2) implications for the design of policies as well as food products.

Methodological Implications: Taking Context into Account in Studies of Food Decisions and Judgments

Context Effects and the Validity of Experimental Methods in the Study of Food Consumers

Whether it is for the purpose of sensory evaluation of products, of dietary behaviors observation, or of economic evaluation, experimental approaches have been a privileged approach to overcome the complexity of food-related behaviors and study the effect of isolated factors (such as new information, price, or a difference in sensory attributes) on a specific outcome variable (consumer's liking, or willingness to buy, or pay, or eat for a certain type of food) (Dougkas et al. 2019). The principle of the experimental approach, in general, is to reproduce in a laboratory a phenomenon in a simplified manner, in order to study it by varying, through a systematic approach, certain factors of interest while controlling others, thus allowing us to demonstrate causal links between the interest factor and the measured variable, all other things being equal (Guala 2008).

Vernon Smith (1982), one of the pioneers of experimental economics, uses the term *parallelism* to refer to the ability of laboratory-issued results to describe general principles of behavior (Smith 1982). According to this view, the principles of behavior observed in the laboratory should apply to other contexts, in the same way that the laws of gravity apply as much in the laboratory as in the street, all other things being equal. Thus, Smith sees the laboratory as a special case of a context, in which theories should normally apply if all their specifications are correctly reproduced. This view of the parallelism between laboratory and real life is quite restrictive: it simply proposes that if all the differences between contexts could be included in theories, or controlled for statistically, then the results would be identical (and thus, reproductible).

The question of the validity and relevance of such an approach to study food consumers comes naturally once the importance of context on perception and decisions is acknowledged: is it really possible to fully specify the domain of validity of the data obtained with experimental methods?

The validity of experimental data is assessed from the point of view both of the *internal validity* of the experiment (i.e., the ability of the experiment to identify the causal relationship of interest) and of its *external validity* (i.e., the robustness of the causal relationship outside the defined experimental context) (Guala 2003). These two sets of questions correspond, respectively, to local and global context effects (Tversky and Simonson 1993), which are generally treated within two distinct lines of research:

- Research regarding local context effects (in the case of food consumption studies, the effects of the methodological procedure, or task, used to measure the behavior) is interested in comparing the ability of different techniques to measure consumers' food judgments or decisions (addressing the question: "What would be the best tool to conduct such an experiment?").
- Research on global context effects (in the case of food, the effects of the situation in which the consumers find themselves at the time of decision) examines the *transferability* of the results from experiments conducted under these conditions ("are the results going to hold in other situations?").

Both these levels play a role in the process with which the judgments and decisions will be made, and subsequently, differences on these two levels should be considered when assessing the final outcome of a study.

Local Context Effects: Characteristics of the Task

In food evaluation studies, the internal validity of experiments relies mostly on the standardization and strict control of external variables. Drawing from the observations and theoretical framework presented above, this view can be broadened to consider potential task-induced context effects. We argue that the task-related characteristics that may lead to context effects could be better identified on the basis of the theories of context effects. In Table 1, we provide some examples of research hypotheses drawn from theoretical principles, as well as possible perspectives for application in experimental practice. We suggest that this theory-based approach should be reinforced in future context-related research, in order to strengthen our understanding of the boundary conditions of internal validity of food evaluation studies.

Global Context Effects: Improving Data Transferability

Global context effects need to be considered in order to assess the external validity of data – its validity outside the context in which it was obtained. In practice, this can be done through two approaches: (1) the reproduction of the measure in multiple real contexts and (2) the complementarity between controlled laboratory experiments and realistic field experiments depending on the objectives of the research.

Reproduction in Multiple Contexts: Increasing the Ecological Validity of Experiments

The principles of standardization that guide the design of experimental protocols, and often condition their publication (Bougherara et al. 2017), are sometimes achieved to the detriment of the realism (also called ecological validity) of the measure. For some authors, it is mainly this lack of ecological validity and the

Table 1 Examples of suggested context-related research practices drawn from theoretical principles

Theoretical principle	Characteristic of the task	Possible impact of context on measure	Suggested research practice
Heuristics and biases	Local context of the task: number and type of associated tasks	Differences in heuristics leading to judgment, for instance, when answering analytical vs synthetic questionnaires (Prescott et al. 2011)	Take possible biases into account in the design of experimental task
	Participants' degree of involvement in the task	Hypothetical bias (e.g., Harrison, 2004) may occur in the responses of individual if the situation is not involving enough, affecting the robustness of measures (Bangcuyo et al. 2015; Hathaway and Simons 2017)	Use incentives to make responses consequential/ use indirect methods to measure the variable of interest
Reference-dependence	Choice of questions and variables	Framing effects may occur depending on the way questions are asked modifying consumers responses	Present same scenarios with different formulations in order to understand differences in consumers choices and evaluations
	Method of measure and variable of interest	Diversity of concepts (preference, liking, acceptability) and lack of uniformity may affect the interpretation of context effects	Increase robustness and reproducibility of similar studies by using standardized instruments and variable names
	Sequence of evaluation	The order of sample presentation has shown to impact consumer evaluation in standardized conditions. Nevertheless, this impact is rarely studied in usual consumption situations	Consider the effect of the first product on a posteriori evaluation and see how the reference point is modulated
Dual-processing	Degree of attention required of study participants	A task that requires specific attention may appeal to reflexive systems disproportionately in contrast to usual consumption situations, which may, in turn, change the outcome of judgment and decision-making	Consider the degree of attention generally given to the evaluation of the food in the consumption situation and design task accordingly
	Wording of questions, complexity of task	Outcomes of a task that is too cognitively demanding may have little direct transferability	Reflect on expected value of the research outcomes: theoretical or directly applied value

subsequent appearance of experimental artifacts that explain the discrepancy between the results obtained in the laboratory and the behaviors observed in reality (Harrison and List 2004). In response to this, and in order to "study real people eating real food in real contexts" (Meiselman 1992), several authors have argued for a need for experiments conducted either in real field situations (Levitt and List 2006; Meiselman 2006) or to make laboratory studies more ecologically valid (Jaeger and Porcherot 2017).

Increasing ecological validity means making the evaluation situation closer, in terms of context, to real consumption contexts. Methodologies such as in-lab recreated contexts (adding realistic physical elements to the testing environment), evoked contexts (evoking a congruent consumption situation by means of a written scenario), virtual reality, living laboratories, or immersive contexts, all aim to address this concern of ecological validity. Such methods, as well as field experiments in natural contexts, are developing rapidly in the field of sensory sciences as well as in experimental economics (Galiñane-Plaza et al. 2019).

However, these attempts to increase the ecological validity of experimental measures have had mixed, inconsistent results so far. As underlined in Galiñanes-Plaza et al. (2019), one issue is the lack of comparative studies allowing to understand the relative added value of each of these "context-enhanced methodologies" and draw clear recommendations for best practices. More importantly, simply increasing ecological validity may be necessary, but is not sufficient in order to improve external validity of experiments. Increased ecological validity, indeed, addresses the concern that standardized laboratory conditions, being artificial, may generate context effects that have no relevance in real situations. Nonetheless, contextualized or field experiments are also conducted in specific contexts (although more realistic ones) and, therefore, are subject to context effects. Achieving greater external validity therefore requires also the reproduction of the same experiment in a large, and varied, number of contexts.

However, this is only possible if the internal validity of the protocol is ensured to allow for reproducibility of the experiment.

Complementarity of Laboratory and Field Experiments

Experimental methodologies can be used to address a large range of purposes. They can be used either to test theoretical predictions; to generate empirical data on a given phenomenon; to predict consumers' response to a new product; or to compare the effects of food policy scenarios (Roth 1988; Saulais et al. 2017). Depending on the type of experimental aim, the question of the external validity of the results represents a different issue, and the way to address the concerns of transferability varies (Camerer 2015).

Ecologically valid and standardized experiments are complementary experimental approaches. A gain in ecological validity is generally achieved to the detriment of experimental control, or vice versa, and the choices of either should result from a trade-off based on the purposes intended for the experimental data. Many experiments on food evaluation or food choices have applied aims, either to predict market success of newly introduced products or to test the impact of policy scenarios on food consumption behaviors. For these studies, the transferability of the data appears to be essential: in policymaking, experiments are used to test policy instruments meant to change consumers' behaviors in a large variety of real food choice environments. A lack of external validity of these tests outside the lab would therefore be problematic. Likewise, in the industry, experiments are conducted in order to identify the features of the "ideal product" for consumers (Jaeger et al. 2003). Context effects, again, pose a problem, and the question of the perimeters of future use of the evaluated product is central. For these applied studies, the transferability will increase with the number and variety of contexts in which the data are gathered.

But for other types of studies, the main aim of experiments is to provide data to contribute to the understanding of principles that govern the influence of a given factor – for instance, on consumers' perception of given attributes of food or on eating behaviors. In that case, the internal validity of the protocol is the most crucial point, requiring a control that sometimes can only be achieved at the expense of a loss in ecological validity.

There is, thus, no unique methodological answer to context effects but rather a need to identify clearly the intended objectives of each experiment and to design experimental protocols carefully to match these objectives in terms of the degree of contextualization that is needed.

The next part of this chapter develops the implications of context effects in the case of applied issues.

Implications for Policy and Product Development: Integrating Context in Innovation Processes

Acknowledging the importance of context effects on perception, judgment, and behaviors leads to consider the context of consumption systematically in product innovation as well as in the design of policies. This means a change of perspective, from looking at context as an additional variable that must be considered once the new product's properties or the policy are selected to including context as a full component of the product or policy design process. In this perspective, all the elements that define the task that the consumer must perform when making a judgment or a decision need to be part of the initial designing process.

Doing this requires us to be able to characterize food choice environments and their interaction with products and consumers. Food choice environments comprise some elements which the designers (whether they are policymakers or new product developers) can influence at least in part in their design (this includes, but is not limited to, factors such as pricing, information, variety, availability, accessibility, bundling of products, rules of consumption, etc.). But part of the choice environment also includes contextual variables that may come into play without any possible control of the designer over it (such as the weather, people's emotions, the political context, etc.). We will discuss these implications for the design of (i) public policies and (ii) new food products.

Taking Context into Account in Policymaking

If decisions rely in part on context through the use of heuristics, then it is possible that some decision environments may, by their structure, favor certain choices or judgments – for example, in the case of food, it has been shown that larger portions lead to an overestimation of the quantities wanted by consumers, regardless of, for instance, their level of hunger. In policy terms, these interactions between the consumer and the way products are presented (also called the "architecture of choice") are especially important in the face of the profusion and dynamics of the current food market environment: to what extent could the choice architecture constitute a risk factor for consumers and society in terms of well-being, health, and the environment?

In the nutrition and health policy domain, this shifts the paradigm on which strategies toward changing dietary practices rely. If some of the unhealthy or unsustainable choices of consumers are attributable to the choice architecture, then three new directions are available to the legislators: (a) to regulate the characteristics of choice architecture in order to (re-)orient decisions in a more favorable direction; (b) to educate or *empower* the consumer with keys to better decide in a given choice environment; and (c) to reconsider the way traditional policies are designed by trying to anticipate consumers' response to the way they are framed.

Adapting Food Choice Contexts to the Consumer: The *Nudges* Approach

From the identification of systematic biases in consumer decision-making emerged the idea that choice contexts could be actively modified by policymakers in order to re-orient choices in a (socially or individually) more favorable direction. This approach, popularized as "nudges" by Thaler and Sunstein in 2008, is referred to as *liberal paternalism* when it refers to the public policy instruments it generates (*paternalistic* because it implies that someone, a "choice architect*,"* actively builds the environment in a way that pushes the individual toward a certain decision and *liberal* because setting the environment of choice only points to certain options, without deleting any) (Thaler and Sunstein 2008).

If nudges are gaining growing popularity in several domain of public regulation, the relevance and acceptability of their application in the context of food decisions are not so trivial. The criticisms (and associated scientific issues) of the use of nudges are essentially methodological and ethical.

In methodological terms, research on nudges is rapidly growing. In May 2019, among the 15,600 entries that search engine Google Scholar returned for a request with the keywords "food" and "nudges" since 2008, over 7600 references had been published between 2016 and 2019. However, several recent meta-analyses have highlighted the lack of robust evidence for the effectiveness of such interventions in promoting healthier food choices (Bucher et al. 2016; Hollands et al. 2013) and especially the lack of theoretical foundations on which these behavioral programs are generally developed (Szaszi et al. 2018) and the difficulty in identifying solid principles because of the heterogeneity of methods and vocabularies used in this field (Wilson et al. 2016). For these reasons, it is difficult to assess whether food nudges that have been found to be efficient in a given context can be transposed efficiently to others. Several works have called for more research on the boundary conditions of efficiency of such actions.

Another largely under-researched, yet critical point, is the feasibility of implementation of such actions by professionals in the food and beverage and in the foodservice sectors; in other words, the conditions of operational success. This question is crucial in assessing the relevance of these interventions, especially in the long term and with context in perspective. Indeed, if these actions are too expensive, too difficult to implement, or if they negatively affect customer satisfaction, they will be quickly abandoned by the industry in the absence of legal obligation to implement them (Saulais 2015; Bergeron et al. 2019; Saulais et al. 2019).

On the ethical front, the debate revolves around the political justification and the legitimacy of such interventions (Guala and Mittone 2015), especially with regard to the definition of the standard that should be the target of interventions. The acceptability of the principle of nudges by the population (Reisch et al. 2017) and ethics associated with the general principles on which this approach is based have been widely discussed (Blumenthal-Barby and Burroughs 2012).

Nudges are -sometimes hastily- presented as superior to traditional policy instruments. However, it should be noted that the main proponents of nudges describe them as a complementary, rather than an alternative, policy approach (Thaler 2018).

Empowering Consumers to Face Changing Contexts

Nudges are based on the premise that when decision-makers rely on the choice environment, they make a trade-off between effort and accuracy: in other words, they mobilize less cognitive resources, but that leads to decisions that are "less accurate" ("less rational" in the sense of standard economics) than those that would be based on pure logic (Kahneman 2003). This vision of heuristics as a source of less effective decisions has been criticized by some authors (Polonioli 2013). One of the main points of this critic is that food choice environments have evolved rapidly in the course of the past half-century and that heuristics, rather than being inefficient, may simply not be adapted to these new choice contexts. Another critic is that potential outcomes of food decisions are not always known: for example, the specific ecological or health impact of consuming a product at a given time is uncertain. There is, therefore, no clearly identified "logical" decision to refer to and thus no way to qualify a decision as "inefficient."

In this perspective, the policy challenge becomes to help decision-makers to face those constantly changing food choice environments. Making consumers conscious of how they interact with the choice environment when making decisions aims to "de-bias" consumers so that they are not disproportionately influenced by the choice architecture and make decisions based on their own preferences. This approach, labeled "boosts," is generally presented as opposed to nudges, in that nudges take decision biases as a starting point to shape the environment so that it can lead to targeted behaviors (Grüne-Yanoff and Hertwig 2016). Very little research, to date, has been conducted to test "boosts" as an intervention strategy to influence food choices. However, although not labeled as such, some food education programs designed to engage consumers in making informed choices could be identified as falling in the "boosts" category.

Reassessing Policy Instruments in Light of Context Effects

Context effects should be considered carefully in the design of public policies. Depending on the context, some product attributes may appear more salient to consumers, which could impact their response to some policies, such as "fat taxes" (taxes on unhealthy food options), "thin subsidies" (subsidies on healthier food), or nutritional information.

The contributions of behavioral economics to public policy are therefore not limited to nudges (Loewenstein and Chater 2017). Better considering context effects can also – and foremost – contribute to optimize the effectiveness of traditional policies (Liu et al. 2014). For instance, because food choices rely on automatic processes, research indicates that the effectiveness of nutrition labeling policies depends not only on the information provided but also on the way labels are designed and on the amount of time that consumers have for decision (Crosetto et al. 2016).

Context Thinking in New Product Development

The experimental procedures within the framework of evaluation of new products in the food industry need to be reconsidered in light of possible context effects. The testing location, the way food products are presented during testing, the characteristics of the tested population, the measurement task, and the reference set by the consumption situation are all elements that may impact the validity of results and need to be examined. The associated methodological choices should be made in light of the objectives of the study and the stage of product development.

The technology readiness levels (TRL) scale, originally developed by the NASA to measure the level of maturity of a technology (Mankins 1995), could serve as a reference framework in the food and beverage industry to position the various experimental approaches that can be used for food innovation and to assess the degree of contextualization necessary at each stage. A simplified version of this scale, adapted to the development of new food products, is proposed below (Fig. 2). Typically, a *living lab* could be used at step 5 or 6, to validate a part of the innovation or a prototype in a relevant environment, an environment that is significant for the innovation studied but controlled and partially recreated, or (in some particular cases) at stage 7, in an "operational" environment, an environment where the test constraints have been lifted to create a particular case of a real life consumption situation. For example, if we are looking to develop a product with a new environmental-friendly characteristic that would, in its final form, be signaled by a label on the market, we may first be interested in finding out whether this specific characteristic is valued by consumers. This can be done by measuring consumers' willingness to pay for different products bearing this characteristic, presented in the form of an

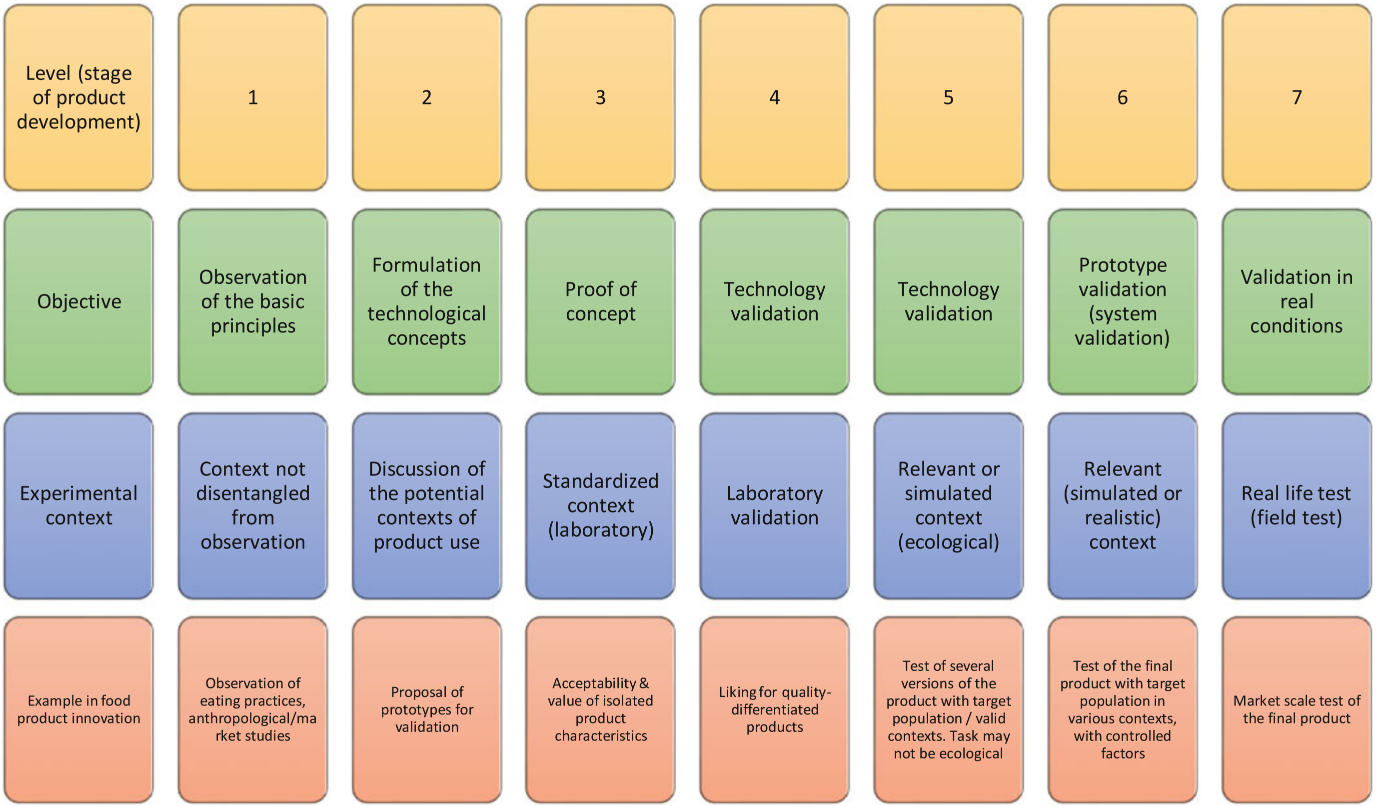

Fig. 2 A proposal for a simplified adaptation of NASA's technology readiness levels to the development of food products

element of "raw" information (without commercial logo and requiring full attention of the consumers) in the laboratory (level 4). At level 5, this characteristic would be inserted into the product of interest with several options for the logo, in a laboratory situation. At level 6, the product would then be tested in a living lab in its final form (product + logo), presented as it would be given on the market (for instance, in a supermarket aisle), but by controlling external factors (including maintaining a certain homogeneity of information on other products in the aisle that would not necessarily be present in all final markets). Finally at level 7, this product would be introduced under the usual conditions of consumption (full market test).

The TRL framework is useful to plan a full process of technology maturation; however, food innovation majorly differs from aeronautics in the sense that food product development generally involves less stages, less investments, and less time, than technological development in most sectors. Another major difference is that the variables of interest, collected during tests, are focused on consumers' responses rather than on physical parameters. Consumers' preferences and habits evolve very rapidly, and thus the validity of data collected expires as rapidly. For this reason, thoroughly respecting the guidelines and practice recommendations listed in the TRL figure would require many additional costs, but also development delays which imply a potential loss of data validity. Overall, the question of finding the right balance between accuracy of research data, time and monetary constraints, and the search for transferability becomes central to the practice. How can these aspects be reconciled?

One key lies in the careful examination of the area of applicability of the results. This area depends on the stage at which the product development is and the purpose of the study in this product development sequence. Design thinking is an approach that aims to resolve these issues by placing humans at the center of the innovation process, mobilizing users from the observation of users to new ideas generation, and all the way to market implementation of new products. This integrated process is thought to allow more rapid and dynamic product innovation.

Conclusion

The empirical observations and theoretical propositions presented in this chapter converge toward the idea that the way in which food is made available to consumers, whether they result or not from an active construction by the suppliers, by the experimenter, or by the policy-maker, influences product evaluation and choices and behaviors. The physical and temporal features of the object within the situation but also the information available and the structure of the decision-making task all have the potential to generate context effects, because of our perceptions, own beliefs, our past experiences, or our state at the time of choice.

Mapping contextual variables through systematic empirical research and further explaining the mechanisms of context effects are necessary research avenues to pursue in order to provide a clear methodological path. For that purpose, researchers in the food domain need to integrate perspectives from multiple disciplines and use complementary sets of data – including both experimental and non-experimental and qualitative and non-qualitative data.

Appendix

Study	Studied variables	Studied factor	Studied product	Results
Contextual variables describing the situation				
Edwards et al. (2003)	Liking	**Context**: army training camp, university staff refectory, private boarding school, freshman's buffet, private party, residential home (elderly), student refectory, day care center (elderly), university 4-star restaurant, hotel 4-star restaurant	Chicken à la King and Rice	Different results were obtained among the different contexts regarding product sensory attributes (appearance, taste and texture, as well as satiety)
King et al. (2004)	Liking	**Context and social environment**: 5 CLT (plain room and recreated restaurant context and a regular restaurant)	Side salad with dressing, small pizza, and an iced tea	Context and social environment had a different effect of meal components evaluation
Boutrolle et al. (2005)	Liking	**Context**: central location test (CLT) vs home use test (HUT)	Fermented milk with two different degrees of fat content	Same results were obtained in both contexts but higher scores were obtained in the HUT >Robustness at CLT
Sester et al. (2013)	Drink choice	**Context**: immersive scenario with differences in furniture (wood and blue furniture)	Different drink options	Drink choices differed depending on the ambiance set
Di Monaco et al. (2014)	Liking	**Context**: social environment in a controlled setting	Croissants	Social environment negatively affected liking scores

(continued)

Study	Studied variables	Studied factor	Studied product	Results
Cho et al. (2015)	Food intake and sensory perception (flavor)	Light color: white, yellow, and blue	Omelet and mini-pancakes	Blue light had an effect on food appearance impression and decreased men food intake. Food flavor perception was not affected
Contextual variables describing the product				
Poelman and Delahunty (2011)	Liking and preference	**Product**: food preparation (different methods: baked, boiled, mashed, stir fried) and color	Sweet potato, cauliflower, and beans	Differences in the preparation method differently affected participants liking and preferences. Moreover, differences among the products and the type of preparation were observed. Atypical colors influenced participants preferences but not liking
Piqueras-Fiszman et al. (2012)	Food perception	**Product**: shape and color of the plate	Mousse	The color of the plate influenced the perception of the product, whereas the shape did not affect
Michel et al. (2014)	Liking, food perception, and willingness to pay (WTP)	**Product**: three different meal presentations	Dish	The most artistic presentation obtained higher liking results and was perceived as tastier, and participants were willing to pay more for it
Velasco et al. (2014)	Food matches between color and flavor (cross-cultural study)	**Product**: different packing colors	Crisps packaging	Specific food flavors are related to specific colors (red = tomato; green = cucumber). Complex and unspecified flavors are related to different colors depending on the country

(continued)

Study	Studied variables	Studied factor	Studied product	Results
Bernard et al. (2019)	Food perception and WTP	**Product**: different label information (origin)	Watermelon	Product with information increased participants perception about the product (tastiness) and were more willing to pay for it
Contextual variables describing the consumer				
Platte et al. (2013)	Fat and taste perception	**Consumer**: psychological status (mood)	Five different sensory stimuli (sweet, sour, bitter, fatty, and umami)	Sweetness and bitterness perception was positively correlated to depression and anxious moods
Giacalone et al. (2015)	Situational appropriateness	**Consumers**: product familiarity	Beers: more or less familiar to consumers	Product familiarity determines the situational appropriateness of beers. Less familiar beers were more context-dependent than familiar ones
Bernard and Liu (2017)	Taste perception	**Consumers**: beliefs about local and organic ingredients	Different apples: organic, local, and conventional	Labeled apples were higher rated than unlabeled one. Moreover, participants with stronger beliefs in organic and local ingredients rated the taste of those apples higher than the conventional ones
Schifferstein et al. (2019)	Familiarity, purchase intention, and intended preparation method	**Consumer**: expectations related to color	Carrots	Carrots' color showed to have an impact on consumers' expectations related to sensory attributes like freshness and nutritional value
Spinelli et al. (2019)	Product experience	**Consumer**: emotions related to ingredients and preparations	Different dishes	Different emotions were associated with different ingredients and concepts (fresh

(continued)

Study	Studied variables	Studied factor	Studied product	Results
				tomato flavor with cheerfulness and light-heartedness; surprise and curiosity with the idea of naturalness, appeals to the imagination in cooking, and fancifulness)
Contextual variables describing the consumer				
Earthy et al. (1996)	Sensory preferences	**Task**: order of questions	Different samples with different milk chocolate powder and sugar context	Participants tend to be less critical when a global hedonic question came prior to the attribute questions, especially for the most disliked samples
Popper et al. (2004)	Liking and sensory attributes perception	**Task**: questions formulation (different scales: overall liking, intensity scales, just about right (JAR), attributes liking)	Four variations of a dairy dessert	Differences in questions formulation leaded to different liking results: JAR had a stronger effect on the modulation of the results
Prescott et al. (2011)	Liking	**Task**: number or questions (synthetic versus analytical)	Tea drink	Higher liking results were obtained in the synthetic task compared to the analytical evaluation task

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Part XI

The Ethics of Eating

An Overview of the Ethics of Eating and Drinking

52

Jessica Fanzo and Rebecca McLaren

Contents

Abstract

Eating and drinking are ethical acts. When we make decisions about what to eat and what not to, we are making decisions that impact our own health, the well-being of those who work in the food system, animal welfare, and the environment. Food ethics is the interdisciplinary study of how what we eat – including the way it is produced, distributed, marketed, prepared, and ultimately

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consumed – impacts human, animal, and planetary health and well-being. Food ethics also analyses the justice or fairness of these impacts. Food ethics raises many difficult questions that do not always have clear or easy answers, such as how do we produce enough food to feed everyone well and equitably; how do we ensure that everyone has access to high-quality, nutritious food that is culturally appropriate; how do we do this in a way that treats workers fairly and respectfully, is considerate of animal welfare, and is environmentally sustainable; and how do we shift power across the food system in favor of the public good over multinational food companies. This chapter will explore these questions and more, hopefully encouraging thoughtful discussions and potential solutions for the future.

Keywords

Food ethics · Food security and nutrition · Animal welfare · Environmental sustainability

A Grand Global Challenge: Ensuring Food Security and Nutrition for Everyone

The Burden of Food Insecurity and Malnutrition

One of the great challenges of modern times is how to ensure everyone has access to plentiful, safe, and nutritious food and beverages that are produced in an equitable and environmentally sustainable manner. Every human being has the right to adequate, safe, and nutritious food. The realization of this right is not being realized in most countries and cannot be achieved without equitable, sustainable, thriving food systems that provide the food and nutrition security for our world's population now and into the future.

World hunger is on the rise, after 15 years of decline, due to perpetual poverty, conflict, and climate change-related disasters (FAO et al. 2018). Additionally, malnutrition in all its forms in children and obesity in adults are still problems (Initiatives 2018). Every country is affected by malnutrition in at least one form, whether it be undernutrition, micronutrient deficiencies, or obesity and 88% struggle with multiple forms (Initiatives 2018).

What People Are Eating

Food systems provide the food and beverages that make up diets around the world. The ideal diet is one that is safe, healthy, rich in nutrients and energy, affordable and accessible, and culturally appropriate. However, the ideal is not the norm. While malnutrition is multifaceted and multifactorial, one significant contributor is suboptimal dietary patterns.

Data from the Global Burden of Disease study shows that suboptimal diets are now a major risk factor for disease, disability, and death (Afshin et al. 2019), surpassing both tobacco and high blood pressure (Swinburn et al. 2019). Historically, most diet-related disease and death stemmed from communicable diseases and diets insufficient in calories and nutrients; however, now most of the mortality in the world is in the form of noncommunicable diseases such as heart disease, stroke, cancer, and diabetes (Afshin et al. 2019; Initiatives 2018). Suboptimal diets tend to be low in vegetables, fruits, whole grains, and seafood and fish high in omega-3 fatty acids and high in red and processed meat, packaged foods, and sugar-sweetened beverages (SSBs) (GBD Collaborators et al. 2015; Afshin et al. 2019).

Shifting Diets

With the decline in global poverty and increasing urbanization over the last few decades, dietary patterns have shifted significantly across the world (Ivanic and Martin 2018). On the positive side, vegetable, fruit, and animal source food (ASF) consumption has increased, whereas intake of trans fats has declined in all regions. On the negative side, processed meat consumption increased in all regions of the world. SSB and packaged food consumption also increased in most regions. While there is variation in regional trends, sodium intake is significantly higher than the recommended amount in all regions of the world (Glopan 2016; Initiatives 2018). People are also cooking less and eating away from home more due to lifestyle changes (Kearney 2010). In Latin America, for example, food eaten away from home has been steadily rising across several countries including Mexico and Brazil (Popkin and Reardon 2018).

A country's economic status does not necessarily indicate a population consumes healthy diets. Independent of wealth status, all countries consume too few vegetables and fruit, too many SSBs, and too much sodium. In high-income countries, populations are also consuming significant red and processed meat and trans fatty acids, which do not align with a healthy diet (Willett et al. 2019; Initiatives 2018).

What Constitutes an Ethical Issue for Eating and Drinking?

Exceptional Facets of Eating and Drinking

Eating is an ethical act. By choosing what we eat and drink, we are making decisions beyond our immediate survival and needs and participating in something much grander. Food and beverages are rooted in the history of humanity and development and are integral to our values, traditions, cultures, religions, and everyday situations that make up our societies. What we choose or choose not to eat and drink defines who we are and who we aspire to become. These choices are often intertwined with our beliefs and values, our physiological drive toward certain foods and drinks, and our relationship to the origins of food.

Humanity is realizing that decisions about what food we eat can dictate or be dictated by food systems and even beyond the food system – to planetary, economic, and social systems. “Perhaps the main reason nutrition has thrust planetary health into public consciousness is the role of food in culture. Food is essential to life, and diet and culture form the very fabric of life” (The Lancet Planetary Health 2019).

Defining Food Ethics

Food ethics is a field of study that examines the ethics of human conduct in the production, processing and packaging, distribution, preparation, and consumption of food. It looks at the reasons and rationales of the entirety of the food system – from production to consumption and the societal significance of food in the larger global architecture of development. For non-philosophers, food ethics raises issues of food and social justice, food sovereignty, and sustainability that involve many actors including governments, food and beverage industries, food system actors and producers, and, of course, consumers and citizens (Thompson 2015).

Considering the Ethical Issues of Eating and Drinking

The Many Ethical Issues of Eating and Drinking

There are many ethical issues with regard to eating and drinking. A significant number of ethical issues involve equity: equity of access, knowledge, and demand. In relation to food security and nutrition, there are significant inequities, including who has access to high-quality nutrients that provide for optimal human health. Additionally, not everyone has equal access to knowledge and “know-how” of what is healthy and what is sustainable. And who has the right to provide that knowledge? Consumers and food system actors have prejudices and expectations that impact both the demand and supply of food and the relationship between the two. Some have a louder voice than others.

What are the health, societal, and environmental consequences of various eating habits and the food systems in which food is produced? What ethical obligations, if any, does society have in consuming certain foods and beverages that make up our collective dietary patterns? How are our individual and societal decisions about what to eat expressive of cultural, religious, aesthetic, and moral values? Do the answers to these questions generate moral obligations to adopt, or to abandon, particular eating habits? This overview will examine some of the most immediate ethical issues and constraints that face our global population when it comes to the foods produced, moved, and ultimately consumed around the world.

The Growing of Foods: Environmental Sustainability and Animal Welfare

Introduction

One of the world's greatest challenges is ensuring our growing population has enough healthy food without overstepping the boundaries of what our planet can endure. Meeting this challenge requires a deeper understanding of the health, environmental, and ethical issues associated with food production and consumption.

Human Health

As countries accumulate wealth, populations often shift from plant-based diets rich in vegetables, fruit, and legumes to ASFs and highly refined foods (Hawkes and Popkin 2015; Popkin et al. 2012).

There are profound inequities, both globally and within countries, with respect to access to and affordability of nutritious, perishable foods because of their cost and availability through functioning supply chains (FAO 2014). One example of this inequity is the consumption of ASFs. Although many countries are shifting from plant-based diets to more ASFs (Keats and Wiggins 2014; Zeisel and da Costa 2009), access to ASFs among the poorest remains limited in both availability and affordability. This limitation can affect health because some ASFs provide nutrients that are more difficult to obtain in adequate quantities from plant-source foods alone (Black et al. 2013; Dewey and Adu-Afarwuah 2008). Deficiencies of these nutrients lead to serious health impacts, including anemia, blindness, and stunting. In contrast, over-consumption of red and processed meats contributes to increased risk of obesity and chronic diseases such as heart disease and colorectal cancer (You and Henneberg 2016; Bouvard et al. 2015). The benefits of ASF consumption are nuanced: for nutritionally vulnerable populations, ASFs can provide essential nutrients that are otherwise hard to obtain, but for others, consumption of these foods needs to be limited to mitigate the risk of chronic disease.

Environmental Sustainability

Animal production systems and practices can create substantial negative environmental impacts because of greenhouse gas emissions (GHGe) and other air pollutants, contamination of surface and groundwater, conversion of land (usually forested) for grazing, and degradation of ecosystem services. These impacts arise directly from the animals (e.g., wastes) and indirectly from the production of animal fodder (e.g., clearing land for feed or pasture). In many agricultural landscapes; however, animals are positively valued as investments, sources of fertilizer and energy, and important contributors to ecosystem services.

In an interconnected, globalized food system, balancing climate and environmental stewardship, as well as fostering human and animal health, is a significant challenge. It requires concerted efforts to reduce consumption of ASFs in high-income countries, encourage moderate consumption in growing economies, and increase access to ASFs for the poorest and most nutritionally vulnerable populations.

Animal Welfare

Animal welfare is how an animal is coping with the conditions in which it lives and is cared for. An animal is considered to be in a state of good welfare if it is safe from harm; healthy; well nourished; comfortable; not suffering from unpleasant states such as pain, fear, and distress; and able to express innate, natural behavior. Proper animal welfare requires disease prevention and veterinary treatment, nutrition, appropriate shelter, management, humane handling, and humane slaughtering. Indicators of poor welfare include impaired growth and reproduction, bodily harm or damage, increased disease and immunosuppression, and reduced life expectancy (Broom 1991).

The industrial revolution brought changes in the way animals were viewed, relying on them more heavily for consumption. Now, many of the animals consumed globally are raised in concentrated animal feed operations (CAFOs) or on large-scale factory farms, in which animal welfare principles are considered only for industrial production purposes and for food safety for humans (Armstrong 2016). Many of the factory farms put animals in a more “unnatural state” than their wild predecessors would be exposed to or behave like.

Ethical Issues

There are major concerns with the expansion of industrialized animal systems and demands for meat (Willett et al. 2019; Nierenberg 2018; World Resources Institute 2018). Additionally, food systems are designed for efficiency, not animal welfare, amplifying concerns. This efficiency has environmental impacts as well as impacts on human and animal health. Antibiotics are used to reduce infections usually from underlying care issues of sanitation or overcrowding in factory farm animal systems. Agriculture uses about 70 or 80% of the antibiotics sold in the USA alone. There is a growing concern of increased antibiotic resistance now and into the future (IACG on Antimicrobial Resistance 2019).

If certain resource-intensive foods are considered critically important for human health, then their distribution and access must be equitable – and any existing imbalances need to be addressed. There are also low-resource alternatives that should be considered to fill nutrient gaps for all countries. These foods, such as farmed fish, mollusks, insects, and protein-rich plant food, may be less popular but can make significant contributions to nutrition while leaving a smaller footprint on the planet.

The dietary choices of people in high-income countries have significant ramifications for less wealthy populations. The energy-intensive lifestyles and diets of those who can afford them are significant anthropogenic contributors to climate change. However, economically poor households are likely to experience a disproportionate burden of climate change impacts (Olsson et al. 2014). Food security among these households will most likely deteriorate under future climate scenarios, and diets could worsen along with nutritional outcomes, reversing years of progress. Those who are wealthier will suffer less, even though their choices have far-reaching consequences. Society must address the questions of justice that are central to the increasingly globalized nature of food choices intertwined with environmental degradation.

From environmental and food security justice perspectives, addressing these ethical issues requires concerted efforts to reduce consumption of animal products in high-income countries and to discourage high consumption in growing economies with populations that are now wealthy enough to increase meat and dairy in their diets. Some have argued that a 30% reduction in production and adult consumption levels of ASFs would meet national GHGe targets and would simultaneously reduce years of life lost from heart disease by 15% (World Resources Institute 2018).

The Quality of Foods: Fresh, Organic, and Local Foods and Their Movements

Introduction

Food varies greatly in its quality, including how fresh it is as well as if it is organic or locally produced. Some of these characteristics impact how nutritious the food is, although the size of these impacts and the impact itself are sources of debate.

Freshness

While the vegetables and fruit at the grocery store may look fresh, there is a lot of variation in the length of time between when the produce was picked and when it is sold in the store. Additionally, many consumers are unaware of how old this food may be. Apples and potatoes are typically stored the longest, often stored for up to 12 months before being sold, while carrots may be stored up to 9. Additionally, produce may sit on grocery store shelves for days or weeks, especially if there is low turnover (The Guardian Staff 2003). While consumers have no control over the age of the produce at the grocery store, they can buy fresher food directly from farmers either at growers-only markets or through community-supported agriculture (CSA) shares. However, farmers markets and CSAs are not available everywhere and are often more expensive than the grocery store.

The freshness of vegetables and fruit is important because produce has the highest nutritional value right after it is picked. The largest causes of nutrient losses are heat, light, and oxygen. When produce is kept in storage between the field and the grocery store, the temperature and humidity levels are optimized for preservation, but there are still losses. One study looked at 19 vegetables and fruits and found that after 15 days in the refrigerator, many had lower levels of vitamin C and antioxidant activity. While there was a range in the levels of decrease, vitamin C decreased by over 70% in tomatoes and almost 50% in beets. For antioxidant activity, the largest decreases were over 81% in bananas and 73% in tomatoes (Galani et al. 2017).

Organic

Organic food has expanded dramatically over the past decade (United States Department of Agriculture 2017). One of the main benefits of organic food is that it is grown without, or with fewer, synthetic pesticides. While organic farmers can still use natural pesticides as well as a handful of synthetics ones, they generally use much less. Consequently, organic vegetables and fruits have less pesticide residues.

The USDA Pesticide Residue Monitoring Program inspects produce for pesticides and found that organic produce had an average of 0.8 pesticide residues, while conventional produce had 3.2 (United States Department of Agriculture 2016). One review of 343 studies found that organic produce had 4 times less pesticide residues as well as much lower concentrations of the toxic metal cadmium (Barański et al. 2014).

While there is a consensus that organic food has less pesticide residues, the studies on nutritional value are less clear. One difficulty is that vegetables and fruits can have vastly different nutritional values even when grown in the same way. Comparing produce that is grown in different places and at different times, as well as with different practices, is very difficult. Despite these difficulties, researchers have repeatedly tried to confirm or deny that organic produce has more nutrients. One review of 55 studies and another of 223 studies found that organic produce does not have any significant nutritional benefits (Dangour et al. 2009; Smith-Spangler et al. 2012). However, a later review of 343 studies found that organic produce does have more nutrients. This review confirmed some of the earlier results, such as that organic and conventional produce had similar levels of vitamin C and E and many minerals. However, this review found that organic vegetables and fruits had between 19% and 69% higher antioxidant activity (Barański et al. 2014). Another study comparing the same crops in adjacent fields found that organic tomatoes had 79% and 97% more flavonoids compared to the neighboring conventional tomatoes (Mitchell et al. 2007). Another review of 170 studies found organic milk had a significantly better fatty acid profile with 7% higher PUFA and 56% higher n-3 PUFA (Średnicka-Tober et al. 2016a). Another review of 67 studies found that organic meat also had a better fatty acid profile with 23% higher PUFA and 47% higher n-3 PUFA (Średnicka-Tober et al. 2016b).

What all of this means for people's health is even less clear. While the USDA and Environmental Protection Agency (EPA) claim that the pesticide residues found on produce are completely safe, others disagree. There are questions about how pesticides with similar mechanisms of action may add to the effects of one another, potentially even with synergistic effects. There are also questions about cumulative exposure over the life span (Boobis et al. 2008). Eating organic foods is associated with lower pesticide exposure. One study looking at urinary pesticide levels found that children and adults who ate organic food for 6 days had significantly lower pesticide levels in their urine (Hyland et al. 2019). One study found that organic diets were associated with reduced risk of cancer (Baudry et al. 2018), but overall the clinical benefits of eating organic foods are unclear (Smith-Spangler et al. 2012).

Organic farming also has other benefits, such as reducing the pesticide exposure for farm workers and those living in the surrounding areas. Organic farmers often grow more crops and varieties, increasing biodiversity. Organic farmers may, but not always, have more sustainable practices. They often enrich the soil with compost, nitrogen-fixing crops, cover crops, and crop rotation and may use no-till practices. This results in more biodiversity, richer soil and less erosion, and less water and air pollution.

Local

There has been a recent call to "eat local," and many people are increasingly trying to buy food that was grown and produced locally. Both individuals and organizations, such as schools, are sourcing more of their food from local farmers. The number of schools using local food in their cafeterias was 2,095 in 2009 compared to 400 in 2004 and only 2 in 1996. While there is no precise definition for what the distance should be for food to be considered local, the Food, Conservation, and Energy Act of 2008 limited it to 400 miles, and this was later adopted by the USDA. Most people buy local food from farmers markets and CSAs, both of which are increasing. There were 5,274 farmers markets in 2009 compared to 2,756 in 1998, and there were 1,144 CSAs in 2005 compared to 400 in 2001 and only 2 in 1986. Today there are even more of both throughout the country (Martinez et al. 2010).

Local food has several advantages. One of which is the ability to get fresher produce that has higher nutritional quality. It supports local farmers, increasing the resilience of the local food system and local economies, making communities more self-reliant. Additionally, many people buy local produce from smaller farms with more sustainable environmental practices. However, local food is not always more sustainable. While local food does travel fewer miles, this does not always result in less GHGe as it is usually transported in much smaller volumes and via less efficient transportation methods. Additionally, food miles are one of the smallest sources of GHGe in the food system. Local food is also more expensive and more difficult to access.

Ethical Issues

While fresh, organic, and local food have benefits for human and planetary health, they are not accessible to everyone. Some communities do not have any grocery stores, let alone ones that sell organic produce or a farmers market. Additionally, organic produce is much more expensive than conventional, often 20 to 100% more (Martin and Severson 2008), and not everyone can afford to eat all, or even some, organic food. It is ethically unacceptable that only those who can afford to buy organic can get the added health benefits and avoid pesticide exposure. It is unacceptable that the true cost of food, including the health and environmental impacts, is not reflected in prices but instead is born by the poorest and most marginalized.

The Distribution of Foods: Availability and Access

Introduction

Food security is when all people have physical, economic, and social access to safe, sufficient, and nutritious food at all times to meet their physical needs for a healthy life. Two critical components of food security are food availability and access. When people do not have access to healthy foods, they may be at increased risk of being overweight as well as for diet-related diseases such as diabetes, cardiovascular disease, and some cancers. Alternatively, people can be at increased risk of being undernourished (Feng et al. 2010; Holsten 2009; Glanz et al. 2005).

Food Availability and Access

Food availability is when there is enough food for all people on a consistent basis. This depends on food production and reserves. However, this does not ensure food security for communities or individuals. Food security also requires access, or when all people have enough resources to acquire food. This depends on availability but also on physical and economic access. Food distribution, or where food is located, the built environment, and people's mobility, access to transportation, and time determine physical access. How much food costs and how much money people have to spend on food determine economic access to diets (Powell et al. 2013).

Cost of Food and Food Prices

The cost of food disproportionately impacts the poor because they spend a higher proportion of their income on food, with poor households in low-income countries spending 50 to 80% of their household budget on food (FAO 2011).

Evidence, mainly from high-income countries, indicates that healthier diets tend to be more expensive, with healthier diets costing about USD 1.50 more per day (Rao et al. 2013; Drewnowski and Specter 2004; Drewnowski 2004). Additionally, healthier diets are more expensive per calorie than diets with lower nutritional quality (Darmon and Drewnowski 2015). Vegetables and fruits are especially prohibitively expensive for many (Miller et al. 2016; Teo et al. 2013). Globally, the price of a basic diet, which only meets caloric needs, often exceeds daily wages. Therefore, many can only afford the least healthy food – low in nutrient density and high in sodium, sugar, and unhealthy fats (Aggarwal et al. 2012). Unfortunately, daily consumption of these low-quality, high-energy diets increases the risk of obesity and the chronic, noncommunicable diseases associated with being overweight.

As incomes increase, it is projected that three billion more people will enter the global middle class by 2030. Dietary data analyzed from 187 countries found that higher incomes are associated not only with higher consumption of healthy foods but also with a substantially increased consumption of unhealthy food items, indicating that the links between socioeconomic status and diet quality are complex (Imamura et al. 2015). As incomes increase, diets will continue to shift from those centered on traditional staples, coarse grains, and roots and tubers to more diverse diets (Alexandratos and Bruinsma 2012; Kearney 2010). This is and will continue to generate increased demand for ASFs; processed, packaged foods; and take-away foods (Glopan 2016; Ranganathan et al. 2016; Drewnowski and Popkin 1997). High-income countries such as the USA already have high demands for ASFs. Countries such as China and Brazil have seen increases in income and concomitant increased demand for animal protein (Tilman and Clark 2014). Future modeling across different shared socioeconomic pathways shows that global food demand will increase by 47% by 2050. Demand for ASFs will double, with a slowing demand for starchy staples (Gouel and Guimbard 2019). In some areas, there is also a growing demand for healthier foods with fewer unhealthy fats, less sugar and salt, and fewer additives.

Food Environments: Food Deserts and Food Swamps

The food environment is the physical environment, political and cultural context, and the economic conditions in which people acquire and consume food. This includes food outlets where people buy food; the built environment that allows people to access these outlets; food promotion and advertising; people's incomes, educations, and values; as well as society's political and cultural norms.

The term food desert has been used to describe both urban and rural communities with few healthy food options. These communities may not have any places to buy fresh produce, and any produce that is available may be wilted and discolored. These communities may not have any grocery stores, and the nearest ones may be miles away. Additionally, people may not have access to personal vehicles or effective public transportation to get there. The term food swamp has been used to describe communities with many unhealthy food options such as corner stores, carry outs, and fast-food restaurants. These outlets sell processed foods high in sugar, salt, and trans and saturated fats. Food swamps have been found to have a greater impact on obesity than food deserts (Cooksey-Stowers et al. 2017). Many food justice activists prefer the term food apartheid over food desert or swamp as these terms describe natural environments, not human-made ones. Additionally, these terms do not describe the structural factors, such as racism, that have created these food environments.

Ethical Issues

There are many ethical issues in how food is distributed. Often there is enough food, but it is not equitably distributed, leaving many people hungry or without healthy food options. It is unacceptable for people to go hungry or suffer from disproportionate rates of noncommunicable diseases solely because of where they live. Additionally, these issues were created and are still perpetuated by structural factors such as racism and economic injustice.

The Use of Foods: Knowledge, Culture, and Food Waste

Introduction

With urbanization, rising incomes, changing lifestyles, and social media, many consumers are getting more and more information about the links between diet and health, contributing to shifts in dietary patterns. However, consumers are often not fully informed about how the food system works, what constitutes a healthy diet, and what is sustainable or, more broadly, ethical.

Awareness, Knowledge, and Culinary Literacy

The increasing complexity of food production and lengthy food supply chains has placed greater burdens on consumers. Many consumers are inundated with media articles about the health of our diets and the food system. Deciphering the science and the “latest findings” is a challenge. While some messaging on nutrition, such as eating more vegetables and fruit and less salt, has been consistent and is more widely understood, other advice about what is considered a healthy, sustainable diet is more complicated and often contradictory. Cryptic and diverging information about health and nutrition has left many consumers confused as to what makes up a healthy diet and what foods are sustainable and ethical (Kraemer et al. 2016).

By providing information and skills to consumers and then allowing them to make their own choices, consumer demand shifts are possible (Keats and Wiggins 2014). This shift can then influence food supply and broader systemic and environmental changes. Increasing consumer demand for healthier foods with fewer unhealthy fats, less sugar and salt, and fewer additives has impacted food producers. Educating consumers about where food comes from and enhancing the public’s awareness and knowledge of what is considered a healthy diet may also have long-term benefits in maintaining consumer confidence. Food labelling, health statistics on menus, dietary guidelines, nutrition literacy programs, and cooking classes can increase consumer education and knowledge (Hawkes et al. 2015; Afshin et al. 2017). Furthermore, price incentives for healthy foods, health-related food taxes and subsidies, and stricter regulation of junk food advertising provide some policy options to help make consumer choices more geared toward those that are more healthy (Hagmann et al. 2018).

Culture and Tradition

Culture is inherent in agri*culture*. Food comes from the land and is grown from the knowledge, traditions, and norms of the people who cultivate that land. Therefore, food can be a powerful lens to preserve social traditions and norms, in both positive and negative ways. The types of foods we consume, the ways in which we prepare and cook meals, and the way we eat those meals are the foundations of many traditions around the world that embody cultures and what we value. Food systems, and the people and institutions that engage with them, are consistently shaping and being shaped by social norms, our culture, and historic traditions (Counihan and Van Esterik 2012).

Food choices can be deeply personal and often hinge on our sense of identity, ideals and aspirations, and habits. Food itself is central to our sense of identity, often being shaped by the geography, hierarchy, and diversity of a certain culture. Everyday events, special occasions, and celebrations influence food consumption, often calling for special foods.

Yet, the food environment around us is altering how we access, prepare, and consume food, including the ever-growing influence of supermarkets as well as restaurants, bodegas and corner stores, small kiosks, and vending machines. Social media is also now shaping desires, competition, and food choices. While some of the world still purchases from local, informal markets, food is increasingly being purchased in larger markets and has traveled longer distances, sometimes from distant parts of the world. These purchasing patterns have been influenced by rapid urbanization, income growth, and expansion of modern food processors, distributors, and retailers (Gómez and Ricketts 2013; Lu and Reardon 2018).

Food Waste

Approximately one-third of the food produced for human consumption is lost at the farm gate or wasted at the retail and consumer levels – of the roughly 4 billion tons of food produced each year, approximately 1.2 to 2 tons are wasted. This costs society USD 750 billion per year (Gustavsson et al. 2011). How food is wasted depends on the region and country. In Europe and North America, most of the food that is wasted is in the hands of retailers and consumers (Willett et al. 2019). In sub-Saharan Africa and South and Southeast Asia, more food is lost on farms with significant spoilage of fruits, vegetables, root crops, and some ASFs. Wasting food wastes resources; wasting 1.4 billion hectares of land and 250 km^3 of blue water to produced uneaten food (Willett et al. 2019). The global food waste also amounts to 3.3 gigatons of CO_2 equivalents. Wasting food also wastes nutrients. A recent study found that lost food, particularly fruits and vegetables, in the USA contains significant amounts of key nutrients that could help people meet their daily recommended intakes (Neff et al. 2015).

Ethical Issues

When we think about how to nourish the world in an equitable, safe, and healthy way, one often hears the argument that we just need to produce more food and largely that has been the paradigm. However, there is an alternative argument, one that involves a more equitable distribution of wealth, income, and available food. It is key to ensure that everyone has enough food that is culturally appropriate while also wasting less food. Additionally, it is also imperative for consumers to understand what they are eating, where their food comes from, and the potential impacts food has on health, the environment, and other concerns such as labor practices and animal welfare. The autonomy to choose foods is helped or hindered by knowledge, information, culture, and tradition.

The Regulation of Foods: Public Health Policy Options

Introduction

Food policy is the area of public policy concerning how food is produced, processed, distributed, marketed, and purchased. The policies of governments largely determine what is available and accessible to eat (Institute of Medicine and National Research Council 2015). Ideally, these policies would help ensure that all people have access to safe, healthy, affordable food; protect air, water, and land; support farmers and workers; and uphold rigorous standards for animal welfare. Despite shortcomings in these policies, there are opportunities for change (HLPE 2017).

Increasing Unhealthy Food Prices Through Taxes

Making unhealthy foods more expensive and nutritious foods cheaper may be one way to influence consumers' behavior and subsequent food intake (Thow et al. 2014; Eyles et al. 2012). There is strong evidence that taxes and subsidies are effective tools for changing dietary intakes. Studies showed SSB consumption can be reduced between 20 and 50% through taxation, while the consumption of subsidized vegetables and fruits can increase between 10 and 30% (Thow et al. 2014).

One argument against food taxes is they impose a larger burden on the poor than on the rich. Adding food subsidies to taxes could help alleviate this potential regressivity and enable consumers to switch to more healthy foods without incurring additional costs (Thow et al. 2010). Imposing substantial taxes on fattening foods may improve health outcomes such as overweight, obesity, and chronic diseases (Thow et al. 2010).

Improving Food Labelling

Nutrition labelling, usually on the back of packages (BOP), has been commonplace in many countries for several decades. It aims to provide consumers with information about the nutrient content of a given food. The Codex Alimentarius Commission, established by the United Nations, has developed standards for nutrition guidelines on food products. These labels require some degree of nutritional literacy, are context dependent, and are difficult to interpret for many people. For this reason, there have been recent moves to adopt easy-to-interpret labels (e.g., traffic light, star ratings, etc.) on the front-of-the pack (FOP) or on store shelves. It is believed that labels of this type would be easier for consumers to interpret and may lead to better food choices. Consumers can more easily interpret graphic FOP labels that incorporate colors, symbols, and text to indicate nutrition or health compared to labels that only emphasize numeric information, such as daily recommended amounts expressed as grams and/or percentages (Hersey et al. 2013).

Although many countries have adopted both FOP and BOP information on energy and specific nutrients since the development of the CODEX guidelines, there is limited evidence to indicate that these labels have influenced consumer comprehension or purchasing decisions (Mandle et al. 2015).

Dietary Guidelines

"Food-based dietary guidelines (FBDG) are an attempt to translate a vast (and always incomplete) evidence base regarding relations between foods, diet patterns, and health into specific, culturally appropriate, and actionable recommendations. Such guidelines are intended to influence consumer behavior and, in some countries, also inform a range of national food, nutrition, and health policies and programs" (Herforth et al. 2019).

While dietary guidelines may help people make healthier choices about food, they also serve other purposes. First, guidelines can provide a unified voice to the public on where the government stands on the latest dietary advice in the context of health promotion and disease prevention. Second, they serve as the foundation for food and nutrition policies and programs that are instituted within a country and impact budgetary allocations for these programs such as school lunches and food safety net programs. Third, the food and beverage industry often responds to changes proposed in dietary guidelines by reformulating products and answering to consumer demands (Afshin et al. 2017; Mozaffarian 2016; Mozaffarian and Ludwig 2010).

FBDG are available in 90 countries globally: 7 in Africa, 17 in Asia and the Pacific, 33 in Europe, 27 in Latin America and the Caribbean, 4 in the Near East, and 2 in North America (Herforth et al. 2017, 2019). These guidelines also often have universal recommendations across countries such as to consume a variety of foods; to consume fruits and vegetables, legumes, and ASFs; and to limit salt, sugar, and fat. However, very few guidelines address environmental factors such as GHGe and water pollution (Fischer and Garnett 2016) or sociocultural factors such as labor conditions in their recommendations (Herforth et al. 2019).

Regulating Unhealthy Food Marketing

Promotions, marketing, and advertising influence consumer decisions on what foods to purchase and consume. There are many techniques to market and advertise foods that influence consumer behavior, including social media, print and television advertising, in-school marketing, toys and products with brand logos, packaging, and product placements (Story and French 2004).

Marketing and advertising influence consumer preferences and increase consumer demand for certain food products. Marketing to children is especially problematic. While children are influenced by their parents or caregivers' dietary habits, they are also susceptible to outside influences such as food marketing and advertising and; therefore, require special protection. There have been steps taken over the past decade to reduce marketing to children, most notably with the WHO recommendations on marketing of foods and nonalcoholic beverages to children, endorsed by the World Health Assembly in 2010. However, stronger actions are needed, including regulatory approaches by governments to restrict and ban these types of marketing practices (Kraak et al. 2016).

Governments have a responsibility to intervene and regulate such as by banning unhealthy food promotions and marketing or other methods targeting children (Harris and Graff 2011; Harris et al. 2009). With regard to advertising junk food to children, various types of legislation should be considered to put strict measures in place to protect children and assist parents and caregivers in promoting healthy eating at the household level. Education of parents and caregivers on good child feeding practices can also impact food-purchasing behavior. Governments are also justified in intervening in schools to promote healthier approaches to eating and physical activity and ban companies from sponsoring sports programming in order to protect children.

Additionally, actions are needed to protect mothers and infants from infant formula marketing. Barennes et al. (2016) suggest measures such as large-scale education campaigns, exclusion of the formula industry from nutrition education and policy roles, and strong penalties for violations of the International Code of Marketing of Breast-milk Substitutes (Barennes et al. 2016). The International Code of Marketing of Breast-milk Substitutes needs to be strictly enforced through international legislative enforcement and accountability mechanisms.

Ethical Issues

Governments face intrinsic tensions in their efforts to implement innovative policies to incentivize the production and consumption of healthy foods (Thow and McGrady 2014). At the same time, food and beverage companies see marketing and advertising, product placements, pricing policies, and packaging as a response to consumer demand. This view puts the responsibility solely on the consumer to make the "right" choice. However, the present balance of power is highly in favor of multinational food and beverage corporations, and greater efforts must be made to create healthier food environments for consumers (Baker and Friel 2014; Malik et al. 2013; Monteiro et al. 2013; Monteiro and Cannon 2012).

Governments can use fiscal instruments, such as taxes on SSBs and unhealthy junk foods, and regulatory mechanisms, such as bans on marketing to children, to support healthier diets and hold the food industry accountable. However, that is often met with calls of "nanny state" influence. Social movements and civil society organizations (CSOs) can act to rebalance the power across the food system in the public interest. According to Swinburn et al. (2015), "power and accountability structures need to be aligned in such a way that governments and civil society, acting on behalf of public interest, outweigh the interests of the private sector" (Swinburn et al. 2015).

Conclusion

This chapter presents the potential and defined ethical issues that encompass the food and beverages that the world's population consumes from the global food system. In many cases, there are no right or wrong answers; however, each issue is enveloped by moral decisions that must be made and often create conflicting views on how to move forward for a food secure and just world. Without more thoughtful debate about the ways forward on the ethics of food security and nutrition and how it fits into our globalized food system, inequities will remain. It is our hope that this chapter outlines some of these issues and stimulates productive discussions and potential solutions for the future.

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Vegetarian Eating

53

Josh Milburn

Contents

Abstract

The philosophical literature may seem to be replete with arguments for vegetarianism based on harm to animals. However, these arguments turn out to be arguments for veganism, not vegetarianism. This chapter explores whether anything can be said for vegetarianism. Some reasons motivating vegetarianism seem to be very personal, and so not the sorts of things that could be the foundation of a moral argument. Meanwhile, though they may hold some weight, arguments about vegetarianism as a "middle way" between veganism and omnivorism are highly contingent. Both of these routes, then, may seem unsatisfying to the vegetarian. Could there be a principled case for vegetarianism? Tzachi Zamir is the one philosopher who has argued at length for vegetarianism over veganism, but a close examination of his arguments show that they are not as compelling as they first seem. A final option remains open: there may be potential for arguments critiquing the eating of animals' flesh and/or their bodies that are independent of concerns about harms to animals in food production. Such arguments, which have

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been hinted at in animal ethics, offer a critique of meat consumption, but not, necessarily, of egg and dairy consumption. Perhaps, then, they could form the basis of a principled case for vegetarianism that does not immediately become a case for veganism. The consequences of such an argument, if one can be made, are not simple.

Introduction: Thinking About Vegetarianism

It is difficult to find, or come up with, arguments for vegetarianism. To anyone familiar with the academic literature on the ethics of eating meat, or anyone who has ever offered sincere thought to the issue, this might sound like a silly claim. Is the philosophical literature not replete with arguments for vegetarianism? Are there not arguments for vegetarianism in the work of some of the most prominent ethicists of the twentieth and twenty-first centuries? Are the reasons in favor of vegetarianism not obvious to anyone who has read about the suffering of animals in agriculture and the environmental impact of the meat industry?

In order to answer these questions, vegetarianism needs to be distinguished from a range of other diets. Vegetarians are people who do not eat meat. For our purposes, "meat" includes the flesh or body of any animal, including fish and invertebrates. Less restrictive diets include what is often called *omnivorism*, which is a diet including a more or less "normal" amount of meat. Using *omnivorism* in this sense is problematic: strictly speaking, all humans are omnivores. Omnivory is a matter of biology, not of practice, culture, attitude, or ethics. Nonetheless, this common convention will be followed. Precisely how much meat an omnivorous diet contains will depend on the social, economic, and cultural context. Vegetarianism must also be distinguished from various kinds of demi-vegetarian diets, including pescetarianism (like vegetarianism, but including the meat of fish) and reducetarianism (which involves a conscious attempt to reduce, but not necessarily eliminate, meat – and perhaps other animal products – in one's diet). Crucially, however, it must also be distinguished from *more* restrictive diets, including veganism. Vegans avoid *all* animal products in their diets (and likely more broadly) – not just meat. And what we find when we consider prominent and mainstream arguments for vegetarianism is that they are really arguments for veganism.

Can anything be said for vegetarianism, rather than veganism? Specifically, are there any arguments that should convince individuals to be vegetarian, but not vegan? Exploring that question is the purpose of this chapter. Thus, the chapter will not review standard arguments for and against the consumption of animal products. For recent and in-depth reviews of these questions, readers are invited to consult Abbate 2020, Doggett 2018, Fischer 2018, Katz and McPherson 2019 [present volume], and McPherson 2018. Instead, this chapter will explore arguments for vegetarianism in contrast to omnivorous diets, but also – perhaps more importantly – in contrast to vegan diets.

In the second section, the chapter will indicate how classic cases for vegetarianism are actually cases for veganism. It will then move on to explore, in the third section, some relatively straightforward reasons that people may favor vegetarianism over veganism that do not really draw upon moral reasons at all. In the fourth section, the chapter will ask whether one could defend vegetarianism as being enough for one to do one's duty and critique veganism as being overly demanding. We will see, though, that any argument for vegetarianism on these grounds faces some tricky problems. While these problems may not be insurmountable, they do mean that the argument holds only very contingently. In the fifth section, the chapter will turn to the arguments of Tzachi Zamir, the only writer in the philosophical literature to argue at length for vegetarianism over veganism. His case relies on a vision of a vegetarian utopia contrasted with a vision of a vegan utopia and a claim about effective campaigning on behalf of animals. Nonetheless, we will see that there are serious problems with his arguments. In the final substantial section, the chapter will explore whether there may be something about the eating of animals' bodies or their flesh that makes meat-eating, in contrast to eating eggs and dairy products, a particular wrong. If there is, that could ground a case for vegetarianism without also grounding a case for veganism in principle and perhaps – crucially – in practice. A short conclusion follows.

Arguing for Veg(etari)anism

There are plenty of cases for vegetarianism in the academic literature, but, on closer inspection, they turn out to be cases for veganism. By way of example, let us look to the arguments for vegetarianism that revolve around harm to animals. Other kinds of arguments – including environmental arguments – will be explored later.

Let us take Robert Nozick's case for vegetarianism. This appears in *Anarchy, State, and Utopia*, which is one of the most-read works of the twentieth-century political philosophy. He begins by asserting – reasonably, we might think – that "[a]nimals count for something" (1974, p. 35). "Suppose," he says, "that *eating* animals is not necessary for *health* and is not less expensive than alternative equally healthy diets." Thus, the advantage of "eating animals is the pleasures of the palate, gustatory delights, varied tastes" (1974, pp. 35–36, emphasis Nozick's). The question is whether "they [that is, the pleasures], or rather . . . the marginal addition in them gained by eating animals rather than only nonanimals, *outweigh* the moral weight to be given to animals' lives and pain" (1974, pp. 36–37, emphasis Nozick's). The death of these animals, Nozick says, is surely *incidental* to the pleasure gained by eating them – but that does not prove that the eating is permissible:

> Suppose then that I enjoy swinging a baseball bat. It happens that in front of the only place to swing it stands a cow. Swinging the bat unfortunately would involve smashing the cow's head. But I wouldn't get fun from doing *that*; the pleasure comes from exercising my muscles, swinging well, and so on. It's unfortunate that as a side effect (not a means) of my doing this, the animal's skull gets smashed. To be sure, I could forego swinging the bat, and instead bend down and touch my toes or do some other exercise. But this wouldn't be as enjoyable as swinging the bat; I won't get as much fun, pleasure, or delight out of it. So the question is: would it be all right for me to swing the bat in order for me to get the *extra* pleasure of swinging it as compared to the best available alternative activity that does not involve harming the animal? (1974, p. 37, emphasis Nozick's)

Nozick can see no way to justify the eating of meat that does not also justify the swinging of bats in the above case. It could be that an omnivore could accept this – eating meat *and* swinging bats are acceptable. Nozick doesn't say this explicitly, but he presumably holds that such a judgment flies in the face of the intuitive notion that animals count for something, or at least the unstated additional assumption that this "something" is non-negligible (cf. Milburn 2017, 2018b). Instead, in Nozick's view, "the extra benefits Americans today can gain from eating animals do *not* justify doing it. So we shouldn't" (1974, p. 38, emphasis Nozick's).

In this argument, Nozick talks about meat and, in other places, speaks of his vegetarianism. But it should be clear that the argument actually works far better as a case for veganism than as a case for vegetarianism (Milburn 2017, fn. 2). Eggs and milk are not necessary for human health, and alternatives are accessible to many in the West. The farming of eggs and milk involves the infliction of a great deal of death: male chicks are killed shortly after birth, while male calves are killed as unnecessary or are raised for meat (and thus killed). Meanwhile, both hens and cows are killed at a fraction of their lifespan as their productivity drops. These practices – and many others common in the industries – lead to a great deal of suffering. Such practices are required if we want to have access to eggs and milk at prices anywhere near as cheap as those currently commonplace. So, exactly the same argument that Nozick offers for vegetarianism can be run for veganism. Indeed, Nozick's arguments resemble those of Anna Charlton and Gary Francione (2016), though the latter explicitly focus on veganism, rather than vegetarianism. Charlton and Francione paint a picture of a man named Fred, who keeps animals in his home in pain and then kills them, simply because doing so offers him pleasure. But we recognize that this is not a good reason for him to torture and kill these animals. When it comes to eating animals, "we are all Fred" (2016, p. 296). As such, unless we wish to jettison our view that animals – to parrot Nozick – count for something, we should be vegans. (Here, Charlton and Francione are offering their "common-sense" case for veganism, and not defending their "abolitionist" position.)

Nozick's case for vegetarianism thus sounds more like a case for veganism. The same sort of observation can be made about the respective cases for vegetarianism of Peter Singer (1980) and Tom Regan (1975), the twentieth century's foremost animal ethicists. The precise details of these arguments need not concern us, in part because they are not dissimilar to Nozick's, but especially as – perhaps with a few caveats – neither Regan nor Singer would have too much trouble admitting that they were ultimately talking about veganism. The word *veganism*, it is perhaps worth noting, was little used in the USA in the 1970s.

A final example is offered by the arguments of Carol Adams (1990), whose *The Sexual Politics of Meat* offers, according to its subtitle, "a feminist-vegetarian critical theory." In the book, Adams links the eating of meat to sexism, tying together the treatment of animals in a meat-eating culture and the treatment of women in a patriarchal culture. However, this link holds no less with milk and eggs than it does with meat. Indeed, eggs and milk are the key examples of "feminized protein" – the production of protein from plants via the female reproductive system. Thus, Adams's critique of patriarchal eating practices is far from complete when addressing only meat-eating; there is room for feminist critiques of dairy and eggs to be *at least* as fervent as feminist critiques of meat. Adams now describes her position as "feminist-vegan" (2010) and has written that though *The Sexual Politics of Meat* "was subtitled *A Feminist-Vegetarian Critical Theory*, in terms of [her] understanding of feminized protein, and its use and abuse of female bodies, it could have been *A Feminist-Vegan Critical Theory*" (2017, p. 23).

Let us take this as indicative: though the philosophical literature is *ostensibly* replete with arguments for vegetarianism, these are actually arguments for *veganism*. This is due to the very real existence of death, suffering, and exploitation in the egg and dairy industries.

Personal Motivations for Vegetarianism

We may think that all of this is by the by and that – philosophers' arguments for vegetarianism aside – we can easily come up with reasons to be vegetarian that are not reasons to be vegan. One set of arguments will drop the focus on the death and suffering of animals as the motivating concern for vegetarians and look to other factors. Many of these reasons – however important they are for individual vegetarians – should not be taken to be particular good reasons *for other people*. They are thus not, no matter how good or bad, the right *kind* of "reasons" for vegetarianism. Ethicists are concerned with *all* reasons for action, but they are *most* interested in reasons for action that do not depend on idiosyncratic beliefs. The "ethical" perspective taken by this chapter seeks reasons for vegetarianism that are not unique to a particular person, culture, or people. Instead, it seeks reasons that should be applicable *generally*. This does not mean that they will not rest upon potentially controversial claims about science or ethics – but these claims may be ones that *should* be generally accepted, whether or not they *are* generally accepted. The reasons explored in this section are not like this. They are personal, or rest upon beliefs that are not the *kind* of beliefs that an ethicist would typically call on all people to hold.

One reason for vegetarianism could be health. Some vegetarians may hold that vegetarianism has health advantages over omnivorism *and* veganism. Equally, of course, many vegans hold that their diet has advantages over vegetarianism and omnivorism, and plenty of omnivores hold that their diet has advantages over veganism and vegetarianism. Were it the case that these vegetarians were unambiguously correct, this might – along with some claims about the ethics of healthy eating – form the basis of a moral argument for vegetarianism. There is, however, likely some truth to the claims of the vegetarians, the vegans, and the omnivores (especially when atypical dietary needs are considered). The healthfulness of a diet is not a simple matter. Well-planned, balanced vegan, vegetarian, *and* omnivorous diets can all be healthful, though – crucially – all can carry risks that are not associated with the others. For example, while iron deficiencies can be associated with both vegetarian and vegan diets, these diets are also associated with lower risks of heart disease (Melina et al. 2016). So, while some vegetarians may be motivated by health, it remains to be seen that this argument should convince others – there is no evidence of a consensus among dietitians about the all-things-considered "best" diet for health, and different kinds of health concerns are going to pull particular people in different directions.

Some vegetarians might be motivated by religious concerns. So, for example, many Jains, Buddhists, Rastafari, Sikhs, Seventh-day Adventists, and Hindus follow vegetarian diets. There are also minority vegetarian traditions in other faiths, including Christianity and Judaism, as well as individual believers of a range of faiths (and none) who see religious or spiritual significance to their vegetarianism. Other religious practices may blur the lines between veganism, vegetarianism, and omnivorism. For example, Hindu vegetarians will frequently abstain from eggs as well as meat, while restrictions on particular meats are typical among even omnivorous Jews and Muslims. Naturally, if someone holds that their religious doctrine (or personal spiritual development) demands, encourages, or endorses vegetarianism but does not demand, encourage, or endorse veganism, that will be a very good reason for them to be vegetarian, but not vegan. It is true that veganism is less typical as a religious practice – though certainly not uncommon of among many of the broadly vegetarian groups, including Jains, Rastafari, and Seventh-day Adventists. Meanwhile, members of some new religious movements – such as the followers of "Supreme Master" Ching Hai – are overwhelmingly vegan. Reasons for being vegetarian that are grounded in religious beliefs are not transferable to people who do not share these religious beliefs. Nonetheless, healthy *internal* debates in particular religions' ethical discourses on veganism and vegetarianism should not be overlooked by scholars interested in the ethics of eating meat (see, e.g., Linzey and Linzey 2018) – they should not, however, be taken to be universalizable in the way that arguments from philosophical ethics can be.

Similarly, some vegetarians might stick to their vegetarianism, even in the face of a vegan alternative, because vegetarianism is part of their cultural inheritance in a way that veganism is not. So, for example, someone who was raised as a vegetarian may not have any attachment to the goal of reducing harm to animals. Vegetarianism need not even be something that they have particularly thought about. There is nothing fundamentally irrational about this. Again, though, we should not take a given person's cultural practices to be normatively significant for the rest of us – beyond, potentially, as something to be respected, within reason.

We can note a final reason for being vegetarian that can be quickly dispensed with as entirely personal: some vegetarians may have an aesthetic objection to meat, but not to eggs and dairy – they do not like meat's taste, texture, or similar. Thus, these people have a perfectly good reason to be vegetarian but not vegan. However, unless this aesthetic reason is tied to something deeper, there is no reason to think that their vegetarianism is something that anyone else should take up.

These, to repeat, are not the kinds of reasons that should serve to convince others. Perhaps they could become the right kind of reason. For example, if there really was a God commanding us to be vegetarian rather than vegan, that could be normatively significant. But, short of proving that there is such a God, the religious vegetarian should not expect to convince skeptics. What is more, the person who is vegetarian for one of these reasons should be ready to acknowledge that there may be ethical reasons that override their more personal reasons. For example, while someone belonging to a culture that has a given practice has a good reason to engage in that practice, they should be ready to admit that, if the practice is unethical or unjust, their cultural practice should give way to good moral sense.

Vegetarianism as a Middle Way

Are there any arguments for vegetarianism (and not veganism) that are not deeply personal? Surely some arguments – in everyday dialogue, if not the philosophical literature – will point toward vegetarianism's status as a "middle ground" between veganism and omnivorism. So, we could *acknowledge* the positive arguments for veganism related to the moral status of animals, or the environmental damage associated with animal agriculture, but nonetheless hold that we are doing "enough" if we switch from omnivorism to vegetarianism and argue that an imperative to switch to veganism is too demanding.

This kind of argument is vulnerable to at least two kinds of counters. The first observes that vegetarianism need *not* be thought of as a suitable compromise position between omnivorism and veganism, insofar as meat need not be more harmful (in environmental, animal-welfare, or all-things-considered terms) than eggs and milk. Mark Budolfson (2015, 2018) is one philosopher who has collated empirical evidence to support this claim by calculating "harm footprints" of different foods. Much of this supports the claims of the vegetarian motivated by environmental concerns. Take Budolfson's figures related to beef production. He suggests greenhouse gas emissions of 102 kg CO2eq (i.e., the release of greenhouse gases doing the equivalent damage of 102 kg of carbon dioxide) per kg of protein produced and 93 kg CO2eq per 10,000 kcal produced. Cabbage, on the other hand, sees 25 kg CO2eq per kg of protein and 13 kg CO2eq per 10,000 kcal. When it comes to water usage, beef requires 75,969 liters to produce 1 kg of protein and 60,645 liters to produce 10,000 kcal of energy. Cabbage requires 21,875 liters and 11,200 liters, respectively. Cabbage significantly wins out. As the vegetarian might expect, milk ranks somewhere in the middle, producing 60 kg CO2eq per kg of protein (which needs 25,270 liters of water) and 31 kg CO2eq per 10,000 kcal (needing 13,049 liters of water).

The trouble is that once we start adding in *other* possible products, the omnivore < vegetarian < vegan picture starts to fall apart. One particularly disruptive example is mussels, which produce a mere 6 kg CO2eq per kg of protein and 8 kg CO2eq per 10,000 kcal. (Budolfson provides no data on how much fresh water they require, but, given that they are farmed hanging in the sea, one imagines very little.) If the vegetarian is motivated by finding a "middle ground" between omnivorism and veganism, it is not obvious that they should be dropping mussels rather than milk. (It is worth acknowledging, incidentally, that Budolfson's picture also troubles the vegan argument.)

What if the motivation for vegetarians is not environmental but animal-focused? The simple fact is that – counterintuitively or not – it is not clear that there is less harm in the farming of eggs and milk than there is in the farming of meat.

Consider, by way of example, milk farming. Karin Kolbe (2018, pp. 472–474) identifies four key areas of suffering resulting from just one practice in the dairy industry: the separation of cow and calf. This is something practiced even on organic, high-welfare farms. It leads, Kolbe argues, to deprivation to the mother, who would prefer to be with the calf; deprivation to the calf, leading to health problems; welfare problems associated with the *other* farms to which the calves are sent; and the slaughter of calves at a very young age. Kolbe also offers detailed statistics for the number of calories of milk produced per death of a male calf – neither deaths of female calves nor the cows themselves are included in this. Within the European Union, this varies from 473,668 per male calf in Slovenia to 1,175,992 per male calf in Denmark, but the average is 804,712 per male calf. While this is greater than the calories produced by killing smaller cattle bred for beef – a female highland cow (the smaller sex of a small breed) provides some 500,000 calories – even the highly efficient milk production in Denmark cannot compare to meat production in terms of calories per death when it comes to larger breeds of cattle raised for beef. A male Charolais produces some 1,750,000 calories of meat, while a Blonde d'Aquitaine bull produces 1,625,000 (Kolbe 2018, pp. 474–476). Kolbe thus concludes that the production of dairy is a greater ethical problem than the production of beef: "suffering of animals and death per calories created are higher in dairy farming than in meat production" (2018, p. 469).

Perhaps something similar is true of eggs. Chickens are very small, and though they lay lots of eggs in their lifetimes, they are unable to produce anywhere near the amount of food through laying eggs as a cow can through being slaughtered. Thus, a lot of chickens living short lives full of suffering and then being killed when their productivity drops might seem to be a greater ethical problem than a single cow being killed – even if she, too, has led a life of suffering followed by an early death. More animals means more suffering and more death. This leads Nick Cooney (2014, pp. 3–9) to argue that it is much more important for those concerned with reducing animal death and suffering to eliminate eggs than eliminate beef. Consuming eggs leads to more animal deaths a year (2 chickens per omnivorous American versus 1/8 a beef cow per omnivorous American), more days of animal suffering a year (a year per omnivorous American for egg-laying hens, 23 days per omnivorous American for beef cows), and indeed – Cooney argues – more *intense* suffering.

Finally, we can add that mussels once again create a puzzle – at least if Budolfson's assessment of them is right:

> . . .mussels have essentially no animal harm footprint at all – partly because mussels are not conscious and so harvesting them does not involve animal harm that has any important weight, and partly because the land and water footprint of mussels is very small[.] (2018, p. 91)

The point of these quantitative explorations of harm is the following: if vegetarians are genuinely interested in identifying a "middle ground" between veganism and omnivorism, it is not clear that vegetarianism (as we understand the term) is it. Now, perhaps we can quibble with the numbers or assumptions of Kolbe, Cooney, or Budolfson. Regardless, vegetarians must do some careful arguing to show that their position *is* a suitable middle ground. We should not jump to any conclusions about (particular) meats being so much worse than milk and/or eggs.

But this leads us to the second worry. Even if vegetarians *can* justify vegetarianism as a suitable "middle-ground" approach between veganism and omnivorism, they will need to justify favoring the "middle ground" rather than the "extreme" – i.e., if these vegetarians acknowledge worries about harms to animals or the environment, why be vegetarian rather than vegan? Two possibilities present themselves. One will be that adopting the vegetarian position is more likely to be effective as a political matter. This is something that will be touched upon in the next section. The second is that veganism is too demanding – i.e., that it calls for a high level of change in our lives, one that is disproportionate to the harm it aims to prevent (or speak against).

No doubt it is sometimes true that switching to a vegan diet is difficult and, for individual vegetarians, that will explain their decision not to go "all the way." The (putative) relative difficulty of following a vegan diet, of course, is highly contingent (and the same is true when it comes to political expediency). It is going to be far easier to follow a vegan diet in some places than in others, and – in much of the Western world, at least – it is quickly becoming far *easier* to follow a vegan diet than it was. And, of course, vegans may challenge the moral relevance of this difficulty. Even relatively difficult changes – they might say – are required to combat the horrors of animal agriculture and/or climate change.

There is, however, an important contextual argument that is open to the vegetarian in response to these vegan challenges. This is that vegetarianism is an established, recognized dietary identity in a way that other "demi-vegan" diets simply are not. Thus, the vegetarian could say, *given that* (in a given context) veganism is difficult for them and *given that* (in the context in question) vegetarianism is a recognized identity in a way that other possible dietary identities are not, vegetarianism is the appropriate diet for them. This recognition of vegetarianism – where it exists – is significant for three interrelated reasons.

First, it simply makes things practically easy for the individual in question: to put it in blunt terms, they can ask for the vegetarian menu in restaurants and look out for "suitable for vegetarians" messages on food packaging. But there is another side to this: there is a clear, bright line for the individuals to follow. They can tell relatively easily whether something is "suitable" for them – if it contains dead animals, it is not. If it does not contain dead animals, it is fine. This can help deal with the kinds of biases that, as individuals, we face. Clear and precise rules are easy to follow; vegetarians are less likely to waver in their commitments than people following more complicated diets for ethical reasons (see Rothgerber 2015).

Second, in belonging to a movement – the vegetarian movement – the individual vegetarian is more likely to be practically (including politically) efficacious than if they chose to follow their own idiosyncratic diet. This is true even if their own idiosyncratic diet would be, *were it adopted by all vegetarians*, more efficacious than vegetarianism. This efficacy is not limited to the point about the numbers involved. It relates to its communicability: the vegetarian cares about animals, so she does not eat them. On the other hand, the adherent of an unnamed demi-vegan diet cares about animals, so she does not eat some animal products and some plant products (or perhaps does not eat some products produced in certain specified ways). It is not hard to see whose message is easier to transmit – not only is the vegetarian's message simpler, but it can be transmitted in a single, familiar word.

Third, vegetarianism is already recognized as a less extreme form of veganism – what is more, vegetarianism is likely far *more* recognizable than is veganism. Thus, whether or not the vegetarian is right to think that vegetarianism is *really* a good middle ground between veganism and omnivorism, they will be *perceived* as treading that middle ground, and that may be what matters, *if* their vegetarianism is intended – in part or in whole – as a symbolic sociopolitical statement.

We seem to have reached a good argument for vegetarianism, and *not* veganism. This argument, however, depends on contingent, wholly changeable (putative) facts – facts, indeed, that will vary geographically and historically. These concern veganism's relative inaccessibility, vegetarianism's relative accessibility, the relative familiarity of vegetarianism, and the relative unfamiliarity of other possible "part-way to vegan" diets. Though this kind of argument has some potential, the vegetarian may want a less contingent argument for their position. For that, we will have to look elsewhere.

Zamir's Case for Vegetarianism

The only philosopher to argue at length for vegetarianism in contrast to both omnivorism and veganism is Tzachi Zamir (2004, 2007). Zamir argues that a vegetarian utopia is a more compelling vision – for both humans and animals – than a vegan utopia. The benefits to humans include, primarily, access to eggs and milk. The benefits to animals are assessed on three grounds:

1) Quantitative. More animals will exist in a vegetarian world than a vegan world. Now, this speaks in favor of a meat-eating world over a vegetarian world. This leads to…
2) Qualitative. Many animals in the contemporary meat industry do not have lives worth living. This, however, is a contingent point. Why could we not have a meat-eating world in which animals lived happy lives? After all, Zamir's vegetarian world would be one much kinder to animals kept for eggs and milk – as he accepts, their lives are often very bad on contemporary farms – so why could he not propose a world much kinder to animals kept for meat? This leads to…
3) Teleological. "[I]t may be the case," Zamir writes, "that a pleasant life should not be lived if it ends in a way that is immoral" (2004, p. 372). When we bring a being into the world with a plan – such as killing and eating them – we must ask whether such a plan "constitute[s] a misrecognition of what having a life means" (2004, p. 372). In what we might call a humane-farming utopia, where animals are bred for meat but are raised in humane ways, animals may live in a way that

"is better than not living: but it is not hard to imagine someone saying that such a life should not be lived" (2004, p. 373).

Zamir's conclusion is that a vegetarian utopia is able to benefit both animals (in quantitative terms) and humans relative to a vegan utopia, is able to avoid the qualitative harms replete in contemporary forms of industrial agriculture, and is able to avoid the teleological wrongs involved in farming for meat ("humanely" or otherwise). Thus, the vegetarian utopia is to be preferred both to the vegan utopia and the humane-farming utopia.

If Zamir's conclusion was simply one about how ethical and political systems fostering high levels of respect for animals could, in principle, support ultra-humane forms of egg and milk production, then he would find himself in good company. For example, many recent approaches theorizing ideal forms of human-animal relationships in political philosophy – despite being written by vegan animal-rights advocates – have left room for the consumption of eggs and dairy (see, e.g., Cochrane 2012, pp. 86–89; Donaldson and Kymlicka 2011, pp. 134–132; Wayne 2013). Admittedly, these philosophers and political theorists likely see much *less* room for the consumption of eggs and milk in an ideal state than does Zamir. But they seem to be clear examples of what Zamir calls "tentative vegans" (2004, p. 367) – people who accept that, in principle, the consumption of eggs and milk is permissible but who argue that, *currently*, given the harms perpetuated against animals in the milk and egg industries, we should be vegan. But Zamir wants to go a step further than these theorists and advocates for vegetarianism (and *not* veganism) in *practice*, and not merely in theory.

His argument for this is thoroughly pragmatic: "selective consumption, rather than a total ban, allows pro-animal people to financially support institutions that take steps in the right direction" (2004, p. 374). He proposes three criteria to judge whether supporting an institution (e.g., eating eggs from *this* farm) is commendable. These are worth examining at some length.

First, the step forward must be substantial; not just any improvement justifies support for a flawed institution. For example, though Zamir holds that the institution of child labor (like the institution of egg production) is not *inherently* unjust, one should not buy from factories using child labor just because they, unlike their competitors, offer the children a break and a cup of tea (2004, p. 375). If Zamir is right, though, there is presumably *some* level of improvement that would justify supporting such factories. Zamir holds that, despite the continued killing of unproductive females and practically all males, egg and milk farms that allow their animals to roam freely are making a large step forward, and so should be supported (2004, p. 375).

Tentative vegans may well want to dispute this. Francione and Charlton – who, it should be noted, would be *principled*, rather than *tentative*, vegans – say that "free-range" policies "are to animal ethics what padded water boards for use at Guantanamo Bay" would be to prison reform (2017, p. 300). There are two sides to this critique. One is that the steps taken by these institutions are not large. The other is that, *even if* they were, supporting steps "forward" might miss the point, insofar as the institutions remain fundamentally unjust. (To be clear, on Zamir's own framework, the killing of these unproductive animals is still a serious problem – he does not hold that the lack of freedom enjoyed by cows and chickens is the only, or even largest, injustice in the contemporary egg and milk industries.) To adapt Charlton and Francione's example, it would surely be a large step forward for an institution which tortured innocent prisoners to stop torturing them, but we might think that we should never be supporting institutions that imprison the innocent – whether or not they torture them. (Zamir could respond that imprisoning the innocent is always wrong, while egg farming is not always wrong. We will get to this shortly.)

Second, Zamir holds that a choice to support egg and milk producers should consider the effectiveness of the action. Veganism is typically harder than vegetarianism, meaning that many potential converts could be lost. Zamir holds that this means that veganism is counterproductive, but this is actually far from clear. To justify that claim, one would have to weigh the impact of a smaller number of vegans against a larger number of vegetarians, and, in any case, one would need to clearly tie the impact of these groups to a particular goal; what matters is not just short-term reform, but – Zamir's own words – "the overall political goal" (2004, p. 377). It is not simply a matter of judging how much impact one has over the next week, but a case of judging the extent to which the collective actions bring us closer to the ideal. Even if Zamir is right that veganism is counterproductive by (say) leading to greater harm to animals at the present time – and that is far from clear, as it is ultimately an empirical issue – it may be that it is more productive in the long run. The most effective route to the top of a mountain sometimes takes one downhill.

There are, Zamir thinks, limits to this strategic prudence. Zamir rejects demi-vegetarianism. Though prudential (i.e., though he takes it that demi-vegetarianism will attract more converts than vegetarianism or veganism), demi-vegetarianism, "like occasional molesting," involves "occasional participation in a morally wrong act and is hence unjustified" (2004, p. 376). He rejects the obvious vegan response that support for the egg and milk industry is wrong. He is uninterested in assessing the merit of competing descriptions of vegetarian consumption – e.g., of the merits of describing actions "as supporting reform [versus] as supporting fig-leaf exploitation" (2004, p. 376). He justifies his rejection of the obvious vegan response by again referring back to the value of cooperating with reforming (but imperfect) institutions (2004, p. 376). This is insufficient. This point does not differentiate cooperation with a reforming egg or milk industry and cooperating with a reforming meat industry, which is what he needs for his argument to hold. All three industries involve, by his own admission, great wrongs – so why is he committed to supporting two of the industries, but not the third? (Note that, in any case, differentiating between these industries may not be as easy as Zamir seems to assume.)

Zamir seems to differentiate between the meat industry (on one hand) and the egg and milk industries (on the other) by arguing that the meat industry is *inherently* unjust, while institutions of milk and egg farming are not. He opposes the consumption of meat on the grounds that it "complet[es] a temporally extended wrong" – that is, it completes the wrong started by the farmer, thus bringing together the ethics of consumption and the ethics of production – and that there is a "conceptually distinct wrong of participating in a wrong practice, even when one's consumption does not increase suffering" (2007, p. 48). (The importance of tying together consumption and production is that causal-impotence objections to ethical eating will contend that *this act of eating* has no impact on *that act of production* and thus that refusing to eat meat on a given occasion will have no impact on the animals harmed by the meat industry. This is discussed at length in the reviews of arguments about meat-eating cited in this chapter's introduction, so will receive no further examination here. [See also Nefsky 2018.]) In an unpleasantly evocative passage, Zamir compares the eating of meat, even when the act of consumption does not contribute to harm, to the use of a child prostitutes when "the pain or harm done to the children involved" will not be increased by the abuse, either because the prostituted child will not notice "one more indistinguishable client" or because the "client" can make the situation better for the victim – for example, by "tipping generously or behaving nicer than other clients would" (2007, p. 48). Zamir, however, refuses to extend the same analysis to the consumption of eggs and milk:

> . . .avoiding eggs and dairy because of the immoral production practices these rely on cannot be conceptualised in terms of avoiding the completion of or participation of a wrong in the same sense of the prostituted child or the killed animals example. Unlike eggs or milk, no reform to a child-prostitution establishment will justify participation. (2007, pp. 49–50)

The problem here is that child prostitution and meat-eating are not analogous in the way Zamir makes them out to be, even within his own framework. Thus, while Zamir has adequately distinguished child prostitution from eating eggs and milk, he – once again – has not adequately distinguished eating eggs and milk from eating meat.

Why are child prostitution and meat-eating not analogous in the relevant sense? Zamir actually repeatedly accepts that meat farming *could* be reformed to be consistent with his position: his "formulation of vegetarianism allows for eating and using animals that have not died from planned killing for the purpose of eating them" (2007, p. 49). Thus, crucially, his "position does not prescribe a ban on raising animals for the purpose of eating them after they die on their own" (2007, p. 49). Thus, while "no reform to a child-prostitution establishment will justify participation" (2007, p. 50), there *is* reform to a meat-producing institution that will justify participation. Consequently, the in-principle distinction between farming meat (on the one hand) and farming eggs and milk (on the other) dissolves. In both cases – *according to Zamir's own position* – the practices are real-world problematic while ideal-world plausible. He thus cannot appeal to ideal-world possibilities to permit the consumption of eggs and milk in the real world unless he is also willing to appeal to ideal-world possibilities to permit the consumption of meat in the real world.

Perhaps the distinction is found in the third of Zamir's criteria to identify farms worthy of support. He asks animal advocates to judge "the magnitude of the loss experienced by the exploited entity as part of obtaining a particular product" (2004, p. 377). Crucial here is the claim that chickens do mind having their eggs taken and cows do not mind having their milk taken. We can grant this (contentious) claim for the sake of argument, but its relevance for our actions here and now is questionable.

The loss to the unproductive chickens and cows, and to male calves and chicks, is absolute. They are killed. "[T]aking eggs and milk does not create suffering and loss," Zamir writes, and "[b]oycotting products, the taking of which does not create suffering, seems extreme" (2004, p. 378). If Zamir is arguing that contemporary egg and milk farming are free of suffering and loss, his claim is false. Calves are separated from their mothers, udders are afflicted with mastitis, and cows undergo the terror, injury, and deprivation associated with transport and slaughter whether they are given a degree of freedom or not. And the male calves and spent cows who are killed lose everything. (Similar could be said about egg farming.) And, what is more, Zamir holds that it is "excusable" to purchase eggs and milk from *less* humane farms if products from *more* humane farms "are implausibly difficult to obtain" (2004, p. 378). So even if more humane forms of farming *were* free from suffering and loss, Zamir would still excuse vegetarians who support those institutions that do cause suffering and loss. So it cannot be that the moral distinction between eggs and milk on the one hand and meat on the other is that the former's acquisition does not *in fact* result in a "high magnitude of . . . loss" (2004, p. 377).

The distinction instead seems to be that their acquisition does not *necessarily* result in a high magnitude of loss. I have already shown that Zamir cannot commit to this being the distinction, as he is open to an ideal-theoretic meat industry in which animals kept for meat are not killed. However, let us imagine that things were otherwise and thus concede that eggs and milk do not *necessarily* involve the infliction of a high magnitude of loss *even while meat does*. If one is designing ideal institutions, this *conceptual* fact is important. But if one is talking about our actions here and now – and let us recall that this is a condition that Zamir has introduced to talk about our "non-ideal" actions – it is surely the *practical* fact that matters. Compare: shooting is a hobby that need not entail a loss for anyone. A highly responsible shooter could engage in her hobby only at carefully managed clay-pigeon shoots. There is nothing *essentially* harmful about shooting. But that fact seems to have absolutely *no* bearing on the condemnation we would rightly direct at someone who shoots *people* for sport – and the condemnation that Zamir *does* direct at those who shoot *animals* for sport (2007, p. 11). Equally, that the harm in some harmful animal agriculture is not essential to the form of animal agriculture cannot justify or excuse those who support the harmful animal agriculture in question.

Tentative vegans are thus going to have a lot of concerns with Zamir's arguments for vegetarianism here and now, even if they are sympathetic to his claim that a vegetarian utopia is preferable to a vegan one. Zamir has a dilemma: given that he has failed to distinguish between the ethics of eating meat (on the one hand) and the ethics of eating eggs and milk (on the other), his argument leads him either to tentative veganism (i.e., veganism in practice, whatever the ideal-world diet) or conscientious omnivorism (i.e., omnivorism favoring putatively humane farms). Either way, his arguments do not lead to vegetarianism here and now.

It is worth closing our engagement with Zamir by questioning the "vegetarian" status of his utopia (2007, pp. 54–56; 104–106) – respectable though his vision may be, it just is not clear that it is really a "vegetarian" utopia at all. Now, it is, as he carefully argues, not a *vegan* utopia. But that does not make it a *vegetarian* utopia. We have already seen how Zamir is open to eating the bodies of animals who have died naturally and, indeed, of farming animals *so that* we might eat their bodies when they die naturally. Meanwhile – something Zamir does not address – technological advances have opened the door to the possibility of growing meat without killing any animals (see Donaldson and Carter 2016; Milburn 2016). Cells taken from animals can be grown in a laboratory environment into safe and edible meat, with commercialization not far away. There is no obvious reason that this "clean" meat would not be consistent with Zamir's position. Presumably, then, there are a wide range of ways that Zamir's "vegetarian" utopia is, ultimately, omnivorous. Not only, then, are there important worries about Zamir's vegetarianism in practice, but it is unclear whether he even advocates vegetarianism in theory. The vegetarian seeking a grounding for her position would be well advised to look elsewhere.

Alternative Cases for Vegetarianism: Consuming Flesh, Consuming Bodies

Perhaps a vegetarian seeking principled arguments should move away from appeals to the wrong of *producing* meat. She could look instead to the wrong of *consuming* meat or animals' bodies. I say meat *or* animals' bodies as these are two different arguments, and, in practice, they will pull in different directions – for example, those who take that it is wrong to eat *meat* may be troubled by clean meat or even highly realistic plant-based "meats," while those who object to eating animals' *bodies* may not be.

Arguments pushing in this direction are present but underdeveloped in animal ethics. As such, this section is best understood not as an argument in favor of vegetarianism but as an indication of how such an argument could be built.

Concerns about the eating of animal flesh – rather than with the suffering and death necessary to acquire it – appear in work criticizing clean meat and plant-based meat analogues. So, for example, John Miller (2012) and Matthew Cole and Karen Morgan (2013) critique clean meat for reinforcing a problematic vision of the place that meat has in Western cultures – though their arguments may not be unique to Western cultures – thus pointing toward an objection to eating meat *regardless* of the presence or absence of suffering and death. Such critiques are not unique to critical theory. Bob Fischer and Burkay Ozturk (2017) argue by analogy to imitation-human-skin lampshades that there is something morally dubious about consuming meat analogues. By extension, perhaps they could argue that there is something wrong with consuming "real" meat independently of any contribution to death and suffering of animals. And Susan Turner (2005) argues against the production/consumption of meat ("fake" or otherwise) regardless of the suffering and death involved, arguing that animals may have a right "not to be represented as a mere resource" (2005, pp. 4–5).

Crucially, for current purposes, these kinds of arguments are about meat specifically – they need not generalize to other animal products. They thus provide the seed of an argument for vegetarianism, but not veganism. For example, it is clear that Turner's argument does not extend straightforwardly to the use of eggs and milk, while it is an open question whether Fischer and Ozturk's does. Others exploring these questions have explicitly affirmed that their arguments against meat do *not* extend to milk and eggs. For example, Rebekah Sinclair (2016) – drawing upon Adams's vegetarian/vegan critical theory – challenges "meatless meats," rejecting the idea that meat is food, but does not extend her to challenge to products seeking to mimic milk and eggs. This is because milk and eggs "do not imply a necessary animal death" (2016, pp. 231–232). This claim is vulnerable to similar counters to Zamir's arguments, but the central insight – about the difference between meat on the one hand and other animal products on the other – is plausible. It makes sense to reject the idea that meat is food in a way that it does not to challenge the idea that, for example, milk is food:

> Milk exists solely as food; in this sense, it is different from flesh/meat, which exists first as the body of an animal. To deny that milk is food seems to suggest that infants, human and nonhuman, who drink their mothers' milk are consuming something that is not food. This seems to be straightforwardly incorrect. (Milburn 2018a, p. 272)

This passage is a response to a "metaphysical" challenge to the idea of milk as food. The same paper – though a contribution to the literature on animal rights – defends the status of milk as food against four other arguments: ethical, disgust-based, health-based, and racial (see Milburn 2018a, pp. 271–274). Where eggs fit in this kind of split is an interesting question – and one that anyone seeking to defend vegetarianism using this approach should address.

Let us turn to respectful treatment of animals' corpses. Chloë Taylor argues that "the dominant Western worldview is deontological with respect to dead humans and utilitarian with respect to dead animals of other species" (2013, p. 95). What this means is that (we assume that) we respect an animal when we use (especially eat) as much of their corpse as possible, while using (especially eating) a human's corpse is (seen as) the height of *dis*respect. Perhaps we can understand vegetarians as seeking to challenge this – and they can challenge it *independently* of concerns about the death and suffering of animals used in agriculture, thus providing a seed of an argument for vegetarianism, but not veganism. Sue Donaldson and Will Kymlicka are two theorists who challenge the disrespectful treatment of animals' bodies and who thus oppose the eating of (some) animals' bodies independently of any belief in the wrongness of killing animals or making them suffer. (To be clear, Donaldson and Kymlicka certainly *do* condemn the killing and hurting of animals.) They write that ideas of respectful corpse treatment

> are culturally (and religiously) variable, marking the boundaries of community. This could mean that while there are some ways in which we should never treat a corpse – human or animal, citizen or foreigner – there are special obligations we owe to members of the community. . . . Perhaps, then, we ought to treat the bodies of domesticated animals the same way as human bodies in any given society or community, but the same obligation does not apply for corpses of those from outside the community. (2011, p. 151)

This means that the bodies of domestic animals cannot be used to produce meat, but does not commit the authors to any claim about milk or eggs. This argument – as indicated by Donaldson and Kymlicka's talk of "members of the community" – is tied up in their particular "zoopolitical" theory. But similar arguments need not be.

Cora Diamond (1978) characterizes part of what it means to see someone as a person or, indeed, an animal as a "pet," as seeing them as "not something to eat" (1978, p. 469). Someone drawing upon this kind of approach could argue that appropriately seeing a being as an animal – as a "living creature, or fellow creature" (1978, p. 474) – and appropriately *relating* to that animal would involve refusing to recognize their body as a resource and as food. This is the direction in which Diamond moves when criticizing Singer for apparently being "perfectly happy to eat the unfortunate lamb that has just been hit by a car" (1978, p. 472). Diamond admits that it "does normally, or very often, go with the idea of a fellow creature, that we do eat them" (1978, p. 475), but this is exactly what the vegetarian seeks to challenge. For Diamond, this idea of a "fellow creature" offers a real possibility for an argument for vegetarianism, though she does not fully develop it:

> I introduced the notion of a fellow creature in answer to the question: How might I go about showing someone that he had reason not to eat animals? I do not think I have answered that so much as shown the direction in which I should look for an answer. (1978, p. 477)

Crucially, for our purposes, rejecting the idea that the "fellow creature" is an edible thing offers us the beginning of an argument for vegetarianism that does not quickly become an argument for veganism. That the fellow creature is not an edible thing does not preclude the fellow creature being a *source* of edible things.

Where do these half-arguments – arguments about the wrongs of eating flesh or eating corpses – leave us? Let us imagine that one or both can be expanded into a full argument for the wrongness of eating meat that says nothing about any wrong in eating eggs or dairy. On the one hand, such an argument could be wholly freestanding, in which case the vegetarian has a perfectly coherent argument for vegetarianism against both the omnivore and the vegan. But it would be a curious vegetarian indeed who was motivated not because of the suffering and death of animals but because of a relatively abstract concern with the wrong of eating animals' flesh or desecrating their corpses. More likely, this argument could be *combined* with an argument about the wrong of inflicting death and suffering on animals. It is a wrong/bad involved in killing or hurting animals to acquire food, and, *in addition*, there is a wrong in consuming meat/corpses, but *not* in eating eggs and milk.

Where does *this* position leave us? Let us draw upon the terms introduced by Zamir. This argument gives us a compelling vision of a vegetarian, rather than vegan, utopia. Depending precisely what is meant by "meat" or "corpses," our vegetarian utopia will certainly not permit Zamir's corpse farming, may or may not permit clean meat, and perhaps will not even permit plant-based "meats." But it *will* allow eggs and milk. As such, the vegetarian here and now would be justified in rejecting "principled veganism," leaving them with the options of tentative veganism, vegetarianism, and omnivorism. This new argument (remember that we are yet to develop this argument – we are assuming that it can be developed) gives the vegetarian a clear reason to reject omnivorism, even in more humane forms, as they hold that there is a wrong in eating meat.

They are thus left with vegetarianism and tentative veganism. Given that they object to death and suffering, they are presumably not going to want to support the egg and milk industry – though perhaps, to again echo Zamir, they may hold that supporting relatively humane egg and milk farming will help the industries transition toward more just forms. But they certainly are *not* going to object to, say, eggs from backyard chickens (see Fischer and Milburn 2017) or milk produced in particularly humane ways, whether this is from no-harm farming or technological means (see Milburn 2018a). So, the "tentative vegans" imagined might actually be – to coin a phrase – "particularly selective vegetarians" in many real-world cases. They will *not*, though, be "particularly selective omnivores." No matter how free from suffering and death meat production is, *these* vegetarians will likely reject it: roadkill (Bruckner 2015), and Zamir's corpse farming are out. Clean meat, meanwhile, *may* be out.

To summarize: If these arguments about the wrong of eating meat/corpses can be made to work, they offer us a freestanding argument for vegetarianism, but not veganism. It would be an *odd* argument, though, as it makes no reference to the death and suffering of animals. But if it is *combined* with more standard arguments, it can still give us an argument for vegetarianism, and not veganism. Granted, this argument would permit vegetarians only to support the most humane forms of acquiring eggs and milk (or, at a minimum, *relatively* humane forms of acquiring eggs and milk) – but it would provide something that, to date, has been lacking in the literature in animal ethics and food ethics: a consistent, principled argument for vegetarianism.

Concluding Remarks

It is very hard to argue for vegetarianism. Most arguments for vegetarianism, on closer inspection, are revealed to be arguments for veganism. This chapter has reviewed the one developed argument for vegetarianism in the philosophical literature and found it wanting. However, it has offered two other routes that one could take to argue for vegetarianism. One is thoroughly pragmatic and highly contingent. This would see vegetarians defend their position on the ground that vegetarianism is a good "halfway house" to veganism and veganism is too demanding. The other, however, is more principled. It argues that eating meat or utilizing the corpses of animals is wrong, independently of any wrong involved in supporting harm to animals. This can provide a principled (if bizarre) freestanding argument for vegetarianism but, if combined with more standard arguments about the wrong involved in harming (or supporting harm to) animals, could offer vegetarians a principled basis for supporting some limited forms of egg and milk production while wholeheartedly rejecting farming animals for meat.

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Veganism as a Food Ethic

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Corey Katz and Tristram McPherson

Contents

Abstract

In this chapter, we distinguish veganism from neighboring eating patterns and explain different ways of understanding a vegan ethic. We then consider several values at stake in eating and using animal products. Finally, we consider ways of using conclusions about value to assess animal agriculture, individuals' food choices, and social and political institutions.

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Introduction

Millions of people around the world are vegan. But what precisely is veganism? What can be said in favor of a vegan food ethic? And what are the implications of adopting such an ethic? This chapter takes up these questions.

The section "Veganism and Food Ethics Introduced" introduces the idea of veganism as a food ethic. It distinguishes veganism from neighboring views and explains different ways of understanding a vegan ethic. Few people just *find* themselves with a vegan ethic, in the way that you might find yourself angry, or having just binge-watched an entire season of a trashy TV show. Often, at least, people become vegan for what they take to be good *reasons*. In this chapter, we suggest a simple framework for reasoning about veganism. On this framework, we first identify (some of) what is *valuable* (the section "Values at Stake in Eating and Using Animal Products"). Then, we consider ways of using our conclusions about value to assess animal agriculture, individuals' food choices, and social and political institutions (the section "Putting Values to Work in Assessing Veganism"). Although we will occasionally argue for conclusions in this chapter, our main aim is not to argue for or against veganism. (For an argument in favor of veganism, see McPherson 2016.) Rather, it is to put the reader in a position to understand and critically evaluate the most important reasons that have been offered for embracing or rejecting a vegan ethic.

Veganism and Food Ethics Introduced

In this section, we aim to orient the reader to different ways of understanding what a vegan ethic might be. We begin by distinguishing the vegan pattern of eating from others. We then introduce the idea of an *ethic* and discuss different ways of understanding veganism as an ethic. Finally, we introduce the use of *reasoning* as a basis for adopting or retaining a vegan ethic. This section will prepare the reader for the following sections, which explore important kinds of reasoning that one might use to argue for or against veganism.

We can begin by provisionally understanding veganism as a pattern of eating which does not involve the consumption of products made *from* animals (such as meat), or *by* animals (such as milk, cheese, or eggs). It is useful to distinguish this vegan pattern from several other salient patterns. These include:

- The omnivore, who eats both plant and animal products
- The lessmeatarian, who limits but does not eliminate their eating of animal products (Discussed in Bittman 2007)
- The pescatarian, who eats seafood, but otherwise refrains from eating meat
- The ostrovegan, who eats plant products as well as some shellfish (Go Vegan Box n.d.)
- The vegetarian, who eats food made from plants, and food made by animals (such as milk), but not food made from animals

- The fruitarian, who only eats products made by plants, such as fruits, nuts or seeds, but not foods made from plants, or foods made from or by animals
- The freegan, who seeks to eat in a way that is less wasteful and "consumerist," and more environmentally friendly than alternative diets, for example, by focusing on recovering edible food that has been discarded by corporate restaurants or supermarkets (Freegan Info 2018)
- The locavore, who aims to eat locally produced food (Barnhill 2016)
- The person who refrains from eating gluten
- The person who seeks to eat only organically grown food

As should be clear from this list, the vegan pattern is *more restrictive* than some of these alternatives (such as the omnivore, vegetarian, and ostrovegan), less restrictive than others (the fruitarian), and distinct but compatible with others (the freegan, the locavore, etc.).

While the preceding provides a provisional understanding of veganism, it is not adequate as a characterization. For example, suppose that Abbas scrupulously avoids animal products, but that his rival sometimes sneaks some beef broth into his soup. It is plausible that Abbas counts as vegan despite sometimes eating animal products. By contrast, suppose that Bita would eat meat if she could, but finds herself on a desert island with only fruits and vegetables to eat. Even if Bita has a vegan diet, it is plausible that she is not vegan. Finally, suppose that Caz believes that it is wrong to eat animal products, but occasionally succumbs to cravings for cheese. We might call Caz a *weak-willed vegan*.

These examples show that veganism is best understood as a feature of a person's psychology, not merely his or her behavior. Specifically, veganism appears to be a kind of practical stance or commitment. Perhaps, to be a vegan is to embrace vegan eating as in some way *better* than less restrictive alternatives. We will call veganism understood in this way *a vegan ethic*.

So understood, there will be many variants of the vegan ethic. For example, one could think that consuming animal products is *wrong*. Or that vegan eating is *an ideal to aspire to* (Gruen and Jones 2015). Or, less intellectually, one could simply be *against* consuming animal products. Vegan ethics can also vary in whether they disfavor consuming animal products *given certain facts about how things are,* or more strongly, disfavor it *however things are*. An analogy may help to illustrate this contrast. There are two kinds of death-penalty abolitionists. Some think that in principle, killing could never be a just punishment. Others think that the death penalty could in principle be just, but that given facts about our actual institutions, it should be abolished.

Once we think of veganism as an ethic, it is easy to see that the *scope* of vegan concern can vary as well. Some vegan ethics focus narrowly on eating, but others do not. For example, many vegan ethics oppose *wearing* animal products, or using them for furniture, as much as eating such products. Some also take their vegan concerns to extend to questions of which policies and institutions to support, and what stance they should take towards nonvegan persons. For example, should they attempt to convince others to become vegan? Should they hold omnivores responsible for their wrongdoing? We return to the scope of vegan concern in the section "Vegan Ethics Beyond Consumption."

In what follows, we will largely be concerned to explore careful *reasoning* that can be used in order to evaluate vegan ethics. It is worth emphasizing that not everyone who accepts a vegan ethic does so on the basis of reasoned arguments. For example, someone might watch a video of factory farming and be motivated to adopt a vegan ethic as a direct response to their horror at the treatment of animals.

Some might even be suspicious of, or opposed to, the use of reasoned arguments to evaluate veganism. A vivid literary exemplar of this possibility is provided by the character of Elizabeth Costello, portrayed in J. M. Coetzee's novel *The Lives of Animals*. In her first lecture, Costello implores her audience to exercise their capacity for sympathy, not for reason (2001, p. 34). She refuses to offer ethical principles for her audience to consider, instead asking them to open their hearts to animals (2001, p. 37). Her lecture suggests that she distrusts the ability of reasoning – exemplified by the philosophers she discusses – to properly orient one to the ethical question at hand.

Costello's view deserves serious attention. Reasoning can and does sometimes lead us astray, and there is no guarantee that it is the most reliable means to orient our attitudes regarding nonhuman animals and veganism. For example, watching vivid videos may be more effective than reasoned argument as a way to move many people towards veganism. Despite this, we think that much can be learned from examining reasoning about vegan ethics. Consider three points.

First, reasoned arguments in favor of veganism can complement the exercise of sympathy. For example, it may make it more difficult to rationalize away one's sympathetic reactions. Second, reasoning can potentially be illuminating in ways that exercises of sympathy (for example) are not. When successful, reasoning can help us to understand *why* we ought to treat nonhuman animals in certain ways, whether we have sympathetic reactions to them or not. Third, reasoning can potentially be informative in ways that the bare exercise of sympathy is not. For example, suppose that one were extremely sympathetic to the plight of nonhuman animals. Should such sympathy lead one towards veganism, or instead to ostroveganism, ethical omnivorism, or another of the patterns of eating mentioned above? Plausibly, reasoning is needed at least to see what precisely a certain sympathetic reaction calls for.

In this chapter, we will focus on reasoned arguments concerning veganism. This is in part because of the significance of such reasoning, just mentioned. But it is also because our professional expertise is in reasoning about ethical questions, not in aptly eliciting emotional reactions in our audience.

We now want to say a little about the sorts of evidence that we will appeal to in reasoning about veganism. This evidence contrasts with the characteristic sorts of evidence deployed in other academic disciplines. For example, in many such disciplines, one paradigm of excellent evidence is the sort that can be summarized by a statistically significant result in a well-designed study.

Where such evidence bears on ethical questions, it is of course important. But many philosophers working in ethics doubt that such evidence can settle many ethical questions. For example, suppose that one established beyond controversy a set of facts about how animals in a given factory farm are treated: the shortness of their lives, the mutilations and illnesses they suffer, their inability to exercise those capacities characteristic of life for their species, etc. (Mason and Singer 1990). Arguably no collection of such information *entails* any ethical conclusion about their treatment. What is needed are further claims about the ethical significance of these facts. And it is not clear what sort of empirical study could establish such claims.

In light of this, philosophers working in ethics typically seek to reason starting from claims that have a different property: the property of being highly plausible on reflection. Moreover, conclusions that result from well-structured reasoning that begins from these highly plausible premises can itself inherit the plausibility of those premises. Very often such connections in reasoning are not immediately obvious. Because of this, careful thinking can sometimes reveal strong support for conclusions that might initially appear surprising or implausible.

There are many different ways to structure one's ethical reasoning. For simplicity, we organize the discussion that follows around the following structure: we first explore a series of *values* that are at play in the ethical evaluation of veganism (the section "Values at Stake in Eating and Using Animal Products"). We then put the values we have introduced to work, in evaluating animal agriculture and our relationships to it (the section "Putting Values to Work in Assessing Veganism"). Our aim is that at the end of this chapter, the reader should be in a good position to understand the most influential reasoned arguments available both in favor of, and against, various forms of ethical veganism.

Values at Stake in Eating and Using Animal Products

This section introduces a series of *values* – ways that things can be good or bad – that are relevant to the ethical assessment of veganism. We organize our discussion in four parts. First, we introduce the organizing idea of *ethical considerability* and the idea that nonhuman animals are ethically considerable. We then consider three values that may be significant given the ethical considerability of nonhuman animals: animal well-being, animal agency, and animal life. We then consider several relevant values that arise from the considerability of human users of animal products, including, pleasure, tradition, and health. Finally, we consider the evaluative significance of the environmental impacts of animal agriculture.

Ethical Considerability

Imagine you are sitting at your desk, feeling bored and aggressive. Here are two things you could do: you could walk over to a co-worker's desk and hit him. Or you could smash the treasured – yet hideous – vase that he keeps on his desk.

It is highly plausible on reflection that you have strong reasons to refrain from each of these actions. But there is a striking contrast between your co-worker and his vase. If you hit your co-worker, you will cause him pain, distress, and possibly physical damage. You might have prudential or legal reasons to refrain from doing so. But, importantly, these effects also appear to be ethically bad, in a way that directly gives you reasons to refrain from producing them.

By contrast, the fact that smashing the vase will also cause it physical damage and probably destroy it does not appear to give you a direct ethical reason to refrain from smashing it. Rather, your reason not to smash the vase arises from the effects this might have on your co-worker; namely, that it belongs to your co-worker, he treasures it and its loss would cause him pain and distress. Put another way, we might say that your co-worker has an *interest* in not being hit that counts against you hitting him. While the vase will also be damaged or destroyed if you smash it, it is not the sort of thing that can have interests. We will say that a being is *ethically considerable* if it has interests that can directly ground ethical reasons to treat it or not treat it in certain ways (Jaworska and Tannenbaum 2018).

A crucial question therefore is: are nonhuman animals ethically considerable? If they are not, then for ethical purposes, they are just things, and we should organize our thinking about them around human interests, much as we would with the vase. To answer this question, we need to think more deeply about what makes a being ethically considerable. Examining a commonly proposed answer to this question is instructive.

Consider the idea that what makes your co-worker ethically considerable is that he is a *human being*, while the vase is not. One thing that makes this idea plausible is that those who criticize practices that treat people differently based on their race, sex, etc., often do so by emphasizing the shared humanity of both those privileged and those burdened by such practices. Even so, if shared humanity were the sole basis for ethical considerability, this would bar any entity that is not a member of the human species from having any level of ethical considerability. This is a difficult position to maintain for at least two reasons.

First, the idea that some nonhuman animals are ethically considerable is highly plausible. For example, imagine finding a stray cat, and torturing her. The cat plausibly has an interest in your refraining from torturing her. And you plausibly have a strong reason to refrain from torturing her in light of that interest. More generally, many people think that cruelty to animals is ethically bad. Others, for example, also think that strict laws should regulate the treatment of animals in medical experimentation, requiring the use of anesthetics and humane forms of euthanasia if the animals must be killed. The most natural explanation for these plausible judgments is that at least some nonhuman animals are ethically considerable, and so ethical considerability cannot be based uniquely on being human.

Second, we might wonder why it is membership in a particular biological species that grounds an entity's ethical considerability. This is because species membership appears to be as arbitrary a ground for differences in ethical considerability as the differences in race, sex, etc., that have often been appealed to in order to claim that some human beings are not ethically considerable. Put another way, appeals to a shared humanity in order to reject the view that skin pigmentation or sexual characteristics make a difference to ethical considerability should not be understood as *literal* appeals to shared membership in the genetic species *Homo sapiens sapiens*. Rather, what appeals to a shared humanity emphasize is that no matter a person's race, sex, etc., that person has attributes that make him or her ethically considerable. Such attributes include the fact that he or she can have hopes and goals that can be thwarted, that he or she can suffer injury and pain, or that he or she can die. Indeed, part of ethical reflection is a search for guidelines that set out if and when it is appropriate to, among other things, thwart another's goals via imprisonment, or cause him or her pain, injury or death. It is the fact that a human being can undergo such things despite his or her race, sex, etc., that make it the case that such differences do not matter to his or her ethical considerability.

If an entity were ethically considerable in virtue of being human, no nonhuman animals would be ethically considerable. But shared humanity is not the basis for ethical considerability. A more credible account is that if an entity has the ability to have its goals thwarted, to suffer pain and injury, and to die, then it is *those facts* that make that entity ethically considerable. Your co-worker's vase lacks ethical considerability because it is made out of glass, and glass cannot have its goals thwarted, experience excruciating pain, and/or be killed. This is why the vase does not have interests. Yet, we know that many animals are capable of undergoing some or all of these things. Thus, while they are not human, many animals have interests and so are ethically considerable. This fact is key for many arguments for a vegan ethic. In the next section, we consider three candidate ethical values that could be argued to ground the ethical considerability of nonhuman animals.

Values Based in the Considerability of Nonhuman Animals

In this section, we consider the well-being, agency, and life of nonhuman animals as values.

Well-being

Popular use of the term "well-being" is often linked to health, for example, numerous governments and institutions have a "Department of Health and Wellness." The use of the term in ethics is broader (Crisp 2017). A being is well-off when it has a good quality of life, is thriving or flourishing. In a slogan, an entity has well-being when its life is going well *for it*. Contrast the vase. It can be in a good or bad state, for example, it can be whole or smashed. But it is not the type of thing that can be well-off or poorly-off; things cannot be going better or worse for it.

Something is good for a human being when it promotes his or her well-being. Bodily health may contribute to making someone's life go well for them, but it is not the only thing that can do so: think of a very healthy person who lacks friends, love, or education. On some philosophical views, well-being is wholly constituted by happiness or pleasure. On other views, lives can also be better or worse for reasons that are independent of happiness and pleasure: for example, perhaps accomplishment or friendship can just make a life better, independently of how much happiness or pleasure they provide.

Many animals, including the mammals and birds most often used in agriculture, can be well-off or poorly-off. First, these animals are sentient, which means they are capable of experiencing pleasure and pain. If experiencing constant excruciating pain makes a human being poorly-off, then it also makes a sentient animal poorly-off. Second, many of these animals are conscious beings capable of emotions. They do not simply react to stimuli but have some level of experiential life. They can experience, for example, fear, boredom, loss, and grief (Bekoff 2010). If living in fear or regularly experiencing loss and grief makes a human's life go poorly for him or her, then these things also make life go poorly for individual members of these species of animals. These features plausibly make it possible for nonhuman animal lives to go well or poorly for them, in a way that contrasts strikingly with the vase.

Well-being is an ethically important value. For example, it is very natural to think that we have strong reasons not to do things to others that are *bad for them*, by causing them ill-health, negative emotions, and pain and suffering (that is one reason why it would be wrong to hit your co-worker). Since many of the animals that are used for their products or for food can be well or poorly-off in similar ways, moreover, it would seem that their well-being is ethically significant.

Agency

Broadly construed, "agency" refers to the ability to initiate action in order to achieve desired goals. For a being capable of agency, exercising one's agency and achieving these desired goals has important value.

Consider an example of each of these dimensions of value. First, consider the use of imprisonment as punishment for serious crimes. Plausibly, one of the central ways in which imprisonment constitutes a punishment is that it radically restricts prisoners' ability to exercise their agency. They can only go outside when they are told, they can only eat what they are told and when they are told, and so on. This restriction of agency clearly has disvalue to those who experience it: this is what makes these restrictions punitive.

Second, imagine you have wanted to be a chef since you were young. You have spent years working as a line cook trying to move up and achieve your goal with no success. You experience extreme frustration and finally give up. Along with any negative emotions you might experience because of this, the frustration of your goals seems to be bad in itself.

Most human beings over a certain age are clearly capable of agency. But now think of a dog. A dog has likes and dislikes, desires, and hopes and has the ability to initiate action in order to achieve these goals. You change his food to a new kind and he refuses to eat for four days. He likes the old kind, wants it, and will do what he can in order to get it back. He also wants to go outside and stands at the door barking until you come and open it. In either case, there is value for him in getting what he wants, and disvalue for him in not getting what he wants, just as there is for the aspiring chef or the incarcerated inmate. If you kept the dog in a cage all day, every day, beyond the disvalue of the boredom and other negative emotions he would experience, it would have great disvalue for him because of the way doing so almost completely suppresses his capacity for exercising his agency.

Like dogs, moreover, most of the animals used in agriculture are capable of agency. This suggests that the restriction of their agency matters ethically: it is a bad outcome for ethically considerable beings. Some degree of control over animals is essential to animal agriculture. And in many actual cases – paradigmatically on "factory farms" – the restriction of animal agency is intense.

Life

That human life has value is manifest. But why is it bad for life to end? One central part of the answer to this question appeals precisely to the values just mentioned. One reason why it is more tragic for a young person to die than an elderly person is precisely that the young person would very often have a future full of well-being and the successful exercise of agency (Nagel 1979; Marquis 1989). And when a person's future promises only agony and frustration of their agency, it is not clear that death is a bad thing to happen to them.

Because the animals used in agriculture are alive and have the capacity for well-being and for agency, then they also have the capacity to have valuable futures. Thus, death also has disvalue for them. This line of thinking supports the judgment we sometimes make that continued life for animals is not in their interests, as we when make the difficult decision to euthanize a pet who is suffering from an agonizing and incurable disease. In such cases, we might judge that living its future life was a fate worse for the animal than death. Whether agricultural animal or pet, when an animal's future life will be full of well-being and valuable experiences, then life has value for the animal and death disvalue. Insofar as practices of animal agriculture engage in mass animal killing, then the disvalue of animal death matters for the evaluation of those practices.

So far, we have been emphasizing continuities between humans and nonhuman animals: in both cases, it is plausible that these entities are ethically considerable, and that their well-being, agency, and life are important values. It is worth emphasizing that this does not mean that it is *as bad* when a dog dies as it is when a person dies. Humans are plausibly capable of important sources of well-being and important types of agency that are not available to extant nonhuman animals. (Here, we leave aside the hard question of whether this is a matter of degree or a matter of kind.) Our aim here is not to argue for a crude equivalence. Rather, our primary point is *noncomparative*: many nonhuman animals are ethically considerable, in a way that makes their well-being, agency, and lives matter in our ethical assessment of our choices and institutions.

Values Based in the Considerability of Humans

In the previous section, we argued that the animals used in agriculture are ethically considerable, such that their pain, suffering, illness, injury, captivity, and death have a disvalue that is directly relevant for our ethical reflection. These considerations provide an ethical foundation for the arguments for veganism that we will consider in the section "Putting Values to Work in Assessing Veganism." However, animal agriculture does not only affect nonhuman animals; it also affects humans. In this section, we consider some of the central *anthropocentric* values that are relevant to assessing the ethical case for veganism.

Gustatory Pleasure

Eating is necessary for survival, yet unlike other things that are necessary for survival like breathing or sleeping, eating can provide us with complex aesthetic experiences and great joy (Trubek and Doggett 2014). For many people, the consumption of animal products plays a large role in these experiences. Given that humans are evolutionarily adapted to consume an omnivorous diet, it is unsurprising that we are generally disposed to take pleasure in the taste of animal products. Furthermore, a great deal of human culinary culture has been dedicated to crafting especially delicious foods out of animal products. At least for many people, foregoing these products would mean foregoing pleasurable experiences that contribute to their well-being.

Tradition

Animal products are linked with valuable traditions in at least two ways. First, the *cooking and eating* of particular animal products can take on symbolic value or play an important role in cultural traditions. In the United States, for example, the preparation and consumption of turkey has become linked over generations with the celebration of the holiday of Thanksgiving. For many, therefore, it has become linked with the value of tradition, memory, family, and so on. A Thanksgiving celebration without a turkey may therefore have less value or symbolic meaning for such people.

Second, the *production* of animal products can also become linked with valuable ways of life in particular cultures. For example, across the globe, traditional ways of life have developed around hunting, fishing, trapping, and herding. Giving up these practices to switch to the production of plant foods would potentially dramatically disrupt valuable traditional ways of working and living.

Health

A central value that bears on food ethics is the effect on one's health of following a certain food ethic. Here the implications for veganism vary. Some human communities are constrained by the environment in which they live such that the hunting or production of animal products is necessary for survival. Inuit peoples who live above the Arctic Circle, for example, do not have ready access to sufficient plant-based foods to survive on a vegan diet. Other human communities are constrained by economic and political structures, such that they could not meet their dietary needs without the consumption of animal products. For both groups, the production, hunting, and consumption of animal products clearly have very important value, in light of being indispensable for health.

In other human communities, however, the overabundance and ready access to animal products in one's diet may contribute to ill-health. For example, the overwhelming majority of North Americans have diets that are unhealthy in part because they involve eating too many calories and too much saturated fat, and too few vegetables and whole grains (Walker et al. 2005). Campbell and Campbell claim that nutritional evidence provides some support for completely eliminating animal products from one's diet (2005, p. 242). While one can be an unhealthy vegan, some choose a vegan diet because being vegan rules out many of the most problematic foods and helps promote the value of personal health.

Environmental Impacts

Animal agriculture has substantial environmental impacts. Here we focus on three examples.

First, large amounts of arable land and water are used to produce grain to feed to animals that could otherwise be used to produce plant-based food for human consumption. Animal agriculture thus puts pressure on increasingly scarce and vulnerable cropland and water resources.

Second, economic pressures on animal agriculture increasingly push toward industrialized farming practices. This has increased the amount of environmentally toxic byproducts generated by farming, which can in turn lead to environmental impacts to land and water resources. For example, concentrated housing of large number of animals can create a level of fecal matter and urine that exceeds the buffering capacity of local ecosystems, leading to nitrogen and phosphorus contamination of surrounding areas (Foley et al. 2011; Peralta et al. 2014).

Third, animal agriculture is a significant contributor of the greenhouse gases that cause global warming, which is arguably the most serious environmental threat to human well-being that we now face. Estimates of just how significant of a contributor it is, however, range wildly, from between a twentieth to a half of all anthropogenic greenhouse gas emissions (Goodland and Anhang 2009; Fairlie 2010, chap. 13; Food and Agriculture Organization of the United Nations 2014).

These impacts have disvalue both for humans and for nonhuman animals. Cropland scarcity, pollution, and climate change are all bad in part because they harm human beings. They are also very bad for many nonhuman animals. This is perhaps most dramatically illustrated by the horrifying acceleration of species extinction due to human activity (Pimm et al. 2014).

Putting Values to Work in Assessing Veganism

So far, we have explained what veganism is and distinguished it from neighboring stances. And we have introduced some of the prominent values relevant to veganism. In this section, we put these resources to work. In doing so it will be useful to identify and distinguish three distinct targets of evaluation:

- Practices of animal agriculture
- Individual practices of consumption
- Political institutions and action

We will discuss these three targets in turn. There are also important connections between how these targets are evaluated, as we will make clear as we proceed.

Evaluating Animal Agriculture

We begin by considering animal agriculture as a target of ethical evaluation. Arguably the central motivation for ethical veganism begins by pointing to the effects of contemporary industrial animal agriculture on the billions of animals that are its central commodities. These animals are made to suffer in myriad ways. Their agency and ability to pursue their desires is dramatically restricted. And they are killed long before their natural life spans (Rachels 2011). In the previous section, we introduced the idea that nonhuman animals are *ethically considerable:* that their pleasure, pain, life, and death matter ethically. Applying this idea strongly suggests that contemporary animal agriculture causes a massive quantity of bad to ethically considerable beings. Moreover, as we also claimed in the previous section, it is plausible to think there are strong reasons against causing these sorts of bads to ethically considerable beings, whether your co-workers or agricultural animals.

How might animal agriculture be defended against this simple argument? There are several possible strategies. We can divide those strategies into two broad groups: those that seek to defend animal agriculture in the aggregate and those that grant the general force of this sort of argument and seek to distinguish some animal agriculture as ethical.

The most direct way to resist the simple argument is to deny the evaluative premise that underlies it. But in light of the arguments in the previous section, it is hard to reasonably deny that nonhuman animals are ethically considerable.

It might be argued that animal agriculture in the aggregate is typically on-balance *good for* the relevant animals (Tannsjo 2017). After all, these animals would not exist but for the relevant agricultural practices. Thus, even if a chicken is confined to a tiny cage and made to suffer before being slaughtered for meat in a matter of weeks, it might be claimed that its life was better than not existing.

There are two difficulties with this sort of argument. First, it might reasonably be denied that the life of such a chicken is really worth living on balance: some lives are surely *so bad* for the beings living them that we rightly regret the existence of those beings. And the short, miserable life of a factory-farmed chicken seems like a good candidate here. Second, it might be that even if some animals would have on-balance good lives, there are ethical reasons against bringing them into existence if one will then substantially harm them.

One might instead seek to defend animal agriculture by appeal to the valuable interests of the humans with a stake in such agriculture: the owners, workers, and consumers who benefit from this agriculture. For owners and workers, the primary benefits will be economic. In the previous section, we also mentioned several ways that producing and consuming animal products might be valuable for humans, including providing gustatory pleasure and allowing humans to participate in valuable cultural traditions.

This sort of defense also faces difficulties on at least three fronts. First, these benefits arise from an activity that also causes harm to ethically considerable beings. It is highly plausible on reflection that these harms undermine the ethical justification for the activity. For example, in cases of slavery, child labor, or economic exploitation, even large benefits to the exploiters do not justify the treatment of the exploited.

Second, some might argue that the amount of pleasure and happiness human beings derive from producing and consuming animal products is so great that it far outweighs the harm done to nonhuman animals. Yet, it is worth emphasizing that many pleasures are intuitively *substitutable*. Consider an example. A delicious pear tastes different from a delicious peach. But it is not clear that someone who is deprived of delicious pears is deprived of pleasure in an ethically relevant sense, if they have ready access to the different but roughly equivalent pleasures of eating delicious peaches. With this in mind, many people have access to many delicious vegan foods. Even if one values a wide-range of enjoyable gustatory experiences, it is likely possible to surround oneself with a dizzying variety of delicious vegan foods, such that one need never be bored at the table. Thus, most humans could gain substantial gustatory pleasure in ways that do not also cause widespread harm to ethically considerable beings.

Third, it is far from clear that humans benefit more overall from producing and eating animal products rather than not. We need to be clear about how to think about the relevant benefits. Consider an analogy. When a prescription health plan is considering whether to cover a name-brand medication, they should not simply consider what the benefits of the medication are, but should consider the benefits of that medication *relative* to a less expensive generic competitor. This is the relevant benefit of the name-brand medication and, in many cases, it will be zero. Similarly, we should evaluate the benefits of animal agriculture to humans in the various mentioned roles by comparing how well-off the relevant persons would be if they were not engaged in animal agriculture. In many cases, there are comparable alternatives available to capital, labor, and consumers who currently benefit from their engagement with animal agriculture. In the previous section, we mentioned the disvalue of the environmental damage wrought by such agriculture, and the harms that eating too many animal products can have on the health of consumers. In light of these facts, most humans might be better-off on balance if we moved away from intensive animal agriculture.

The second way to resist the simple argument that animal agriculture is unethical is to distinguish different *types* of animal agriculture. Very broadly, the idea is that if we distinguish *which animals* are farmed, and *how* they are farmed, we can identify *parts* of animal agriculture which are ethically unobjectionable, even if much of such agriculture is unethical for the very reasons suggested above.

First, consider the question of which animals fall under the scope of the simple argument against animal agriculture. As we claimed in the previous section, it is the fact that a being has the capacity for well-being and agency that grounds its ethical considerability, and not its biological species. Still, it is plausible to think that there are some nonhuman animals that lack the physiological basis for well-being and agency. For example, oysters entirely lack brains, making it very plausible that they never feel anything. This suggests that shellfish may be an important exception to the simple argument against animal agriculture. Further, the environmental impacts of shellfish harvesting and farming are less clearly problematic than much other industrial agriculture (Jacquet et al. 2017). Recall from the section "Veganism and Food Ethics Introduced" that one view distinct from veganism is ostroveganism, which permits the consumption of shellfish. This discussion of the significance of ethical considerability and environmental impacts suggests that ostroveganism may be a plausible competitor to ethical veganism (Cox 2010; Huemer 2019, Day 4).

Shellfish and mammals represent relatively clear extremes on a continuum of considerability-relevant capacities. Between these extremes, we confront two vexed questions:

- What precisely are the capacities relevant to making a creature ethically considerable?
- How can we ascertain whether a type of animal possesses such capacities?

Depending on how we answer these questions, even ostroveganism might turn out to be unreasonably demanding: perhaps certain fish and birds fail to count as ethically considerable, for example.

A different strategy for distinguishing ethically defensible parts of animal agriculture appeals to *how* the animals are farmed. Not all animals raised for food face the grim life of the factory-farmed chicken, after all. A small proportion of farmed animals have lives that are very plausibly worth living (Lomasky 2013, pp. 191–192). Some farms seek to minimize the harmful treatment of animals by promoting their well-being and allowing them to exercise their agency. But almost any economically viable animal agriculture will involve killing the farmed animals. For example, consider dairy farming: milk production in cows declines before their natural lifespans. And it is not economically viable to keep a full complement of adult male cattle through their full lives. One of the values we introduced in the previous section was the value of animal life. A clear objection to actually existing humane animal agriculture is that it involves the intentional killing of animals for human economic benefit or pleasure, values that are normally outweighed by the value of the life of an ethically considerable being.

Evaluating Eating

The previous section evaluated animal agriculture but conclusions regarding that topic do not address the question of how individuals should respond. In this section, we explore ethical reasons for individuals to respond by adopting a vegan diet.

Some values that might be claimed to support vegan eating have nothing to do with the issues just discussed: for example, one might become a vegan purely out of an interest in one's own health. However, it is implausible that health concerns distinctively favor veganism over several of the competitors mentioned in the previous section, including the lessmeatarian, vegetarian, and ostrovegan. Because of this, the most prominent reasoning that favors veganism appeals to a link between the vegan diet and the ethical badness of animal agriculture.

Suppose for the moment that the way in which animal products are made causes vast amounts of ethically relevant bads (despite some of the complications sketched in the section above). One might deny that this had any implications for how one should eat. For example, suppose that you order the chicken entree at dinner. Let the treatment of chicken you will eat be as unethical as you like. Still, the chicken was already dead: you ordering and eating the chicken cannot possibly harm it.

There are several ways to try to bridge this gap. Here we will briefly discuss two prominent approaches.

The first approach appeals to the *expected effects* of one's consumption choices on the values of animal well-being, agency, and life. The canonical presentation of this idea by Peter Singer begins by granting that it is highly unlikely that one's own food choices will ever make a difference to actual animal welfare. However, Singer claims that this is not the end of the story. He suggests there must be some (unknown) threshold, at which – for example – increased numbers of vegetarians or vegans will reduce demand for chicken sufficiently to reduce the number of chickens made to suffer in factory farms. For example, "Perhaps for every 10,000 vegetarians there is one fewer 20,000 bird chicken unit than there would otherwise be" (1980, p. 335). However, we are ignorant of where the relevant threshold is. Perhaps we are away from the threshold, in which case the individual vegan makes no difference to how much chickens suffer. But given our ignorance of where the threshold is, we should take there to be a 1/10,000 chance that we are at the threshold. And if we are at the threshold, then one individual refraining from consuming chicken will save 20,000 chickens from a short life of suffering every couple of months. The probability of this chance for each vegan is the same as certainty that one will save two chickens from suffering. In a slogan: it is vanishingly unlikely that one will make a difference by being vegan, but if one does, it will be a correspondingly massive difference. One might then argue that this is enough to entail that one is ethically required to be vegan (see McPherson 2018, pp. 222–223).

This sort of argument faces several difficulties. Some of these difficulties are empirical in nature (Chartier 2006; Budolfson 2018). For example, some have argued that we have empirical reasons for believing that we are more than proportionally likely to be stably between thresholds of the imagined sort. Others have argued that we should be skeptical of the ability of individual buying decisions to produce any economic signals whatsoever in a large market. Other difficulties are more theoretical in nature. We can certainly grant that a small chance of making a large negative difference is sometimes significant, but it is unclear how precisely to theorize this significance. And it does not always seem to entail that an action is unethical: every time I drive a car, I marginally increase my chances of killing an innocent person. This does not seem to make it unethical for me to drive to the store to buy a snack.

At this stage we are granting for the sake of argument that animal agriculture is an unethical practice. A second approach suggests that we can have ethical reasons to avoid certain problematic relationships with unethical practices; for example, *benefiting from* practices that are unethical, and *complicity with* practices that are unethical.

First, consider *benefiting from* an unethical practice. One might think that other things being equal one should strive to avoid benefitting from such things. And one might think further that in eating animal products, one is precisely benefiting from the fruits of unethical animal agriculture. Yet, it is unclear whether one has reason to avoid mere receipt of an unethically produced benefit. Consider the *freegan*, who seeks to eat in ways that avoid contributing to (allegedly) unethical consumerism. And suppose that the freegan retrieves some meat from a supermarket dumpster and eats it. Such a freegan might insist that this behavior is not unethical because she is also single-mindedly opposed to the animal food system (Bruckner 2015).

Second, some might think that purchasing things produced via unethical activities makes the consumer *complicit with* those performing those activities. Complicity involves a primary person or persons engaged in unethical activities and a complicit person who helps those activities succeed or plays a role in them. Take a bank robbery. Asam and Bert rob a bank and are fleeing the cops. They ring your doorbell and ask if they can hide out. You let them hide in your basement. You didn't commit the crime but your act made you an accomplice to Asam and Bert's crime. It is plausible that being complicit with their crime in this way is itself unethical. Similarly, let's say a dress was made by slaves that a shopkeeper owns and he tells you this. You buy it nonetheless. While it is not you who is enslaving the workers, you do play a role in their enslavement by giving the shopkeeper your money in exchange for the dress. This makes you complicit because in doing so you fill the role of customer, providing resources that help the shopkeeper continue his unethical activities. Similarly, purchasing animal products makes one complicit with the unethical practices used to produce them. As in the bank robbery example, it is plausible that being complicit in this way is itself unethical. So, there may be good ethical reasons to refuse to purchase animal products, as vegans do.

So far, we have been focusing on how to argue for veganism given the assumption that animal agriculture is generally unethical. It is worth emphasizing that similar questions apply for the *ethical omnivore* and the *ostrovegan*, given different assumptions about animal agriculture. Suppose, for example, that one took the cultivation and harvest of shellfish to be ethical, but other animal agriculture to be unethical. This will only support ostroveganism provided that some connection of one of the types just discussed can be forged between the ostrovegan stance and any unethical practices.

Vegan Ethics Beyond Consumption

It is easy to think of veganism as concerned only with questions of what one should buy, eat, or otherwise use. And this invites the idea that veganism is in some sense ethically myopic, motivated by a desire to have "clean hands" instead of concern with the treatment and lives of animals. It is plausible that this is a bad picture of a vegan ethic: to invert the familiar slogan, it seems to suggest that the personal is apolitical. While discussion of veganism has largely focused on consumption, it is arguable that a vegan ethic can have much broader implications, which we briefly explore here.

As we noted in the section "Veganism and Food Ethics Introduced," veganism might be associated with different ethical statuses. For example, it might be good to be a vegan, or veganism might be ethically required. If it is required, the requirement might be more or less serious. (Contrast the seriousness of the requirement to keep your promises with the requirement not to engage in genocide.) The implications of a vegan ethic beyond the question of consumption will vary with the seriousness of its ethical status.

For example, if veganism is merely a good way to be, this may have quite limited implications beyond one's consumer choices. By contrast, suppose that being a vegan is a serious ethical requirement in light of the ethical considerability of nonhuman animals and their horrendous treatment in agricultural systems. (Some vegans believe this. For example, Michael Huemer claims that eating animal products was the worst thing he has ever done (2019, Introduction)). It would be very surprising if this sort of conclusion had no implications for ethical and political questions beyond one's consumption choices. Here, we will sketch several potential avenues for such implications.

Consider first a classic question of political philosophy: the nature of *ideal* socio-political arrangements. It is striking that leading accounts of this ideal rarely include substantive discussions of the relation between these arrangements and nonhuman animals. Given that a vegan ethic is grounded in the judgment that animals are ethically considerable, it would fit naturally with a view of ideal socio-political arrangements which ensures that all ethically considerable animals are protected from unethical treatment. Yet there are important questions about how this aspect would affect the overall structure of existent views of ideal arrangements (Nussbaum 2006; Donaldson and Kymlicka 2011; Plunkett 2016). For example, one important question concerns the relationship between a vegan ethic and liberal political ideals that make a place for pluralism, reasonable disagreement, and individual freedom. A stock liberal idea is that there is a profound contrast between how ideal socio-political arrangements should treat those who hold *reasonable* views with which their fellow citizens might reasonably disagree, in contrast to how it should treat those with *unreasonable* views. A liberal vegan ideal would thus need to determine whether the omnivore's view is reasonable, such that an ideal liberal state *should not* use its coercive powers to prevent, for example, farmers from keeping and harming animals, or unreasonable, such that the ideal state *should*, for example, outlaw the production or consumption of meat.

Consider next implications for how we evaluate our *actually existing* political institutions. If animals are ethically considerable, the systematic nature of their mistreatment may have implications for whether existing political institutions are flawed but legitimate or are systematically unjust. In turn, this evaluation will have implications for how citizens ought to relate to those political institutions. For example, it may affect what sorts of reasons one has to respect or resist the law, or to treat one's engagement with one's political institutions as something more than strategic.

More straightforwardly, if the treatment of nonhuman animals is an ethical catastrophe in our midst, this may demand political action of each of us. What sort of action it demands – from voting, protest and civil disobedience, through to more radical possibilities – will depend both on the legitimacy of one's political system, as well as strategic considerations.

Finally, consider the ethical implications of veganism for our relationship with each other. If eating animal products is very seriously unethical, how should this affect one's relationships to nonvegans? Should the vegan be willing to go to restaurants with others who will eat animal products as part of a shared social activity? Consider an analogy. If we learned that someone we knew had trafficked in slaves, this would strikingly alter whether it was appropriate to form or maintain a friendship with this person. Is it fitting for the vegan to react to the omnivore in the same way (Michaelson 2013)?

Conclusion

The number of people choosing a vegan diet has been growing at an increasing pace and mainstream brands, grocery stores, and restaurants have increased their vegan offerings in response. Many all-vegan restaurants have opened and some chefs have committed to producing all-vegan menus to show that vegan cuisine can be both as experimental and as satisfying as any other. An interest in personal health and concern with the environmental effects of animal agriculture do lie behind this trend. In this entry, however, we have emphasized the ethical criticisms of the way animals are treated in contemporary agriculture that motivate many people to choose a vegan diet. We have also endeavored to show that this ethical basis might push veganism beyond a personal food ethic to have wider social and political implications.

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Fair Trade Foods

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Nefratiri Weeks and Laura T. Raynolds

Contents

Abstract

This chapter discusses the fair trade movement as an institutionalized social movement attempting to correct the ethical and environmental concerns with globalized agro-food supply chains. Using institutional political economy and virtue ethics, the authors discuss the successes of consumers in creating mechanisms for recognizing ethically produced products in retail outlets and in creating institutions to support virtue-oriented social action. The structure of global governance and capitalist production logics in global production networks are discussed as key sources of ethical ambiguity in the production of food and drink. Significant tensions and limitations in obtaining ethically produced products include the mainstreaming of the fair trade movement, the proliferation of ethical

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labeling and their adoption by conventional producers and retailers, and the structure of global governance as lacking accountability and failing to uphold social justice across the Global North/South divide.

Introduction

Concerns about the ethical dimension of consumption have generated numerous social movements seeking to correct social injustices and environmental harms in production practices and have worked to create more ethical food choices in retail outlets. These successes are important to consumers who demand ethical choices for eating and drinking, as ethically motivated consumers view their consumption choices as important for their personal identity and for their political stance against social injustice and environmental harm. Demands for ethical products have succeeded in creating both an ethos of pressure for greater corporate accountability, such as that seen in corporate social responsibility, as well as mechanisms to identify ethically produced and environmentally sustainable products in retail outlets. There has been substantial growth in social labels addressing issues of fairness and for eco-labels addressing issues of environment and raw material sustainability across agro-food chains, industrial production, and raw material sustainability efforts.

Recent research finds that 62% of consumers report that they “want companies to take a stand. . . on issues like sustainability, transparency or fair employment practices” (Accenture Strategy 2018, p. 2). The number of eco-labels has increased from fewer than 50 in 1990 to 450 in 2012, while sales for fair trade labeled products have grown consistently throughout the Global North over this same period (Bartley et al. 2015). In the UK, which has the largest fair trade market in the world due to NGOs, active media reporting, and consumer choice, fair trade labeled coffee grew by 700% between 2002 and 2012, and in the US fair trade coffee sales have “boomed” throughout the 2000s (Bartley et al. 2015). In addition to the rise of eco- and social labels and associated standard setting practices, consumer demands for ethical products have also worked to alter the structure of global governance itself through the creation of nongovernmental organizations (NGOs) and transnational advocacy networks that seek to ensure social justice and increase mechanisms of corporate accountability and environmental sustainability. While ethically motivated consumers have made important inroads in the development of labeling, standard setting, and the creation of organizations to support ethical consumption, there is more work to be done.

This chapter traces the successes and limitations of consumer-based social movements in the transformation of food production and in the creation of ethical food and drink through the case of fair trade. Fair trade began as an alternative trading network and has evolved into a consumer-driven, and now institutionalized, social movement attempting to correct social injustices in food systems through political and economic interventions in globalized supply chains. To conceptualize the fair trade movement and the structure of globalized agro-food chains, the authors build theoretically on institutional political economy and virtue ethics. Institutional political economy is a field of study that focuses on the institutions that compose the political and economic structure of global production, consumption, and governance. This approach reveals how the colonial system established the framework for the contemporary production and trade of key food and beverage products, such as coffee, tea, fruits, and spices (McMichael 2012). The approach highlights how institutions maintain historically based inequalities between the wealthy countries of the Global North and the poorer countries of the Global South, inequalities which are critical in analyzing ethical issues in global food production. Virtue ethics is a field of study that focuses on the ethical and value-oriented motivations of human beings. It provides an approach to the purchasing choices of consumers as simultaneously personal and political. Below, the authors discuss the history of these approaches and their relevance for understanding the ethical issues associated with the production of food and drink and the historical emergence of the fair trade movement. In sum, the combination of institutional political economy and virtue ethics creates an approach to the global structure of production and consumption and to the processes underlying the institutionalization of fair trade within global governance, providing important insights into the ethical issues of eating and drinking.

Institutional Political Economy

Political economy is an extensive theoretical approach that analyzes historical, economic, social, and political processes and structures at the global level. It focuses specifically on how inequalities are maintained between actors at the international level through a complex interplay between political power and capitalist economic processes. As explained by Lees (2012), the historical process of contemporary state formation created inequality between nations through, first, the consolidation of power between European nations and, second, the insertion of colonized nations into the nation-state system. This created "the rough-hewn divide between the global North and global South" that placed nations in a hierarchical relationship characterized by inequalities in power and trade (Lees 2012, p. 212). Following colonialism, an arbitrary postcolonial geography was created throughout the Global South, which remains at the crux of development initiatives (McMichael 2012). In the context of food production, colonialism shaped the Global North/South divide with producers in the Global South supplying low-cost products to consumers in the Global North through a continuing unequal international division of labor (McMichael 2012). Whereas the capitalist economic system is globalized, nations are not, and this has important implications for social justice outcomes in food production.

Institutional political economy builds on political economy with a focus on institutions and organizations. The contemporary global political economy is managed through a variety of institutions, organizations, and actors that form a system of global governance rather than a global government. Global governance is pluralistic and includes nations, public and private organizations, multinational corporations, state-directed enterprises, international organizations, and non-governmental organizations (Weiss and Wilkinson 2014). Stretching across this diverse and unequal institutional terrain are capitalist systems of production that manifest as global supply chains and networks that support production and distribution. The reason production takes place as coordinated supply chains is due to the globalization of the economy (Gereffi 1994). Supply chain analysis traces the production processes that create finished products. The approach has been developed in global production network analysis that examines the entire network of production, including production processes, national settings, organizational relationships, institutional contexts, and the uneven geographies in which production takes place. Coe et al. (2008, p. 274) explain that global production networks are "simultaneously economic and political phenomena" that have specific forms at macro, meso, and micro levels. At the macro level, production networks are embedded in international and national contexts that are characterized by differences in power and "varieties of capitalism," which form the global. At the meso level, networks of production form circuits of capital flows through diverse organizations. At the micro level, global production networks intersect with localities that are uneven and unequal in power, development, resources, and, consequently, outcomes from production. While the core of global production networks are to turn inputs into outputs in a process of production, they extend across national borders and integrate diverse territories in ways that often impede states in the Global South in ensuring social justice outcomes in production (Coe et al. 2008; Utting 2008).

Utting (2008, p. 961) explains that the structure of production across national landscapes "raises the profile of global inequality." Food-producing nations in the Global South are often much weaker than the institutions, organizations, and corporations that form networks of production and can trump states in directing economic processes. Yeung (2014) argues that this takes place through "strategic coupling" between national firms and global industries, which concentrates corporate power and undermines the role of the state so that interfirm dynamics have more impact on the development of nations than states themselves. Utting (2008, p. 960) explains that globalized capitalist production logics guide transnational corporations to maximize profits and, toward this goal, they may cut corners in protections for workers and the environment, leading to "gross violations of human rights." This global structure of production also creates difficulties for governance as multinational corporations appear disembedded from national and legal regulations (Pasha and Blaney 1998). As a result, the social and environmental risks associated with production are often shouldered by the weakest throughout the globe (Jones 2013). Thus production processes maintain historical geographical differences and distribute risks and environmental stress in ways that are often unfair (Coe et al. 2008). According to Sandin and Röcklinsberg (2016), there are significant legal difficulties in "reorienting" food markets in this fragmented terrain of production. These failures have led to a robust literature on justice and accountability in production networks (Scholte 2011; Utting 2008). However, as explained by Dryzek (2012, p. 105), mechanisms to ensure accountability are "weak or non-existent at the global level," which works to alter the structure of global governance itself as nongovernmental organizations (NGOs), and other transnational actors emerge in an organizational framework and attempt to create mechanisms of accountability and therefore better outcomes of social justice. The process is characterized as the appearance of global civil society within global governance (Dryzek 2012).

The transnational actors that compose global civil society include diverse organizations including NGOs, “advocacy networks, social movements, party associations, [and] philanthropic foundations” (Bexell et al. 2010, p. 81). They attempt to correct social harms, injustices, or imbalances of power in global governance, fostering democratization and creating mechanisms of accountability at the global level (Bexell et al. 2010). Scholars disagree over the success of global civil society, as manifested in diverse codes, standards, certifications, and practices for ethical production. While some see the emergence of transnational actors within the framework of global governance as a chance for greater democracy and fairness, many emphasize the limitations surrounding the abilities of global civil society to make substantial changes (see, e.g., Dryzek 2012; Pasha and Blaney 1998). Regardless of the effectiveness of global civil society, social justice outcomes and lack of accountability in global governance are a significant impetus for the ethical consumption movements such as fair trade that attempt to create mechanisms of accountability and signal those mechanisms to ethically motivated consumers.

Many draw from the work of Karl Polanyi in order to explain the emergence of social justice-oriented organizations in market-based capitalist economic systems (Bacon 2010). Polanyi (1944) asserts that the liberalization of the market mechanism, such as that seen in neoliberal globalization, causes social harms and spurs social movements who attempt to correct those harms. While this is a viable and important explanation for both the emergence and structure of ethically motivated institutions in global governance, virtue ethics from management and business literature provides a complimentary understanding of why ethical demands in the consumption of food and drink would lead to the creation of organizations and institutional mechanisms, such as that seen in the fair trade movement and in ethical labeling in general.

Virtue Ethics and Food Consumption

Virtue ethics has a long history and robust literature that extends across philosophy, psychology, and business management (Hooft 2014). With roots traced to the work of Plato, Aristotle, Kant, Confucius, and Stoic philosophers, virtue ethics attempts to get at the motivational bases for social action rooted in moral duty and the pursuit of a virtuous personal identity (Hooft 2014). Developed through the work of Max Weber (1947), Elizabeth Anscombe (1958), Alasdair MacIntyre (2007), and others, the approach has been widely adopted in the business management literature to explain business ethics, business management, and ethical consumption and the emergence of reciprocal supportive organizations. The overlapping work of MacIntyre (2007), Beabout (2012), Garcia-Ruiz and Rodriguez-Lluesma (2014), and Peacock (2015) provides an approach to the ethical motives of consumers as well as the organizations that emerge to support ethical consumer demand and create ethical standards in production.

Virtue ethics frame social action as emerging from morals. In sociology, morals are socially constructed and develop from the social circumstances of actors (Weber 1947). Morals are connected with concepts of "right" and "wrong" and are connected to personal identity. Virtue ethics focus on how agents construct identity in the image of a "good" person as they navigate ethical dilemmas and strive to develop virtues (Hooft 2014; Garcia-Ruiz and Rodriguez-Lluesma 2014). Finally, people express the moral bases for social action in various aspects of their lives, including their engagement with the market and in consumption choices, which can be seen as both a moral expression as well as a political response to social and economic circumstances (Evans and Miele 2017). In philosophy, approaches to ethics are divided between consequentialist and deontological views. In the consequentialist approach, people are concerned with the consequences of their actions and desire good outcomes from personal choices. In the deontological approach, people are concerned with moral principles, and moral principles direct social action. Garcia-Ruiz and Rodriguez-Lluesma (2014) argue that the ethical dimension of social action has successfully been characterized as a concern with both outcomes and moral principles; however, a substantial treatment of values remains. As such, the authors combine outcomes and moral principles with a quest for values in order to more fully capture the "self-development dynamics" shown by consumers in consumption (Garcia-Ruiz and Rodriguez-Lluesma 2014, p. 510). In this view, the navigation of ethical dilemmas in consumption provides an arena for the development of personal characteristics and identity through a quest for virtues and an avoidance of vices.

The moral philosopher Alasdair MacIntyre builds on Weber's work in order to approach the structure and characteristics of organizations, as well as the role of actors, in capitalist bureaucracies. His seminal work, *After Virtue* (2007), is an important theory for business management and approaches to ethical business practices (Beadle and Moore 2006). MacIntyre's approach forms the basis of the "goods-virtues-practices-institutions" framework, which builds on the context of social action for understanding consumer behavior, management practices and bureaucratic role fulfillment, the role of goods in identity formation, and the emergence of institutions. The ethical business literature applies MacIntyre's theory and explains each component of the "goods-virtues-practices-institutions" framework. In this framework, "goods" represent the products acquired through market exchanges which give consumers reasons to act, where action may be based on pursuing prestige, values, or ideal ends. The acquisition of goods poses an ethical dilemma as the capitalist "production of consumption" means actors must navigate value concerns, for example, in pursuing goods as status symbols. "Virtues" are framed as "praiseworthy character traits," such as "courage, justice, tolerance, patience, [and] compassion," and require work and practice in their development (Garcia-Ruiz and Rodriguez-Lluesma 2014, p. 514). "Practices" are social actions embedded in complex human activities that are directed by the desire to achieve standards of excellence (MacIntyre 2007). From these established activities emerge "institutions" where "human life assumes the form of a quest for the good" (Garcia-Ruiz and Rodriguez-Lluesma 2014, p. 516). Yet capitalist bureaucracies are "structured in terms of power and status, and they distribute such external goods as money, power and status as rewards" (Garcia-Ruiz and Rodriguez-Lluesma 2014, p. 515). Organizations navigate ethical dilemmas due to a contradiction between their role in the capitalist economy and their basis in virtue-oriented social action. If institutions succumb to the economic imperatives of capitalist processes, both the organizations and individuals can be corrupted. The quest for virtue development according to a set of adopted values influences both the institutions that are formed from established activities as well as the consumers themselves. In short, MacIntyre's theory reveals the intimate relationship between social structure, social roles, and individual agency (Beadle and Moore 2006).

Gregory Beabout (2012) builds on MacIntyre's theory to create a domain-relative approach to business management. In his theory, actors inhabit worlds where they attempt to practice "standards of excellence" within their respective domains, which exist relative to other domains. Domains may be a particular professional or career field, an academic pursuit, management, or any bounded domain that "has its own internal standards of excellence" and where actors draw from the standards and rules of engagement in a particular "domain-relative" practice (Beabout 2012, p. 406). Actors strive to attain excellence according to ideals set by the domains they inhabit. Consumption is composed of its own domains. Consumers are embedded in networks and adapt commodities or brand-specific products that exhibit "standards of excellence" and that display the brand's values (see also Garcia-Ruiz and Rodriguez-Lluesma 2014). The marketplace provides a domain for consumption behaviors and activities that allows for personal virtue development and the construction of a virtuous personal identity. Building on Beabout's and MacIntyre's theory, Garcia-Ruiz and Rodriguez-Lluesma (2014, pp. 509–510) emphasize that consumption practices and choices manifest as "self-developmental dynamics" where actors "perfect themselves both as consumers and as ethical agents" as they strive to develop "positive character traits leading to human flourishing." Reflecting these insights, the business and consumption literatures reveal how consumer goods are important artifacts of personal identity that can be used in a variety of identity development efforts and how consumer choices are value-based and morally infused. In sum, Garcia-Ruiz and Rodriguez-Lluesma (2014) create a virtue ethics approach that recognizes the context, life cycle, and domain-specific positioning of consumers. Consumers are viewed as conscious, socially embedded human beings who strive for excellence through personal values in the quest for virtues in domains that are constituted relative to other domains. In their consumption choices, like in other life choices, they choose goods they see as "virtuous" and, as such, use goods to develop their personal identities.

However, the structure of the globalized economy creates obstacles for consumers in the realization of the "quest for the good life." Peacock (2015) problematizes the conception of consumer concern with virtues and personal identity by asking about consumers' role in the maintenance and reproduction of unethical business practices. Unethical production practices are maintained through both corporate production techniques as well as consumers who support these practices through their consumption choices. Peacock explains that there is "ethical dubiousness" in many corporate practices and that some corporations may "conceal" injustices to protect their profits and foster a virtuous brand persona. Some consumers may prefer to remain ignorant of unjust corporate practices to save money or attain a desired product inconsistent with their values. While neoclassical economics assumes that consumers have "perfect information," consumers actually inhabit what John Rawls (2001) termed a "non-ideal" world where the genealogies of commodities – including worker's rights violations, unfair wages, or environmental destruction – are hidden and unknown (Peacock 2015). Integrating these insights into a virtue ethics approach, we recognize the partial knowledge and "non-ideal" world of consumers, placing human beings in socially constructed contexts where their morals create social action in domain relative contexts.

The combination of virtue ethics with institutional political economy more fully situates ethically oriented consumers in the domain-specific contexts they navigate in consumption choices. Institutional political economy recognizes the ongoing divide between the Global North and the Global South and the resulting hierarchies and inequalities between nations. As capitalist production logics guide production processes through global production networks, they extend across unequal nations and distribute the gains and harms from production and consumption unequally. The resulting ethical ambiguities in production generate moral dilemmas for consumers in the Global North and have led to the emergence of consumption-specific institutions, such as labeling techniques and supportive organizations, that help direct purchasing choices. As such, institutional political economy and virtue ethics help approach the establishment and institutionalization of fair trade as a labeling system providing market signals concerning fairness in production to ethically oriented consumers.

Fair Trade and the Institutionalization of Ethical Consumption

Fair trade provides an ideal case for exploring value-based consumption strategies as discussed in the virtue ethics framework, the emergent organization of Fairtrade International (FTI), and rise of ethical labeling in general. Fair trade began as an alternative trade network in the 1940s when organizations motivated by a religious concern for global poverty and injustice established handicraft shops selling products made in the Global South to consumers in the Global North (Bartley et al. 2015). These alternative handicraft shops increased over time pursuing a strategy of "trade-not-aid" to increase consumer awareness of unfair global trade conditions and procure a fairer return for artisans (Raynolds 2009). Fair trade moved beyond its handicraft roots in the 1980s with the establishment of a product labeling system intended to signal the "symbolic fairness of the product itself" (Wilson and Mutersbaugh 2015, p. 286) and to expand sales of food products in mainstream supermarkets (Raynolds 2009). Coffee was the first labeled product. The certification of coffee was promoted in part to counter the effects of market liberalization and the end of the International Coffee Agreement in 1989, which led to the destabilization of global coffee prices and record low returns for producers (Bacon

2005). Coffee, labeled for its embedded values of fairness, justice, and sustainability, found a ready market among the rising number of ethical consumers across North America and Europe (Raynolds 2009).

Fairtrade International (formerly called Fairtrade Labelling Organization International) was established in 1997. Fairtrade International develops and coordinates Fairtrade standards, while a now independent organization FLO-CERT acts as a "global certification body" to ensure the implementation of Fairtrade principles (FTI 2018b). Fairtrade International seeks to ameliorate poverty and foster development in the Global South on multiple fronts as its standards require minimum price guarantees, payment of the Fairtrade premium, access to pre-finance, democratic producer organizations, fair working standards, and long-term partnerships between commodity buyers and producers. The Fairtrade premium is a fixed amount above the minimum price which buyers are required to pay producer groups to invest in community projects and promote local development. In 2016, the premium generated US $178.5 million for Fairtrade farmers (FTI 2018b). Farmers invested roughly half of these funds on training, tools, inputs, credit and finance, and direct farmer payments, about 40% on organizational needs and infrastructure to support production and increase crop capacity and quality, and the remainder on health, education, and other community services (FTI 2018b). Fairtrade International sees its efforts as helping to realize the UN Sustainable Development Goals through poverty alleviation, ending hunger, raising health standards, attaining gender equality, fostering economic growth, and promoting responsible consumption and production (FTI 2018b). Over the years Fairtrade International has emerged as an important transnational actor that seeks to challenge the historical inequalities in international trade by linking its visionary goals with pragmatic market engagements to alleviate poverty and empower workers and smallholder farmers in the Global South (Raynolds and Bennett 2015).

Markets for Fairtrade certified products continue to grow across the Global North (FTI 2018a). Global sales of Fairtrade certified products were valued at US $9.59 billion in 2017–2018 (FTI 2018a). The majority of earnings are from seven commodities: bananas, cane sugar, cocoa, coffee, flowers and plants, seed cotton, and tea. Coffee, tea, and cocoa are the "most significant products in terms of farmers and workers involved" accounting "for 83 percent of all farmers and workers in the Fairtrade system" (FTI 2018b, p. 24). In total, there are 1.48 million certified farmers and 185,000 workers producing Fairtrade certified products. These workers and farmers are organized into 1,411 producer organizations located in 73 nations; there are 2.3 million hectares of land under Fairtrade production (FTI 2018b). Fairtrade certification now includes over 20 commodities which are produced in multiple countries of origin; however, "coffee remains the core of the Fairtrade system and accounts for close to half of the value of all certified items" (Raynolds and Greenfield 2015, p. 32). Products bearing the Fairtrade label can be found in mainstream retail outlets throughout the Global North. Table 1 reports the top Fairtrade certified commodities by sales volume for 2004–2014.

As Fairtrade International attempts to correct unfair trade practices between the Global North and the Global South (Raynolds 2009), the consistent growth in

Table 1 Top Fairtrade International labeled commodities by volume (metric tons). Reprinted from (Raynolds et al. 2019)

	2004	2006	2008	2010	2012[a]	2014[a]
Bananas	80,640	135,763	299,205	294,447	331,980	439,474
Sugar	1,960	7,159	56,990	126,810	158,986	196,361
Coffee	24,222	52,064	65,808	87,576	77,429[b]	93,154[b]
Cocoa	4,201	7,913	10,299	35,179	40,559	65,086
Tea	1,965	3,883	11,467	12,356	11,869	11,030
Total[c]	126,160	217,628	505,152	585,772	655,068	840,653

Sources: Compiled by the authors using data from FLO Annual Reports (2005–2006, 2007, 2008–2009, 2011–2012, 2013–2014, 2014–2015)
[a]This column does not include sales by Fair Trade USA and thus understates total certified product sales
[b]Although figures for prior years are for roasted coffee, this is for green coffee beans
[c]Includes other labeled commodities measured by weight (e.g., cotton and quinoa), but not those measured by item or other volume measurements (e.g., flowers, sports balls, fruit juice, wine, and beer)

Fairtrade certified products reflects Northern consumers' ethical concerns over these issues. From an institutional political economy perspective, Fairtrade International and other labeling organizations have emerged as transnational actors within global governance domains as a part of global civil society, where organizations emerge from a concern about the social and environmental injustice inherent in globalized capitalist production. Young (2006, p. 102) asserts that "political institutions are the responses" to the obligation for social justice where "obligations of justice arise between persons by virtue of the social processes that connect them." As revealed by a virtue ethics approach, consumers use mechanisms such as labeling in order to express values, develop virtues, and "avoid the corruption of practices by the institutions in which they are housed" (Garcia-Ruiz and Rodriguez-Lluesma 2014, p. 514). Consumer demand for ethically labeled products is in a reciprocal relationship with organizations. As organizations work to meet consumer demand, they become institutionalized and are even transformed by the institutional context and market imperatives they come to inhabit. Labeling schemes provide mechanisms for consumers who are embedded in Rawl's "non-ideal" world and who want to ensure their consumption aligns with their values.

Ethical Consumption and Fairtrade: Social Movement Challenges and Tensions

While the fair trade movement has had considerable success and has helped create a "culture" of ethical labeling that can be seen in Fairtrade International labeling but also eco- and green labels, organic labels, sustainability labels, and many others (Raynolds et al. 2014), there are important limitations in the movement's ability to ensure ethical production for consumers and even greater limitations in addressing the deep structural inequalities of global production that create the ethical dilemmas that consumers face. The authors briefly discuss three key limitations and tensions: the "mainstreaming of fair trade," the proliferation of ethical labels onto conventional supply chains, and the structure of global governance.

The first limitation revolves around fair trade "mainstreaming" (Raynolds 2009), which remains a highly contested process (Bennett 2015). Carrying the goals of a social movement into the global institutional context is fraught with contradictions, and Fairtrade International has had to navigate the global institutional and organizational demands of the global political economy while maintaining the spirit of the movement (Raynolds 2009). Fairtrade International has been criticized for forgoing the original mission and vision of the movement. There are disagreements over who and what types of products should be certified and what types of organizations should be recognized as Fairtrade (Bennett 2015). Some even ask if the entire labeling system has been subsumed under profit maximizing capitalist principles that promote neoliberal agendas and uphold Global North/South inequalities (Bacon 2010). These debates have important implications for the success of the fair trade movement and can be seen as an inherent aspect of Fairtrade International's institutionalization, as economic and institutional actors navigate and mediate the imperatives of capitalist bureaucracy.

As Fairtrade International navigates the transnational domain of global governance, it is embedded within the logics of global market-based capitalism. Drawing on virtue ethics, consumers and institutions are embedded in domain-relative contexts where they strive to adapt, develop, and promote "standards of excellence." For institutions to promote standards of excellence, in conjunction with other organizations that comprise global civil society, they must legitimate their activities, demonstrate positive returns to consumers, strive to put forth virtuous identities, and exemplify the goals of the social movement. However, because they are also situated in the institutions of global governance, organizations like Fairtrade International are subject to the internal logics and dominant conceptions of success that guide institutions in the global domain, such as economic growth, profitable returns, rationalities of expansion, and modernization style development frameworks. While "fair trade organizations are deeply mission-driven and devoted to movement principles. . .they face significant pressure to adopt conventional business practices" (Raynolds and Greenfield 2015, p. 26). The domains between movement principles and market imperatives represent conflicting "standards of excellence" that create contradictions for movement goals and organizational legitimacy.

Fairtrade International's labeling strategy stemmed from the desire of advocates to expand the presence of labeled products into more traditional retail outlets. However, as Raynolds (2009) argues, "market mainstreaming" has unraveled what was once a unique relationship between fair trade buyers and producers, refashioning networks organized around values of "partnership" to prioritize values of "traceability" in Fairtrade labeled markets. Elaborating this argument, Wilson and Mutersbaugh (2015, p. 281) contend that mainstreaming of Fairtrade products has shifted the movement from "trust-based 'solidarity' networks" toward commodity chains subject to standards based on "certification norms." Fairtrade International's embeddedness in the global political economy means it is subject to the market dynamics of capitalist production and consumption and must therefore establish the legal forms of economic activity that facilitate operation in global markets. While "solidarity – not market opportunity – motivated most pioneer fairtraders through the risky innovation process of creating functional alternative trade relationships where none existed" (Bacon 2010, p. 124), the movement's insertion into broader market processes transforms the movement itself.

A second limitation and tension in the fair trade movement, and in ethical consumption more broadly, pertains to the proliferation of labeling schemas. Due to the success of labeling, Fridell et al. (2005) argue that conventional companies, retailers, and firms have created their own labels to create an ethical façade for consumers, which works to weaken standards and co-opt the fair trade movement (see also Jaffee 2012). As Peacock (2015) points out, corporations and businesses may conceal the genealogies of commodities that reveal injustices in commodity chains. To tap growing ethical markets, numerous corporate actors have tried to capture ethical attributes to promote sales of their own products (Raynolds et al. 2014). The proliferation of ethical labeling onto conventional commodity chains creates a "freeloader" problem, where corporations reap the benefits from ethical labels without real social benefits. Label proliferation accentuates the "non-ideal" world of the consumer, since it becomes harder for consumers to know which products are in fact more ethically produced than others (Jaffee and Howard 2016). In order to combat this growing problem, Bartley et al. (2015) recommend consumers to "look behind the label" in order to understand what standards are actually being upheld by a particular label, which may help combat the growing issue of "green-washing" or "fair-washing" where products contain labels that lack real ethical commitments.

The third tension or limitation to attaining ethical food choices for consumers drives at the deeper, structural aspects of global governance highlighted by institutional political economy. A robust literature discusses the problems with both the structure, as well as the processes, that undergird global governance. There is extensive debate on the rise of multinational corporations as powerful actors who routinely penetrate nation-state borders but lack social accountability, along with the related weakening of nations in ensuring social justice outcomes for citizens (Cutler 2001). Issues of accountability and justice in the production of food remain a key focus. As globalized economic processes structured as global production networks overflow national borders and create social and environmental harms in disparate and unequal geographies, NGOs and other transnational actors emerge to fill governance gaps (Dryzek 2012; Coe et al. 2008). Global governance is composed of private and public actors who hold power and contradictory interests. Corporate concentration and capitalist economic logics create substantial power asymmetries that work to advantage capital while disadvantaging the weakest throughout the globe (Ougaard 2016). In this context, global governance institutions lack accountability and often fail to uphold social justice across national borders.

A range of civil society groups has entered the field of global governance to address these issues. Global governance is comprised of a "variety of actors – public and private – adopting multiple decisions in a web of negotiated relationships, marked by a certain level of interdependence" (Curtin and Senden 2011, p. 169).

As global governance actors are divergent, varied, and pursuing differing ends, the structural form of global regulation creates the "problem of many hands" (ibid., 182). Therefore, while justice and accountability are inherently linked, the inability to hold global actors accountable creates real obstacles to the realization of justice. The structure of global governance and the historical genealogies of capitalist production create ethical dilemmas for mission-driven organizations and ethical consumers in the Global North. While Fairtrade International and its allies work to connect ethically motivated consumers in the Global North with producers in the Global South, correcting the vast asymmetries of power and ongoing injustices that plague the global economy has proven exceedingly difficult.

Conclusion

Social movements promoting ethics in our eating and drinking have successfully highlighted social injustice and environmental harms in global production networks. Ethical labeling has been particularly successful in helping people navigate the non-ideal world they inhabit as consumers and has helped spawn organizations to oversee ethical production standards and strengthen global governance. The fair trade movement, and its institutionalization in Fairtrade International, reveals the successes as well as limitations and tensions in this ethical labeling strategy. While Fairtrade labeling has helped consumers realize their ethical consumption goals, we identify three key limitations in this institutional strategy. First, the mainstreaming of Fairtrade International products creates tensions between movement goals and the conventional capitalist logics inherent in the global political economy. Second, the proliferation of ethical labels in conventional supply chains creates a freeloader problem where unethical corporations appropriate the benefits of growing ethical product markets while failing to correct social justice issues in their supply practices. Third, the structure of global governance embedded in the globalized capitalist political economy creates significant obstacles in creating mechanisms of accountability that could create better outcomes for social justice. The highly fragmented and structurally hierarchical system of global governance, combined with the historical power differences between nations and the concentrated economic power of corporations, creates significant problems for realizing social justice both across and within nations. These tensions and limitations create significant obstacles for consumers seeking to promote the ethics of eating and drinking and for fair trade movements seeking to challenge global injustices through Fairtrade certified agro-foods.

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Ethics of Healthy Eating

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Anne Barnhill and Nicole Civita

Contents

Abstract

This chapter surveys a set of ethical issues related to healthy eating, drawing upon the work of scholars (primarily ethicists) and popular commentators. We focus on three facets of healthy eating and their associated ethical issues: (1) issues that arise when healthy eating is pursued as a public health goal by governments, the medical profession, and other powerful actors; (2) issues that arise with the marketing of "healthier" food products by the food industry, and (3) issues that

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arise when individuals and families adopt healthy eating as a project and goal. This chapter just introduces the rich ethical debate about food and health taking place among academics, advocates, policymakers, and the public.

Introduction

Food and health are inseparable. Food – as the primary source of sustenance and nutrition for most people – influences how the physical body, inclusive of the brain, develops, functions, and ages. The quality, quantity, content, and availability of food contribute to the routine functioning of our biological systems, the etiology and progress of disease, and our prospects for healing from illness and injury. As important as all of this is, the significance of food transcends its impacts on health and the healthy or unhealthy body. Food can also be a catalyst of gustatory delight, a manifestation of culture, a means of expressing identity, and a conduit of care. As such, food can contribute to our mental and emotional well-being as well as our physical health.

Across a wide range of academic disciplines, experts offer informed perspectives on the ethical issues connected to food and health, placing emphasis variously on farming and food production, nutrition, food choice, dietary patterns, disordered eating, and food environments, to name just a few foci. Insightful contributions about the ethics of healthy eating are not limited to scholarship – there is also a wealth of engaging and provoking popular writing that explores ethical values at the food-health nexus. Against the backdrop of such a varied discourse, this brief chapter cannot be comprehensive in its survey of the ethical issues associated with healthy eating or in its representation of the diverse voices who have spoken about the same. Instead, this essay draws primarily upon the work of ethicists and focuses on a subset of ethical complexities related to healthy eating: (1) those that surface when governments and other powerful actors seek to further public health goals – in particular, obesity prevention – by adopting policies that promote healthy eating; (2) those that are wrapped up with efforts to market foods on the basis of their purported health-promoting attributes; and (3) those that arise in the context of healthy eating as pursued by individuals and families.

Healthy Eating as a Public Health Goal

Overnutrition as a Public Health Priority

In high-income countries, healthier eating is embraced as an important public health goal, in order to reduce rates of overweight, obesity, and diet-related illness. Governments at all levels as well as nongovernmental actors (community organizations, philanthropies and foundations, employers, universities, etc.) are implementing programs to encourage healthier eating (Bleich et al. 2018; Lloyd-Williams et al. 2014; Mozaffarian et al. 2018; Reeve et al. 2015). At the global level, healthier eating and obesity prevention have been repeatedly elevated. For example, reducing mortality from noncommunicable diseases, including diet-related diseases, is included in the Sustainable Development Goals adopted by the United Nations in 2015 (for example, target 3.4 is "By 2030, reduce by one third premature mortality from noncommunicable diseases through prevention and treatment and promote mental health and well-being." See https://sustainabledevelopment.un.org/topics/sustainabledevelopmentgoals).

This emphasis on healthy eating is a response to the sharp increase in diet-related illness, overweight, and obesity globally during the last few decades. In 1980, 22% of adults were overweight and 5% were obese globally, but by 2016, 39% of adults were overweight and 13% were obese globally (World Health Organization 2017a, b). In some countries, the rates are significantly higher; 36% of adults were obese in the USA in 2016 (World Health Organization 2017a). Unhealthy dietary patterns in high-income countries involve overconsumption of calories relative to energy needs, and overconsumption of sugar and sodium, but also under-consumption of healthier foods like fruits, vegetables, and whole grains. These dietary patterns have a significant public health burden. Overweight and obesity are linked to noncommunicable diseases including cardiovascular disease, diabetes, kidney disease, and multiple kinds of cancer; according to one estimate, high BMI contributed to 4.0 million deaths globally in 2015 (GBD 2015 Obesity Collaborators et al. 2017).

A recurrent theme of work by public health researchers, as well as work critical of the public health focus on obesity, is that obesity is not merely the result of individual choices. Rather, it is also the consequence of a modernized food system that efficiently produces a surfeit of enticing edibles. As the food system has industrialized, globalized, and bent toward convenience in recent decades, food products that can be optimized for long-distance transport and lengthy shelf life require minimal preparation and are calorie dense became ubiquitous (Institute of Medicine 2015; Roberto et al. 2015; Swinburn et al. 2011). This shift is believed to contribute to both overconsumption (excess consumption of calories relative to energy needs) and underconsumption of healthy foods. Moreover, as the food industry became an ever more competitive sector, food sellers have attempted to win the favor of consumers by increasing portion sizes, formulating energy-dense foods, and offering both at relatively lower prices than smaller portion offerings (which were viewed as sufficient mere decades ago) and less energy-dense foods (e.g., fruits and vegetables) (Drewnowski and Specter 2004; Livingstone and Pourshahidi 2014; Roberto et al. 2015; Swinburn et al. 2011; Wilde et al. 2012; Zlatevska et al. 2014). The industry also rolled out marketing campaigns that associate less healthy foods with high levels of fun, social acceptance, and personal satisfaction to attract busy, bargain-hungry, and increasingly isolated consumers (Dixon et al. 2007; Gorski and Roberto 2015).

Additionally, as demands on people's time increased and dining out came into vogue, consumption of food away from home increased dramatically – though after a precipitous rise between the 1960s and 1990s, this seems to be leveling off in the United States (Smith et al. 2013). Conditions of contemporary living encourage people to favor snacking or "grazing" over meals and to "buy time" by buying convenience foods, which are often calorie but not nutrient dense (Smith et al. 2013;

Capps et al. 1985; Hamrick et al. 2011). As a result of these significant shifts, our daily food environments (e.g., schools, workplaces, marketplaces, and neighborhoods) have been pervaded with inexpensive processed foods that are high in sugar, fat, sodium, and calories; and are aggressively marketed; and are engineered to be hard to resist (Moss 2013; Roberto et al. 2015; Schwartz and Brownell 2007).

Scholars also look beyond our immediate food environments, and identify other features of food systems connected to overconsumption: for example, too little fruits and vegetables are produced for everyone to eat the recommended amount (Bahadur et al. 2018; IOM 2015). Beyond food environment and supply, there are broader and deeper social forces identified as linked to diet, overweight/obesity, and diet-related illness. Some scholars point to technological and lifestyle change (Lang and Rayner 2005), identifying lengthy and sedentary work days, dependence on motorized transportation, limited access to green space, and increasing "screen time" for work and leisure as disruptors of caloric balance. Others focus on the contributory effects of poverty and social inequality, noting that cost barriers, stress and anxiety, intergenerational reliance on lower cost, less healthy processed foods, spotty knowledge of how to prepare healthy foods, taste conditioning, and time constraints associated with holding multiple jobs, enduring long commutes, and being unable to hire assistance with household tasks make it challenging to sustain healthy eating and exercise habits (Escoto et al. 2012; Andajani-Sutjahjo et al. 2004). Some theorize that overweight/obesity and diet-related disease should be analyzed as matters of political ecology, arguing that neoliberalism, the political economic system emphasizing free markets, minimal regulation of industry, and a minimal welfare state creates conditions that allow private enterprises to profit with little regard for public health harms that flow from consumption of marketed products, and that prevent marginalized individuals from having equal access to the conditions that promote health (Guthman and DuPuis 2006; Wilkerson 2010).

Beyond the factors that contribute to the healthfulness of diet and exercise patterns, a growing body of research recognizes that exposure to obesogenic chemical compounds contributes to overweight and obesity by altering metabolic processes and predisposing some people to gain weight (Holtcamp 2012). Such compounds not only persist in the environment as a result of agricultural and industrial activities, but they also make their way into the body via use in production and processing, by leaching from packaging materials, or through inclusion in pharmaceuticals (Holtcamp 2012). The potential deleterious effects of foodborne obesogens – and their ability to blunt the weight-management effects of healthy diet and moderate exercise – raise questions about whether and under what conditions it is appropriate to make use of metabolic and endocrine-disrupting chemicals.

Overnutrition Exists Alongside Other Food System Problems

Adding to the complexity, overconsumption and overnutrition exists alongside other serious problems in the food system that needs to be addressed simultaneously. (See Barnhill et al. 2018 for further discussion of these issues.)

Globally there are significant rates of food insecurity and undernutrition (i.e., more than 10% of the global population were undernourished in 2017) (FAO 2018). The global food system is responsible for a significant percentage of greenhouse gas emissions (19–33%) (Vermeulen et al. 2012), contributes to the erosion of 75 billion tons of soil from arable land (Borrelli et al. 2017), accounts for 70% of consumptive freshwater use (FAO 2017), pollutes air and water, and is the greatest driver of biodiversity loss across the planet (Dudley and Alexander 2017). There are over 24 billion animals – nearly 20 billion of which are chickens – raised for food globally each year, most of them in confinement systems that do not afford them an adequate level of welfare (Robinson et al. 2014). In many countries, the food sector offers the greatest number of opportunities for work – and some of the lowest wages and poorest working conditions. For example, 65% of poor working adults in the world have livelihoods tied to agriculture (World Bank 2016) and in the United States, where the food sector employs over 20 million people – one-sixth of the workforce – only 13.5% of workers report that they earn a living wage (FCWA 2012).

Given the multiple problems in food systems, and their interconnections, it is important to recognize the effect of healthy eating efforts on broader food systems (Barnhill et al. 2018). For example, if Americans followed dietary recommendations about fish consumption, this could deplete global fish supplies and undermine the livelihoods of fishers (IOM 2015). Thus, a big picture ethical consideration, when pursuing healthier eating as a public health goal, is how to promote healthier eating without making other food system-associated problems worse – or, ideally, how to identify shifts that can be characterized as "win-wins" that simultaneously advance public health, environmental, and equity aims (Barnhill et al. 2018; IOM 2015). For example, researchers have identified "healthy, sustainable diets" – dietary patterns that are good for individual health while limiting the negative environmental impacts of food production (Willet et al. 2019). These recommended dietary patterns are typically plant-centered, because of the high environmental costs of animal agriculture, including land use, water use, greenhouse gas emissions, and other sources of pollution. Calls for a global shift towards plant-based diets have been critiqued as insensitive to the fact that certain geographies and eco-regions are not suited to the production of a nutritionally diverse and adequate plant-based diet, as well as to critiques that such recommendations have the potential to deny the world's poorest from experiencing the intergenerational health gains that have been observed in populations that have had long-standing access to meat, milk, and eggs. "One view, originating from meat-eating countries, is that plant-based diets are healthier for people and better for the planet. Another position is that the high-nutrient density of animal foods needs to be balanced against their higher cost and greater impact on the environment" (Drewnowski and Poulain 2018). Accordingly, some recommendations focus on the need to reduce consumption of meat and other animal-source foods at the global level while *increasing* the consumption of animal-source foods among some populations in order to address nutrient deficiencies and protect their health.

Critical Perspectives on Obesity Discourse

The consensus in the public health community is that concerted action on unhealthy diets and overweight/obesity is needed, that this action must involve multiple sectors of society working together and that the case for this societal effort is clear. The public also sees obesity as a significant public health problem (for example, see (Kam 2017) for data on US public opinion about obesity). However, there are critical perspectives on obesity, arguing in various ways that the obesity problem is overblown or that obesity discourse is ethically problematic (Barnhill and Doggett 2018).

One critical perspective is that the public discourse about obesity reflects moral attitudes about eating and body shape. A version of this line of thought is that concern with obesity is a moral panic, in which groups, behaviors, or bodies seen as deviant come to be seen as a threat to society, and the actual risks they pose are exaggerated (Campos 2004; Campos et al. 2005; Guthman 2007). A related ethical critique is that public discussions of obesity are pervaded with moral judgments about people who are overweight or obese (e.g., that they are lazy or lack self-control), and in turn perpetuate these attitudes, contributing to stigma and discrimination against people who are overweight and obese (Puhl and Heuer 2010). Some worry that any focus on obesity problematizes fat people and exacerbates the stigma and discrimination they experience, which can, in turn, spawn a range of states and behaviors (i.e., self-loathing, depression, avoidance of interactions with healthcare providers) – that are at cross-purposes with health and wellbeing (Guthman 2011).

More broadly, a theme of critical work is that we should see public concern with obesity in its broader cultural context as reflecting moral attitudes and cultural norms about eating, body shape, gender, fat, and pleasure (Barnhill and Doggett 2018; Bordo 2013; Wilkerson 2010; Womack 2014). When they interrogate these attitudes and norms, scholars find many problems with them. Bordo (2013) sees mixed cultural messages about eating: our culture encourages us to eat unhealthy foods while also admonishing us to stay in shape and be thin (Bordo 2013, p. 253). Kukla (2018) argues that unhealthy eating is simultaneously denigrated and valorized (those who indulge in gustatory pleasure are “brave and impressive risk-takers unafraid of pleasure”).

Critical work on obesity can be situated within a larger body of critical work on eating, dieting, eating disorders, fat phobia, and weight discrimination (Barnhill and Doggett 2018), including work by feminist philosophers arguing that dieting and eating disorders need to be seen as reflecting gender ideology and the pressure women face to be thin and fit, and need to be seen as forms of gender oppression that perpetuate gender inequality (Bartky 1990; Bordo 1993; Orbach 1978). So, too, recent work argues that concern with obesity reflects ideologies about body size and individual character, and perpetuates stigmatization of and discrimination against people who are overweight and obese (Wilkerson 2010; Womack 2014).

According to another critical perspective on obesity discourse, some public health and medical discourses over-rely on size as a dispositive indicator of health. Others focus on bodies rather than on the conditions under which people obtain nourishment and care or experience validation and connection. When any of these errors in emphasis occur, opportunities to address structural factors and root causes of poor health can be missed.

Ethics of Healthy Eating Efforts

A broad range of efforts to promote healthier dietary patterns have been implemented by a range of public and private actors, including governments at all levels, schools, employers, health professionals, and community groups (Lloyd-Williams et al. 2014; Reeve et al. 2015; Mozaffarian et al. 2018; Bleich et al. 2018). These efforts focus on changing the food environments people encounter in their daily lives, changing how people behave within these food environments, and changing other features of the food system. Commonly recommended tactics include (IOM 2012; Mozaffarian et al. 2018; Roberto et al. 2015; World Cancer Research Fund 2016; World Health Organization 2013):

1. Efforts to change the food environments people encounter in their daily lives and increase access to health-promoting foods (e.g., removing sodas from school vending machines, offering healthier foods in cafeterias in schools and workplaces, opening more grocery stores in underserved neighborhoods, requiring that neighborhood retailers stock fresh produce alongside the typical array of processed foods, and establishing nutritional standards for the types of food donations that charitable feeding organizations will accept and distribute)
2. Programs focused on getting individuals to change their behavior (e.g., wellness programs offered by employers and insurers, nutrition education included in school curriculum, and multi-prong efforts to change dietary patterns)
3. Efforts to regulate and shape the marketplace (e.g., taxes on sugary drinks, bans on the use of especially problematic ingredients in restaurant food and packaged food, mandated disclosures of nutrition information on food labels and restaurant menus, and efforts to limit how, when, and where less healthy foods can be marketed to children)
4. Efforts that focus further up the chain of production (e.g., strategies for incentivizing or reducing obstacles and risks associated with the production of fresh produce; building systems and infrastructure to facilitate the distribution of minimally processed – often local or regional – agricultural products to institutions such as schools and hospitals that serve people who lack access to healthier food; efforts to provide supplemental farm labor for harvesting to avoid the loss of good food in the field; efforts to avoid the wastage of nutritious food, including efforts to sell cosmetically imperfect but otherwise wholesome produce or healthy but nonconforming food at discounted rates)

An overarching ethical concern with healthy eating efforts – particularly those that focus on changing individual behavior within food environments – is whether they should even be pursued. Williams (2015) notes that the evidence for the effectiveness of community-level obesity prevention efforts is disappointing and cautions against wider implementation of these efforts. Williams argues that instead of pushing for wider implementation of obesity efforts, we should focus on policies that address root social and economic causes of obesity and that accomplish other social justice goals, a conclusion also reached by other scholars (Guthman 2011; Kirkland 2011; Williams 2015). Examples include increasing access to preventive health care, improving public transportation, destigmatizing excess weight, and anti-poverty efforts more generally. Nonetheless, public health often remains focused on addressing obesity directly, with efforts that regulate the marketplace, change the food environment, and encourage individual behavior change (WHO 2013; IOM 2012; Roberto et al. 2015). Many efforts aim to change eating behavior in the short run and presumably also aim to change food preferences, norms, and social practices over the long run.

Turning to specific kinds of healthy eating efforts, a range of ethical concerns have been raised in the literature. (This discussion draws on a fuller discussion of these issues in Barnhill (2019).) Ten Have et al. (2013) present a framework for assessing the ethics of obesity prevention efforts and identify eight potential ethical pitfalls with such efforts: they may negatively affect physical health, psychosocial well-being, equality, informed choice, social and cultural values, privacy, the attribution of responsibilities, or liberty. Ethical concern with these pitfalls is reflected in the ethics literature.

Healthy eating efforts that limit choice – such as bans on products (e.g., large sugary drinks), bans on ingredients (e.g., trans fat), and limits on the use of public nutrition assistance (e.g., prohibiting the purchase of sugary drinks using assistance) – raise ethical concerns centered on choice, autonomy, and paternalism. Such efforts have been derided as instances of the “nanny state.” Such efforts are seen as government paternalism – that is, government action that interferes with individuals’ choices or limits their freedom in order to increase those individuals’ welfare. As such, these efforts trigger philosophical objections to paternalism, including the objections that these efforts are unlikely to be effective (since individuals know better than governments what’s good for them), fail to respect individual autonomy, fail to treat people as equals, and are degrading or demeaning (Conly 2013, Chap. 1). In response to charges of paternalism and “nannying,” supporters sometimes frame these efforts not as measures that paternalistically protect consumers from themselves but as measures that protect consumers from food industry actors that intentionally formulate foods to be hard to resist and market these foods in misleading, manipulative, or exploitative ways (Frieden 2013; Roberto et al. 2015). In response, some ethicists point out that foods, even unhealthy foods, can have multiple kinds of personal and social value for consumers – providing pleasure, comfort, convenience, and being part of valued social experiences (Resnik 2010; Barnhill et al. 2014); thus we shouldn’t assume that unhealthy eating is always some kind of mistake that the food industry causes consumers to make.

To skirt the ethical concerns with government paternalism that limits choice, some have embraced healthy eating *nudges* – efforts to change people’s behavior but without blocking any choices or attaching significant costs to choices (Thaler and Sunstein 2008). An example of a healthy eating nudge might be putting the healthiest items first on a menu, or stocking the most easily accessible part of a salad bar with the healthiest ingredients, relegating less healthy items to the harder to reach sections (Bucher et al. 2016; Dayan and Bar-Hillel 2011; Rozin et al. 2011; Wilson et al. 2016). Even though nudges were designed as a less controversial alternative to efforts that restrict choice, nudging has faced some of the same objections, for example, that government nudges won't succeed in making us better off, since the government is not well-positioned to know what's good for us (Sunstein 2014, Chap. 3). Nudging is also objected to as overly controlling, under-handed, manipulative, and anathema to autonomy (Hausman and Welch 2010; Saghai 2013; Waldron 2014).

Concerns for equity and justice form another broad theme in the literature on the ethics of healthy eating efforts. The higher incidence of obesity and diet-related diseases among some racial/ethnic minority groups and lower-income populations in high-income countries is seen as a health equity issue, and considered an instance of social injustice. Efforts that increase access to healthy food in these populations thus have a justice-based argument in their favor: increasing physical and economic access to healthy food is a necessary way to address health inequities – if healthy food cannot be obtained, it cannot be consumed, and less nutritious or inadequate food will degrade the health of people and communities. Two additional justice-based arguments are also given for efforts to increase healthy food access. Inadequate access to healthy food is seen as a failure of social justice in and of itself, whether or not it undermines health, because social justice requires that all people have adequate food access (Alkon and Agyeman 2011; Szende 2015). An additional justice-based argument is that increasing access to healthy food is a step towards addressing past injustices (Szende 2015), since inadequate food access can be the result of other entrenched injustices, such as institutional racism, discrimination in housing, employment and wages (Chilton et al. 2018), intergenerational poverty, trauma, violence, and exposure to adversity (Chilton et al. 2016).

On the other hand, some healthy eating efforts raise equity and justice-based concerns. Taxes on foods, such as sugary drink taxes, are objected to as regressive (meaning that they take a larger percentage of the income of people of lesser means) and therefore unfair (Barry et al. 2013). Efforts that focus on low-income and minority groups, or disproportionately impact them, may seem like unfair targeting of these groups or may seem to imply that such groups are unable or unwilling to make good choices for themselves (Barnhill and King 2013; Kirkland 2011). Another critique is that many efforts focus solely on the undesirable manifestations of historical injustices and inequities – such as impaired food access, diminished food literacy, and unhealthy eating patterns – rather than undertaking the more difficult tasks of unpacking structural violence and standing in empowering solidarity (Cadieux and Slocum 2015). Healthy eating efforts that float on the surface of deeper problems can have the effect of demeaning, belittling, ostracizing, or eroding the trust of the very people that the efforts aimed to serve (Cadieux and Slocum 2015). Such criticisms have been leveled against proposals to exclude sugary drinks and candy from the foods eligible for purchase with food assistance (Barnhill and King 2013), as well as at efforts by well-meaning white elites to "educate" members of low-income and minority communities on the preparation of healthy meals (Guthman 2008).

An arguably less paternalistic – but also less directive and comprehensible – strategy than bans and nudges includes recommendations to consume less healthy foods "in moderation." Such messages can be found in governmental nutrition guidance, talking points of dieticians, lessons by intuitive eating coaches, and advertisements for unhealthy foods. But assertions that unhealthy foods "can be part of a healthy diet" when consumed in moderation, are rarely followed by language that quantifies or explain the concept of moderation. Also lacking is critical consideration of the ethics of such messaging, particularly when voiced by actors who stand to profit from the consumption of such foods – for example, an exhortation in favor of moderate consumption of soda from a soda company. Without more, these messages can undermine or muddle health messaging, leaving eaters confused. Relatedly, because health messaging is diluted when the severity of risk to health is perceived to be low, vague messages about moderation or consumption as "part of a healthy diet" may actually lead to increased consumption of the foods in question or offer cover for those who want to believe that they are eating well (Provencher et al. 2009).

Underattended in the ethics literature is examination of the value that unhealthy eating has – the ways that it provides pleasure, psychological comfort, convenience, and has economic, social, and cultural value (Barnhill et al. 2014; Resnik 2010). It should surprise no one that people favor unhealthy foods because they stimulate good memories (i.e., eating cookies with a departed grandparent), are part of cherished traditions (i.e., deep frying foods for holiday celebrations or tucking into a greasy bucket of popcorn at a movie theater), are typically associated with relaxation, camaraderie, and letting loose (i.e., pizza and beers with friends to start a weekend or French fries and ice cream at a carnival), or are cheap, easy, and quick (i.e., drive-thru fast food or a microwave dinner) (Wilson 2016). The ways in which unhealthy foods serve as links to the past, conduits to community, facilitators of fun, and tools for managing a hectic day or stretching an impossibly small budget are ethically relevant and merit acknowledgement as we aim encourage greater health through food. A fuller account of the value of unhealthy eating would help us understand what's at stake and to design ethically better healthy eating efforts (Devine and Barnhill 2017).

Marketing of "Healthier" Foods

The previous sections examined the promotion of healthy eating as a public health goal and some ethical complexities therein. This section looks at some ethical issues with the commercial marketing of foods as "healthier" foods, which can be in tension with both public and private efforts to improve health through eating. Though food marketing does provide consumers with information, it is not just a straightforward effort to provide consumers with objective information about products so that they can make healthy choices, if they so choose. Rather, it is a form of strategic practice wrapped up in the promotion of "values, visions, and concepts to which products are aligned" (Quigley and Watts 2005).

Along with taste and price, the healthfulness of foods is a primary driver of consumer food choice (IFIC 2018). Many consumers want to buy healthy foods. However, a major ethical issue is that consumers have spotty information about the healthfulness of food products, including food they buy from retailers and from restaurants, and there is information asymmetry between producers and consumers.

This raises ethical questions such as: *Does the food industry have special obligations to market food in ways that are highly transparent and informative, and minimally misleading? If so, what marketing practices are anathema to satisfying this obligation?* And on the other side: *Should consumers be expected to seek information about food, dietary contributions, and the relative healthfulness of alternatives from sources other than the food industry?* In other words, *how skeptical or trusting should the typical consumer be?* Is food purchasing a context in which the buyer ought to beware? Or, given the critical relationship between food and health and the strong collective interest in maintaining public health, s*hould governments create special standards to fiercely protect consumers from potentially misleading or deceptive food marketing?*

Differently situated stakeholders will undoubtedly answer these questions differently. Historically, the food industry groups and their advertisers have, not surprisingly, favored self-regulation, arguing that it allows for quicker, more creative, and more flexible responses to problematic marketing than government regulation (FTC 2006). On the other hand, consumer advocates have argued that self-regulation does not produce significant enough improvement.

Even those who favor muscular government intervention on food marketing acknowledge that it can be difficult to determine where to draw the lines. There is significant consensus about the healthfulness of some dietary patterns (for example, diets high in fruits and vegetables and low in added sugar are healthier than the reverse), but there is less consensus about other matters (for example, the health effects of saturated fat). Even if we can identify in broad strokes what a healthy dietary pattern looks like for an average person, and can identify paradigm cases of "healthy" foods (e.g., vegetables without added sugar, salt, or fat) and of "unhealthy" foods (e.g., sugary soft drinks), questions remain about defining "healthy" foods and comparing the relative healthfulness of foods: *How should we assess and express the relative healthfulness of two or more food products? Which products ought to be compared to each other? What determines which product is "healthier" and for whom?* Finally, *what sources of information ought to be considered in these assessments and who should arbitrate and be the gatekeeper of communication about healthfulness?*

The pitfalls of regulating claims about healthfulness have brought the food industry and its regulators into conflict in recent years (Johnson and Ault 2016). In the United States, the Food and Drug Administration issued detailed regulations mandating the inclusion of specific nutrition facts and detailing the circumstances under which nutrient content and health claims may be made or implied in the labeling of food (21 C.F.R 101.3). But by the FDA's own admission, its regulations do not necessarily reflect current and emerging scientific consensus about what foods can properly be considered "healthy," and may be outdated (Center for Food Safety and Nutrition (CFSAN-FDA) 2016). As a result, some foods that might be generally considered healthy at typical levels of consumption cannot legally be described as "healthy," while others that are no longer believed to be worthy of the claim can. This example illuminates the shortcomings of static regulations and slow-moving bureaucratic processes, in particular as related to the aim of promoting nutrition and public health. This, in turn, raises questions about whether governments have an ethical obligation to regulate in ways that are current and responsive to evolving scientific consensus.

Another issue is the “health halo” effect, in which truthful claims about specific ingredients or attributes (for example, “no cholesterol”) make consumers more likely to conclude that the product has other attributes (for example, low in fat) and to increase consumers’ perceptions of the product’s healthfulness (Andrews et al. 1998; Fernan et al. 2018). Because consumers are so motivated to seek out healthier foods – and approximately 80% state that they consult statements about health benefits on food product labels when deciding what to purchase – producers are compelled to emblazon their product labels with these kinds of ingredient- or nutrient-focused health claims (IFIC 2017). But researchers have concluded that Front-of-the-Pack nutrition labels, a type of health claim, leads consumers to hold more positive attitudes and show a greater willingness to buy food products, regardless of their actual healthiness (Talati et al. 2016). Thus, even when food labeling is technically accurate, it can mislead consumers and oversell the health benefits of products. A closely related issue is that ethics claims on products also make consumers more likely to perceive it as healthier: for example, foods labeled “fair trade” or “organic” are more likely to be perceived as lower-calorie (Schuldt et al. 2012; Schuldt and Schwarz 2010).

Also of concern is that food producers may seize on popular diets that are motivated (at least in part) by health concerns and formulate not-especially-healthy products for adherents of that diet. For example, vegan diets, which may be motivated by health concerns or other concerns (Allison et al. 2018; Greenebaum 2015), are associated with certain health benefits (Dinu et al. 2017). But as veganism has grown in popularity (GlobalData 2017), the market has been flooded with products designed to appeal to consumers who eschew animal products. Many of these products, tasty, appealing, and convenient though they may be, are high in nutrients of concern, such as sugar, sodium, and saturated fat. Thus, even products designed for consumers who have chosen dietary patterns for their health benefits may fall short on that account.

Additionally, some products that might uncontroversially be considered healthy based on their nutritional profiles may expose the tensions between the healthfulness of certain foods for the consumer and their deleterious effects of their production on the environment and public health. For example, almonds are prized for the health benefits and recommended by many nutritionists. 82% of global almond production takes place in California, mostly in the San Joaquin Valley, which has experienced severe drought conditions and aquifer depletion in recent years (Pierson 2014). California almond growers use three million acre feet of water – between 7% and 10% of the states developed water consumption each year, competing with nearby municipalities and their residents for a scarce, life-sustaining resource (Holthaus 2014). While foods such as almonds might have strongly salutary effects on the health those who consume them, these health benefits may come at the expense of those who live and work in the regions where these foods are produced or processed. This raises the question: if foods that promote the individual consumer’s nutrition and health are produced in ways posing risks for public health, what does informative, non-misleading marketing of these products require?

Healthy Eating as Adopted by Individuals and Families in High-Income Countries

Healthy eating is also a personal goal and priority for some individuals and families, and this raises additional ethical issues. According to survey data in the United States, consumers are highly attentive to the connections between diet and health. Subordinate only to taste appeal and price, the healthfulness of a food has been the third most significant driver of food choice. Convenience ranks fourth and concerns for sustainability ranks a distant – but upward trending – fifth. (IFIC 2018). While consumer attentiveness to food and health can be observed in many contexts, it is especially revealing to analyze the online searches that consumers conduct to access information about food. The most common searches related to food were "Ingredients in Food," "Impact of Food on Health," and "Food Safety" (CFI 2018). While drivers of food choice and their priority likely vary around the world, the multiplicity of motivation is universal.

From one perspective, consumers embracing healthy eating is an unalloyed good: if people perceive healthy eating as valuable, and their healthy eating efforts will improve public health, which has social value, this seems like a win-win. Who could argue with individuals and families embracing healthy eating? In fact, there are some ethical complexities that deserve attention. We here discuss just three of these ethical complexities. First, we consider how the economic costs of healthy eating – in terms of both money and time – raise equity issues. Next, we identify trade-offs between optimizing nutrition for oneself or one's own family and optimizing food choice along other ethically important dimensions, including concern for the welfare of the planet, other people, and other living beings. Finally, we acknowledge that healthy eating efforts can be interlaced with or veer into disordered eating and that healthy eating messaging and tools can unintentionally promote conditions such as orthorexia, the obsessive pursuit of a proper, healthful, or so-called "clean" diet.

Healthy Eating, Home Cooking, and Equity

Healthy eating has economic costs, including both money and time costs. These costs, and how these costs are distributed across groups, may raise equity issues. Healthier food can cost more – for example, an average $1.50 more per person per day in the United States (Rao et al. 2013). Moreover, many consumers have been conditioned to believe that healthier foods will or ought to cost more, which allows food producers to command higher prices for such foods without upsetting expectations (Haws et al. 2017). A common bit of advice to those wishing to eat more healthfully is to cook meals for themselves and eat at home. However, to cook healthy meals at home, you must have kitchen equipment, and a kitchen, which not all families have. For example, in a study of 150 American mothers of different income levels, Bowen et al. (2014) found that lower-income mothers often had cramped kitchens and lacked “basic kitchen tools like sharp knives, cutting boards, pots and pans,” making it virtually impossible to make a home-cooked meal.

Along with requiring resources, cooking healthy meals at home takes more time. Healthy eating at home involves various kinds of *feeding work* – cooking meals, but also shopping, cleaning up, planning, understanding family member’s preferences, keeping track of what’s in the refrigerator, learning about healthy eating, and so forth (Carrington 1999). Regularly cooking healthier food also requires a predictable work schedule, which not everyone has, particularly lower income workers (Bowen et al. 2014).

There is a gendered division of feeding work – globally, women as compared to men do 85–90% of household food preparation, as measured in hours of work (United Nations World Food Programme 2019) – and some have expressed concerns that the promotion of healthy eating and home cooking will exacerbate this unequal division of time spent on feeding work. The available data and discussion in the literature largely focuses on cisgender people in different-sex couples, which is what we focus on here. Research (including time-use data, surveys, and interviews) generally shows that same-sex couples have a less specialized and more equal division of domestic work, as compared to different-sex couples, though Carrington (1999) found an unequal division of domestic work in most lesbigay couples he studied (Rothblum 2017). While there is not yet a robust literature on the domestic and feeding labor by transgender and non-binary people, one qualitative study of partnerships between women and trans-men revealed a lack of egalitarianism, a falling back to more traditional gender roles (especially after transition), and indicated that the women in these partnerships often do a disproportionate amount of the domestic work (Pfeffer 2010).

Scholars also express concerns that the societal emphasis on healthy eating reinforces certain ideologies of motherhood and a gendered division of moral responsibility for children’s and families’ eating and health, in which mothers are given more responsibility for children’s health, are expected to engage in a kind of “intensive mothering” that optimizes children’s health and well-being, and are subject to scrutiny and blame about their children’s eating, weight, and health, in particular low income mothers who have frequent contacts with social service system (Hays 1998; De Brún et al. 2013; Elliott and Bowen 2018). In practice, what is consumed within families is influenced by all family members and results from negotiations and compromises (Backett-Milburn et al. 2006; Eldridge and Murcott 2000). Indeed, mothers, including those who fill their role “intensively,” may find their efforts undermined by fathers, who may subvert healthy-eating efforts by favoring fast food and processed meals explicitly avoided by mothers when tasked with feeding the family (Fielding-Singh 2017). Thus, in opposite-sex co-parenting situations where this pattern holds, mothers may find themselves simultaneously undermined and blamed.

For some women, feeding work is a source of joy and satisfaction, and an expression of their identities as women and mothers that they have embraced. For example, Counihan (1988), writing in 1988, describes how Italian women's identity centers around taking care of their families and how food preparation gives them satisfaction and influence within their families. Feeding work remains a valued part of some women's identities, even in new ways: the work of Emily Matchar describes how in the 2000s, an increasing number of (college-educated, white) American women embraced intensive homemaking – including activities like raising chickens, beekeeping, canning vegetables, and making jam – as a form of resistance to the industrial food system and a form of virtuous living (Matchar 2013a). For other women, however, feeding work is not valued in these ways (Matchar 2013b). For example, Bowen et al. (2014) found that for many mothers, making home-cooked meals is a frustrating and stressful experience that requires them to navigate family member's different preferences and brings interpersonal conflict. "We rarely observed a meal in which at least one family member didn't complain about the food they were served," they report.

Thus there are various ways in which healthy eating can exacerbate gender inequities and can be unrealistic for lower income people. Some argue that rather than emphasizing the importance of preparing healthy, home-cooked meals and expecting people to achieve that goal despite multiple constraints, we should look for more equitable and effective approaches, such as cafeterias offering affordable healthy meals for families (Matchar 2013b) or a range of other options:

> So let's move this conversation out of the kitchen, and brainstorm more creative solutions for sharing the work of feeding families. How about a revival of monthly town suppers, or healthy food trucks? Or perhaps we should rethink how we do meals in schools and workplaces, making lunch an opportunity for savoring and sharing food. Could schools offer to-go meals that families could easily heat up on busy weeknights? Without creative solutions like these, suggesting that we return to the kitchen *en masse* will do little more than increase the burden so many women already bear. (Bowen et al. 2014)

Trade-Offs Between Optimizing Nutrition and Other Ethical Goods

Another ethical issue is that there are trade-offs, when adopting dietary patterns and when choosing specific foods, between optimizing personal nutrition and other ethically important attributes of food. For example, efforts to reap the much-touted nutritional benefits of protein-dense foods, some eaters in relatively wealthy societies rely heavily on animal-source foods as a central component of their diet. Undoubtedly, beef, pork, and chicken offer a hefty amount of this favored macronutrient – along with substantial amounts of micronutrients such as vitamin A, vitamin B-12, riboflavin, calcium, iron, and zinc that can be difficult to access elsewhere (Dewey and Adu-Afarwuah 2008). On the other hand, meat and poultry products come with an outsized greenhouse gas footprint (WRI 2016; Clonan and Holdsworth 2012) and raise concerns about the welfare of livestock and the moral implications of creating and slaughtering animals to satisfy our food preferences. Similarly, some fish that offer omega-3s, a nutrient that is typically under-represented in Western diets, are threatened and nearing extinction (Haelewater 2013). While it is true that the health of human beings cannot be wholly decoupled from the health of ecosystems and the functioning of planetary systems (Johnston et al. 2014), there can be moral and practical tensions between optimizing one's own health (or that of one's family) and trying to adhere to a dietary pattern that is environmentally and ecologically sustainable. To square this circle, researchers and advocates increasingly promote "healthy, sustainable diets" – dietary patterns that are good for individual health while limiting the negative environmental impacts of food production (EAT Lancet Commission 2019).

Unintentional Prompting of Orthorexia

Persuasive strategies to promote healthy eating, often paired with messages about physical fitness, come from all quarters. Government initiatives, such as the United Kingdom's 5-a-Day campaign, encourage consumption of more fruits and vegetables (Heimendinger et al. 1996). Schools run anti-obesity program that emphasize balanced diets, portion control, and physical activity (Shirley et al. 2015). Label claims and food advertisements tout the subject-product's health or weight loss-supporting attributes. Social media is filled with "influencers" who provide constant streams of "#fitspo" photos and posts, which aim to inspire followers to adopt optimally healthy diet, exercise, and wellness habits (Khamis et al. 2017; Carrotte et al. 2015). And popular mobile apps, such as MyFitnessPal, encourage health-conscious users to log everything they eat and drink, keep track of their weight, and review analytics about their daily consumption and longitudinal dietary trends. When healthy eating messages are continually reinforced and linked with pursuit of the "perfect body" or of assiduous avoidance of vaguely defined toxins, as is the focus of the clean eating movement, these messages may trigger a recently recognized type of disordered eating – orthorexia, which has been described as "pathologic obsession for biologically pure foods which can cause substantial dietetic limitations and which is able to lead to obsessive thoughts about foods, affective dissatisfactions and intense social isolation" (Brytek-Matera 2012; Turner and Lefevre 2017). Finding the line between promoting health and contributing to orthorexia requires care. Some point to an obligation on the part of influential message-makers to ensure that the content they develop portrays responsible health messages and encourage further research to understand the role that health and fitness influencers have on the dietary patterns, body image, and health behaviors of their followers (Carrotte et al. 2015).

Conclusion

This chapter has drawn upon the work of scholars (primarily ethicists), popular commentators, and market researchers to survey a set of ethical issues related to healthy eating as a public health goal, as a marketing opportunity for the food industry, and as a project undertaken by individuals and families. It introduces the rich ethical debate about food and health taking place among academics, advocates, policymakers, and the public. This ethical debate is bound to continue, given the intense interest in healthy eating among both consumers and the public health community and the plurality of values and ethical views about the same.

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Measuring Meaning of Food in Life

57

Klaus G. Grunert

Contents

Abstract

This chapter introduces the means-end approach to the analysis of the meaning that food has to people. Food has meaning for people because of the goals they attach to food and eating, and research shows that these goals are many and diverse, extending far beyond the basic goal of nutrition and survival. The means-end approach can be used to analyze the meaning that people attach to a particular food product or the meaning that people attach to food in general. For the former, the laddering interview technique is usually used, and results are presented in so-called hierarchical value maps, and several examples are presented. For the latter, food-related lifestyle is a survey instrument that maps the role that food has for people in attaining life values. The main use of this instrument has been for segmentation, and a number of generic segments are presented that emerge from

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numerous studies that have used this instrument. The chapter closes with perspectives for future work in measuring the meaning of food in life.

The Many Meanings of Food

Without food there is no life. Food provides nutrition which ensures survival. But beyond this most basic role of food in life, food has many other functions in life. Food is a genuine form of pleasure and gratification. Food is a means to socialize, providing cohesion in family life or a platform on which to make or keep friends. Food is part of the cultural heritage, and this provides a means of reproducing cultural identity. For some people, it is a means to live out creativity and curiousness and to achieve stimulation. For others, it is a way to create stability in a life that sometimes can be volatile and unpredictable. For many, preparing meals is a way of achieving recognition and personal growth.

Thus, the meanings of food in life are many. Understanding this multitude of meanings has been of interest to a range of researchers almost as diverse as the meanings of food. Anthropologists have tried to understand the role of food in society and its evolution (Mintz and Du Bois 2002). Psychologists and sociologists have tried to understand the motives that drive food choice and eating behavior, the decision-making processes leading to food and meal choices (Shepherd and Raats 2006), and the practices that people engage in when shopping for food, preparing meals, and consuming them alone or with family and friends (Poulain 2017). In addition, there is a strong interest in understanding the meanings of food in life from an applied perspective. People working with the development, production, and marketing of food products need to understand what consumers will look for in food and adapt their offerings accordingly (Grunert et al. 1995). For the past few decades, there has been considerable concern over the fact that many people practice less-than-healthy food habits, and understanding the many meanings that food has in life has been viewed as one way of devising measures that can encourage people to eat healthier (Chrysochou et al. 2010). More recently, there has been much debate about the environmental consequences of food production, and especially about the effect of specific categories like red meat, and again trying to understand the meanings that people attach to these product categories is an important element in the discussion on ways to encourage people to cut down on the consumption of those food items where production is detrimental to the environment (Schösler et al. 2012).

It has probably become clear that the topic of understanding and measuring the meaning of food in life is vast and diverse. There is no way in which we can cover all possible approaches to this in this chapter. Our aim here is more modest: After a brief overview of possible approaches to measuring the meaning of food in life in the next section, we will concentrate on one particular approach that we regard as especially promising and that has proved its usefulness over the past 30 years or so, namely, the means-end approach. We will then devote the rest of the chapter to discussing the means-end approach first to analyzing the meaning of food products and then to analyzing the meaning of food in life in general.

Approaches to Measuring the Meaning of Food

We view "meaning" here as a subjective construct – something that is developed in or in the interaction of minds of people. Two basic distinctions will be introduced here: meaning as a cultural or as an individual construct and meaning as attached to different food products or to food in general. Each of these calls for different measurement approaches.

Culture can be defined as "a system of values and norms that are shared among a group of people and then taken together constitute a design for living" (Hill 1997, p. 67). Food achieves cultural meaning by becoming part of or attached to these cultural values and norms. Cultural values and norms are learned by socialization processes starting in early childhood and once internalized may not be consciously realized, influencing behavior by automatic or semiconscious processes. Cultural meanings of food are therefore difficult to elicit by direct questioning and ethnographic methods that rely on a combination of observational and interviewing techniques are therefore prominent in this field. This notwithstanding, cultural differences in values and norms have been analyzed by survey techniques (the most prominent examples being the Hofstede values (see, e.g., Hofstede 1991), and the Schwartz cultural dimensions of values, Schwartz 1994), and this can be extended to the analysis of cultural differences in the meaning of food, although this raises a host of problems with regard to intercultural validity (see Grunert 2019).

Individual meanings of food are embedded in the cultural meanings, but the analysis of individual meanings of food emphasizes individual idiosyncrasies and/or the identification of groups of people with similar meanings within a cultural unit. Individual meanings of food are mostly analyzed by various versions of qualitative interview techniques and quantitative surveys, reflecting the conviction that such meanings are amenable to conscious individual reflection and hence also to verbal communication.

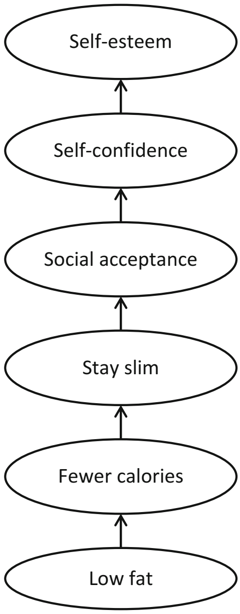
Food-related meanings can be analyzed at different levels of abstraction. At the lower level of abstraction, it is common to analyze the meaning that consumers attach to specific food products and their attributes. Meanings can be and are also analyzed with regard to many other elements of daily food-related life, like brands, stores, shopping routines, modes of preparation, meals, and festivities. Each of these can be analyzed at the individual and at the cultural level.

The Means-End Approach to Foods

Theory

Things acquire a meaning if we can mentally link them to some type of goal or purpose. If we cannot see a goal or purpose, we designate things as "meaningless." Means-end theory has been an approach to the analysis of consumer behavior that attempts to understand the subjective meanings of products and services by looking at how consumers mentally link them to self-relevant consequences and from there

Fig. 1 Example of a means-end chain



to desirable life values (see Gutman 1982, introducing the concept to consumer research, and Costa et al. 2004, and Grunert 2010, for newer overviews). Figure 1 shows a simple example: low-fat ice cream is desired by a consumer because it is known to have fewer calories, which leads to the desirable consequences of slimming and social acceptance, which in turn are related to self-confidence and, eventually, self-esteem. By looking at this means-end chain, we can understand what makes low-fat ice cream desirable for this consumer and which meaning he/she attaches to it.

There are two major theoretical roots to this concept. One is research on life values, which was pioneered by Rokeach (1973) and later brought to prominence also in a cross-cultural context by Schwartz (1992). Life values are basic motivators that drive our choices across a wide range of life situations (Schwartz and Bilsky 1987), and they are viewed as culturally universal. However, because they are abstract, their direct relation to behavior and choices involving concrete objects is usually weak (Vinson et al. 1977). Means-end theory solves this by invoking the idea of a hierarchy of concepts ordered by abstractness, with values being the most abstract, products/services and their characteristics the most concrete, and personally relevant consequences in between. In invoking this idea about a hierarchy of concepts ordered by abstractness, means-end theory draws on Kelly's personal construct theory (Kelly 1955). Kelly's theory is a cognitive theory of personality, and the main premise is that people construe the world by interpreting events through a hierarchical system of bipolar constructs, which allows people to make predictions about the outcomes of these events. Applied to food, this means that people construe the meaning of food by categorizing a particular food item in terms of its characteristics, in terms of the consequences expected because of these characteristics, and in terms of how this food will contribute to attaining important life values, as the example in Fig. 1 demonstrates.

Means-end theory has frequently been applied to understand the meaning of food (see below for examples), but we should note that it has also been applied to many other aspects of consumer behavior (see the contributions in Reynolds and Olson 2001) and even to understanding the meaning that people assign to as diverse phenomena as architecture (Lundgren and Lic 2010) and information systems (Chiu 2005).

Methodology

Measuring meaning structures based on means-end theory usually employs an interview technique called *laddering*. Laddering was developed in the context of Kelly's personal construct theory by Hinkle (1965) and has been the standard tool in means-end research. The basic idea of the method is to ask a respondent a series of questions that leads him/her to construct a means-end chain starting from the bottom – the concrete end – and then push him/her up a ladder of abstraction, hence the name (see also Fig. 2).

Data collection consists of two phases, a first phase eliciting attributes of the foods to be analyzed and a second phase where attributes are extended to ladders by a series of prompts. In the example in Fig. 1, the attribute "low fat" could, for example, be elicited by asking the respondent which attributes are important for her when buying ice cream. Based on that, the respondent would be asked why it is important for her to buy ice cream that is low in fat, generating the answer that this implies lower calories. This in turn would lead the interviewer to ask why it is important to the respondent to buy ice cream which is low in calories, and this process of prompting with "Why?" questions would continue until the value level is reached. The sequence of answers constitutes a "ladder," and typically two to five ladders are generated per respondent in a laddering interview. Analysis of the data consists of three phases: the raw ladders are coded into a smaller set of categories,

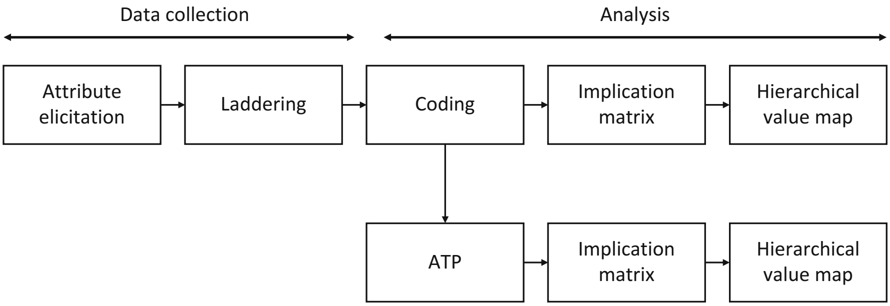


Fig. 2 Basic paradigm of conducting means-end research

which then form the basis for the computation of an implication matrix. This is a symmetric matrix with the categories that result from the coding process defining both the rows and the columns, and the information in the cells are frequencies of how often a certain category succeeds another across the set of ladders (e.g., still following Fig. 1, how many respondents said that selecting an ice cream with low fat implies fewer calories). In the last step, this implication matrix is turned into a hierarchical value map, which has been the most common way of presenting and interpreting laddering data. A hierarchical value map is simply a graph showing those links between attributes, consequences, and values where the frequency of that particular link in the implication matrix surpasses a cutoff level chosen by the researcher. This basic setup, described by Reynolds and Gutman (Reynolds and Gutman 1988), is largely still followed today, although there has been a host of extensions and modifications regarding the elicitation technique (Bech-Larsen and Nielsen 1999; Steenkamp and van Trijp 1997), the way of questioning (Grunert and Grunert 1995), and the analysis of the implication matrix (e.g., Aurifeille and Valette-Florence 1995; Kaciak and Cullen 2006; Valette-Florence 1998). Software tools have been developed to aid in the analysis, most notably MECANALYST and LADDERUX.

Laddering is a qualitative technique used on small samples. For validation of the results in larger samples, the association pattern technique (APT) has been developed (Ter Hofstede et al. 1998). It essentially consists of two empty matrices, one linking attributes and consequences and another linking consequences and values, where respondents are asked to tick those cells where they believe there is an association. The data can be interpreted in terms of response probabilities and can be used as input both for the derivation of hierarchical value maps and for analytical techniques aimed at market segmentation (Ter Hofstede et al. 1999).

Examples

Numerous studies have been published applying the means-end approach to the food domain, and an unknown number of studies have been conducted as part of proprietary corporate research. They share the basic aim of understanding the meaning that consumers assign to a food product and its characteristics or, put another way, the reasons why a food product is a meaningful choice for some consumers. Sometimes, this interest is linked to a product category, sometimes to a particular (often branded) product, and sometimes to products with a special characteristic. Sometimes means-end based studies have been used trying to understand cultural differences in attaching meaning to food (e.g., Nielsen et al. 1998), and in its quantitative version, it can and has been used for consumer segmentation (Ter Hofstede et al. 1999). In terms of practical applications, the two major types of applications have been in product development and in communication design. In product development, the major thrust is in understanding which perceived self-relevant consequences and values are meaning-giving for a particular product category and which product attributes they are inferred from by consumers and then designing a product that consumers will perceived as valuable, also compared to competing products (e.g., Grunert and Valli 2001). In communication design, the main idea is that strong product-related communication should communicate a complete chain including attributes, consequences, and values: Communicating consequences claims benefits for the consumer, communicating values provides motivation, and communicating attributes provides credibility to the claim about consequences. This line of thinking and its implications have been elaborated in the MECCAS model (Reynolds and Craddock 1988; Bech-Larsen 2001).

In the following, we will provide four examples of results from studies using the means-end approach and the laddering method in the food domain. In all four cases, results are shown as hierarchical value maps, the main tool used for communicating results from laddering studies.

Figure 3 shows results from an unpublished study on yoghurt in Italy, based on laddering interviews with 15 shoppers (This is from the study Drivers of Choice conducted by the European Food Information Council and directed by Sophie Hieke and Klaus G. Grunert.). The laddering took point of departure in actual choices made by the respondents as documented in cashier tills, which were used to elicit attributes to start the laddering interview. The results in Fig. 3 show that two consequences dominate in the meaning that these consumers attach to yoghurt, namely, *enjoyable consumption* and *good for health*, a result that is rather ubiquitous for this type of study in the food domain. These consequences are inferred from a range of attributes, mostly linked to ingredients and the sensory profile of the product. Interestingly, enjoyable consumption and healthiness are interlinked – the enjoyable consumption is perceived to lead also to consuming a more healthy, balanced, and moderate diet,

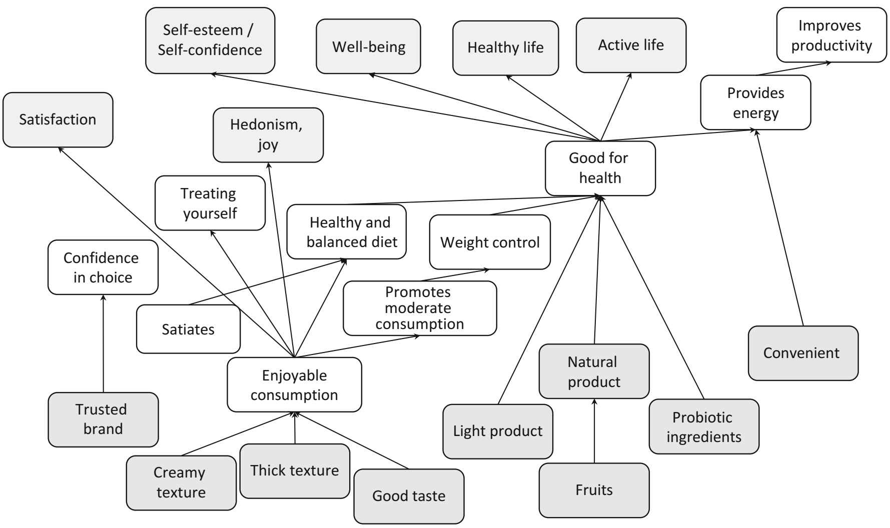


Fig. 3 HVM for yoghurt, Italian respondents

which in turn is perceived to affect health. Both health and enjoyment are related to a range of values from mostly hedonic and individualistic value domains.

The study from which Fig. 4 is derived (De Ferran and Grunert 2007) is an example of research trying to understand what a particular product attribute means to consumers, in this case the attribute "fair trade" in the coffee category. Based on a sample of French consumers, the study shows that consumers link trade to a number of socioeconomic benefits like economic aid, equality, and human rights, which in turn are linked to both collectivistic and individualistic values. In addition, fair trade products are also perceived as being of better taste and quality. The study also showed that the meaning that consumers attach to the fair trade attribute differs depending on where consumers buy these products – those buying them from specialty stores perceive them differently from those buying them in supermarkets (only the latter are shown in Fig. 4).

Arsil et al. (2018) also investigated the meaning that consumers attach to a credence attribute, namely, halal slaughtering of meat, in Indonesia and Malaysia. Figure 5 shows the results from the Malaysian sample. The central perceived self-relevant consequence is ordinance to Allah, which in turn is related to a range of more spiritual values but also to an expected consequence of better health.

Our final example, in Fig. 6, relates to a food service. Jeng and Yeh (2016) used the laddering approach to analyze the way in which restaurant customers in Taiwan view restaurants that position themselves as "green." The results show that the "green" positioning means to consumers both environmental benefits like energy conservation and use of recyclable materials and expectations about better taste and use of local ingredients, leading to the attainment of both personal and social values.

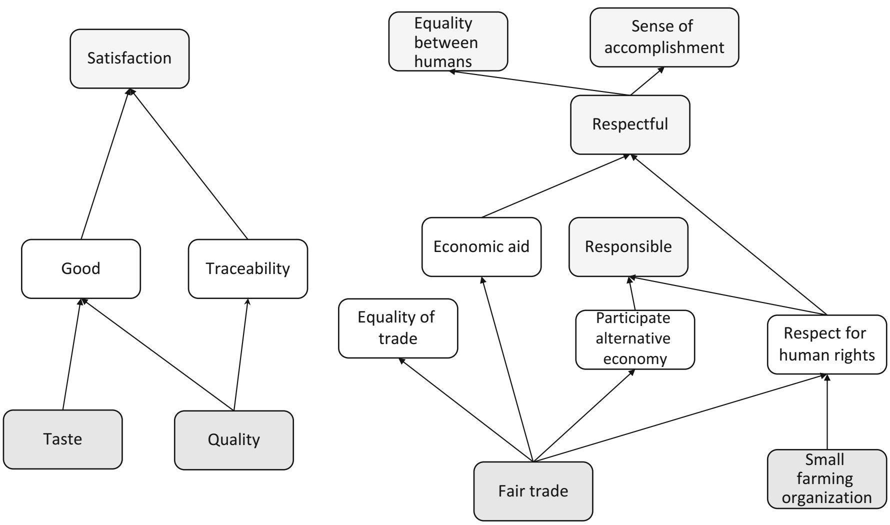


Fig. 4 HVM for fair trade coffee bought in supermarkets, French respondents. (Adapted from De Ferran and Grunert 2007)

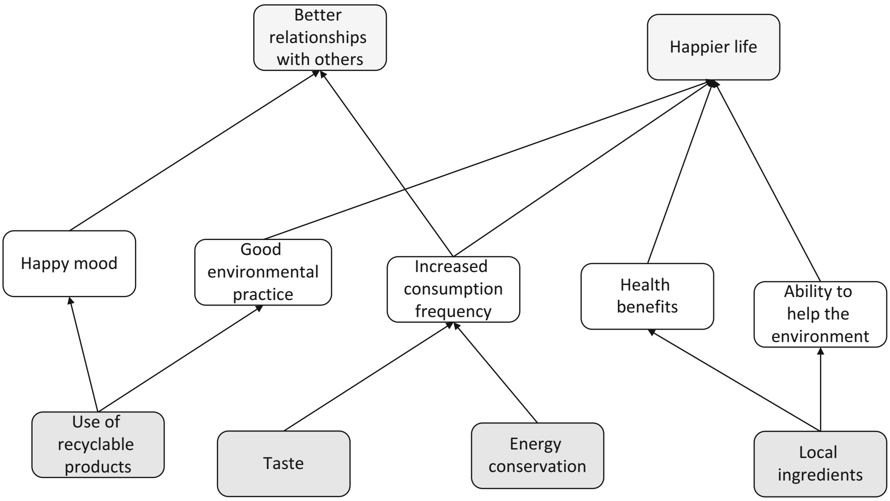


Fig. 5 HVM for halal meat, Malaysian respondents. (Adapted from Arsil et al. 2018)

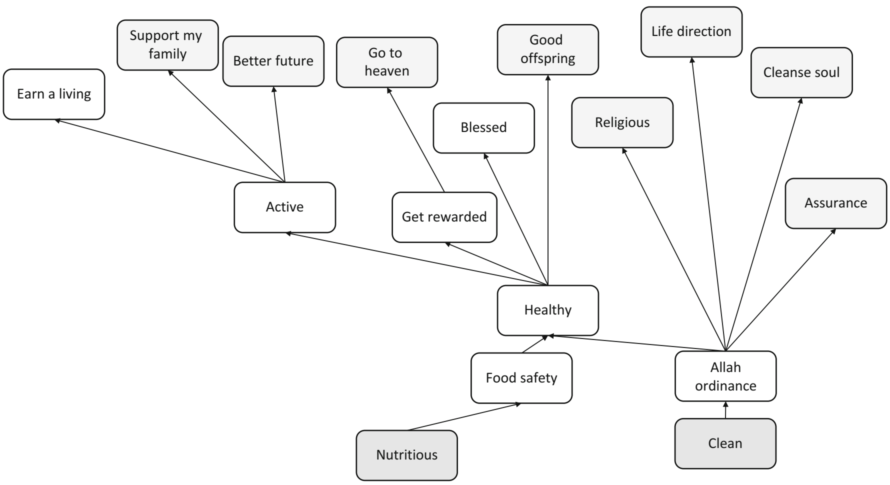


Fig. 6 HVM for restaurant with green positioning, Chinese respondents. (Adapted from Jeng and Yeh 2016)

As the examples show, the means-end approach allows us to understand the way in which consumers attach meaning to options that they have when making food-related decisions – which product to buy and which restaurant to choose. The insights obtained are thus at a microlevel, related to the thousands of decisions that consumers make related to food. Can the means-end approach also be applied to obtain a better understanding of the role that food in general has in the life of people? This we will address in the next section.

A Means-End Approach to Food-Related Lifestyle

Theory

If we can use the means-end approach to analyze the meaning that individual food products have to people, we should be able to do something similar to understand the role that food in a more general sense has in the life of people. Everyday observation suggests that the role of food in life differs between people. Everybody needs to eat, but not everybody is equally interested in food. For some people, food just seems to be a necessity, and the important things in life are something else. For other people, food is enormously important, and they spend considerable resources in terms of both time and money on buying food, preparing meals, eating at home, and eating out. In terms of the means-end approach, this suggests that for some people food has a major role in achieving these peoples' life values, whereas other people try to attain their central life values in other domains of life, not food. People thus differ in the degree of their involvement with food (Bell and Marshall 2003), and they differ in the reasons for the degree of involvement that they have with food.

This basic idea has been embodied in the food-related lifestyle (FRL) concept (see Brunsø et al. 2004). Food-related lifestyle tries to map how people use – or don't use – the food domain to achieve those values that are central to them. Just like product-related means-end chains, it is a cognitive concept that tries to uncover how people, in their minds, relate a range of food-related behaviors to the attainment of life values. The products that people buy are a part of this, but food-related lifestyle also covers those cognitions, both declarative and procedural, that govern shopping behavior, meal preparation, consumption situations, and purchase motives. It is conceived as a means-end approach to lifestyle, providing the bridge between concrete behaviors and preferences on the one side and abstract life values on the other side in a specific domain of life, food.

The concept of food-related lifestyle was originally developed as a segmentation tool to be used by the food industry. Lifestyle is a popular concept in a segmentation context, although it is often only loosely defined and covers an eclectic mix of behavioral and attitudinal concepts. In addition, lifestyle is mostly conceived as a general construct covering all domains of life. The food-related lifestyle concept differs by being defined as a cognitive construct, as being restricted to the domain of food, and by being embedded in a nomological network proposing that food-related lifestyle is related to concrete food-related behaviors on the one side and to general life values on the other. The concept of food-related lifestyle is illustrated in Fig. 7.

Methodology

A questionnaire instrument to measure food-related lifestyle was developed by Brunsø in 1997 (Brunsø 1997; Brunsø and Grunert 1998; see also Grunert et al. 2001), covering domain-specific declarative and procedural knowledge in the areas

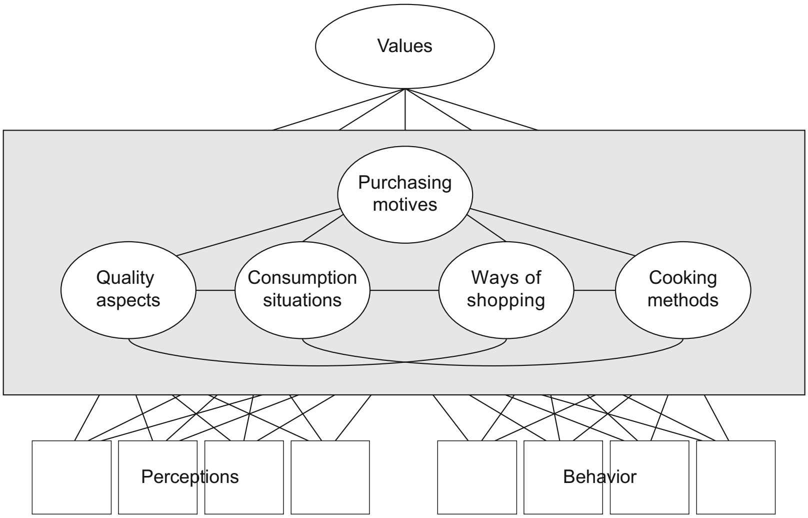


Fig. 7 The concept of food-related lifestyle

ways of shopping, *cooking methods*, *importance of quality aspects*, *consumption situations*, and *purchase motives*. Each area has several dimensions, each of which is measured by 3 items, resulting in a relatively complex instrument of 69 items. As noted above, the instrument was originally developed for distinguishing groups of consumers based on the role that food plays in their life or, to use the marketing term, to use it as an instrument for domain-specific segmentation of consumers (Grunert 2019). The segments derived can then be profiled by additional variables, like consumer demographics, but especially concrete behaviors, most notably the degree of buying certain types of foods.

The instrument was originally developed with the aim to be used in different languages and in different cultural contexts, in order to be able to investigate whether the same types of consumers can be found in different cultural contexts and, if yes, if their frequency distribution varies. For this reason, there has hence been some effort to investigate the instrument's cross-cultural validity. A rigorous analysis of measurement invariance across several European countries (Scholderer et al. 2004, later confirmed by Thøgersen 2017) showed that the instrument did exhibit configural and metric invariance, but not scalar invariance, indicating that while the meaning attached to the different parts of the instrument seems to be almost identical across cultures, there are still culture-specific biases in intercepts such that scale means of the different dimensions cannot be compared across cultures. When applied to distinguish different types of food-related lifestyle, indeed similar types emerged across a range of different applications. The instrument can also be used for tracking the incidence of different types of food-related lifestyles over time, although only one such study is known to us at present (Hansen et al. 2018).

The domain of food can be further subdivided, and accordingly lifestyle types can also be distinguished for more narrow domains. Two examples that have been prominent in the literature are wine-related lifestyle and convenience food-related lifestyle (see below for examples of this).

Finally, as the instrument has been shown to be related to a variety of food-related behaviors, the dimensions of the FRL or a subset of them can be directly used as predictors of food-related behavior, but this application is more remote from our focus on measuring the meaning of food.

While early applications of the instrument used all 69 items, later applications have sometimes selected only some of the dimensions or, when the purpose was to distinguish different consumer groups, have used only 1 item per dimension. In addition, the instrument has been validated by relating it to various aspects of self-reported food-related behavior with good results, and it has been demonstrated that the lifestyle construct indeed mediates between life values and food-related behaviors (Brunsø et al. 2004). Attempt to use the instrument outside a Western cultural context has been less successful, though (Grunert et al. 2011; Reid et al. 2001).

The FRL instrument is a complex and well-validated instrument for measuring the meaning of food in the life of people. It has been used in more than a 100 studies. Its complexity is also a limitation in its applicability, and it seems to be culturally bound to Western cultures (most studies have been conducted in Europe and to a lesser extent in Australia and North and South America). In addition, as the instrument is from 1997, some parts of it appear no longer up-to-date. For example, aspects of social responsibility and especially sustainability are not dealt with in the instrument.

Examples

As noted above, the FRL instrument was originally designed for international segmentation, i.e., to distinguish groups of consumers across national borders that exhibit distinct patterns in how they use food to attain their life values. In spite of this, only relatively few studies have actually attempted this kind of cross-country analysis (see Grunert 2019, for an overview and Thøgersen 2017, for a recent example). As noted above, the FRL instrument has been shown to exhibit metric invariance at least within Western cultural contexts, but lacks scalar invariance, implying that scale means originating from different cultures or countries are not immediately comparable. Early uses of the FRL solved this by analyzing the data on a per-country basis and then making comparisons across countries by qualitative interpretation; a modern solution to this issue is to use multilevel analysis incorporating classification by countries and segments (applied by Thøgersen 2017).

In a paper summarizing several of the earlier studies using the FRL (Grunert et al. 2001), it was shown that by analyzing data from Denmark, France, Germany, and the United Kingdom independently on a countrywide basis, archetypical types of segments seemed to emerge: an *uninvolved* segment of consumers where food did not seem to have much meaning in their life beyond ensuring survival, with low scores on most dimensions of the FRL; a *careless* segment that also puts low priority on food but that nevertheless appreciated novelty and convenience in food products; a *conservative* segment where food is important in attaining life values, mostly by sticking to traditional products, dishes, regular meal patterns, and traditional ways of preparing meals; an *adventurous* segment where food is an important part of life, mainly by providing stimulation and enacting innovation, as a platform for social interaction and achieving self-fulfillment; and finally, a rational segment with a deliberative approach to food, prioritizing health, quality, and product information. Many later studies have found similar patterns of segments. As the process of identifying segments is almost always based on some form of cluster analysis, which is an exploratory statistical technique, clusters emerging on a per-country basis are never completely similar across countries, and the naming of the segments is based on a qualitative interpretation of the pattern of segment means across the FRL dimensions. Likewise, it means that additional segments turn up and are then interpreted as country-specific idiosyncrasies.

In order to achieve a more quantitative comparison of segments across countries, Grunert et al. (2001) computed correlations of FRL dimension means for segments in four countries and visualized their patterns by putting them into a MDS algorithm. The result, shown in Fig. 8, shows that segments that had been named similarly in the different countries indeed tend to be similar, although not perfectly so. Most

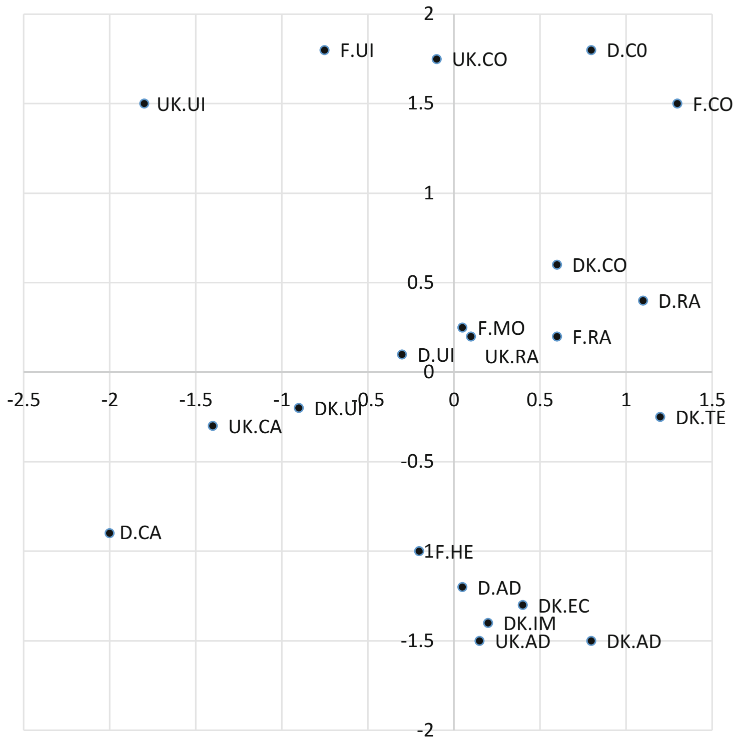


Fig. 8 MDS configuration of FRL segment means. (From Grunert et al. 2001). *DK* Denmark, *F* France, *G* Germany, *UK* United Kingdom, *UI* uninvolved, *CA* careless, *AD* adventurous, *COP* conservative, *RA* rational, *GE* hedonic, *MO* moderate, *EC* eco-healthy, *IM* impulsive, *TE* traditional involved

interesting, though, is the dimensional structure of the configuration in Fig. 8. The horizontal dimension seems to be a kind of food involvement dimension, with those segments with less interest in food – the uninvolved and the careless segments – on the left and the rest on the right. The vertical dimension seems to mirror a tradition vs. innovation dimension, with the adventurous segments at the bottom and the conservative segments in the top. Food involvement and food innovativeness thus emerge as two basic dimensions of food-related lifestyle.

An instrument like the FRL that has been around for 25 years should be ideal for tracking over time, but to our knowledge, there is only one study that has actually tried to do this, and it has used only a part of the instrument. Hansen et al. (2018) used a subset of FRL items to characterize Danish consumers by their degree of quality consciousness, as measured by their emphasis on novelty, naturalness, and convenience when shopping for food, and their general engagement with food shopping and meal preparation. They collected yearly data in the period 2014–2018 and subjected them to latent class cluster analysis, deriving three segments, the quality conscious, the moderate majority, and the uninvolved. Their results show that the size of the quality conscious segment fell continuously from 39.6% in 2014 to 24.7% in 2017, with a small rise to 26.4% in 2018. They also analyzed how these segments relate to satisfaction with food products and willingness to pay for additional quality.

A number of studies have used the FRL as a point of departure for developing instruments that can classify consumers not according to their general food-related lifestyle but with regard to a more specific part of it. Two examples will be named here. Buckley et al. (2007) segmented British consumers according their "convenience food lifestyle." They took departure in the FRL and added items that were dealing specifically with the role of convenience foods. They found four segments, two who were critical of convenience foods and two who were positive. The two who were critical, dubbed *food connoisseurs* and *home meal preparers* by Buckley et al., appear quite similar to the adventurous and conservative segments described above. The two convenience-friendly segments were called *kitchen evaders* and *convenience-seeking grazers*. Kitchen evaders are generally not much into cooking and regular meals, whereas the convenience-seeking grazers adhere to more traditional meal patterns but seek for convenience solution. Buckley et al. showed that the segments were related to a broad range of self-reported behaviors with regard to different types of convenience foods.

As another example of an instrument developed for a narrower set of food- and drink-related life, Bruwer and Li (2017) developed a wine-related lifestyle instrument, using the FRL as conceptual inspiration but developing their own items. In a series of studies in Australia, they found relatively stable segment solutions involving *involved*, *knowledge-seeking wine drinkers*, *conservative*, *knowledgeable wine drinkers*, *basic wine drinkers*, *enjoyment-oriented social wine drinkers*, and *younger*, *relative inexperienced wine drinkers*. In addition, here the basic distinctions based on degree of involvement (here with wine) and tradition vs. innovation seem to play a role.

Finally, the dimensions of the FRL have been used to predict/explain various food-related behaviors directly, without distinguishing between different groups of consumers. For example, Nijmeijer et al. (2004) specified and estimated a structural model involving FRL dimensions on quality aspects, ways of shopping, cooking methods, and purchase motives to predict vegetable consumption. They found that the role of convenience in people's food-related life had a major impact and that the major determining factors otherwise were different between boiled vegetables and salad, with planning meals and having meals as social events being related to the consumption of boiled vegetables, but not of salad.

Perspectives

In this chapter, we have introduced the means-end approach to measuring the meaning of food to people. The means-end approach analyzes the assignment of meaning by looking at how people relate phenomena – food, meals – to goals that are relevant for them. In its original form, it is used to look at the meaning people attach to individual food products, usually employing the qualitative laddering interview technique. Numerous studies have been conducted in the food domain, mainly with regard to applications in new product development and communication. At the more general level, we have introduced the food-related lifestyle approach, which maps how consumers use the food domain to reach goals in their life. Again, numerous studies have been conducted with regard to food employing this technique, mostly with regard to deriving segments of consumers that differ in the role that food plays in their lives.

We believe that these approaches have a huge potential also in future food research. Food is increasingly being developed and marketed based on intangible properties like healthfulness and sustainability, and means-end analysis can both investigate whether consumers actually view these characteristics as part of the meaning of a food product and also give inspiration on how to further consumer demand for food products that will contribute to a healthier and more sustainable life. There is still room for methodological improvement, though. Most published applications of the means-end approach employ the qualitative laddering technique. There is much less published research on its quantitative equivalent, the APT technique (or on any other quantitative equivalent, for that matter), which means that validation of the results based on a broader sample of respondents is often missing. The complexity of the data analysis may be a reason for this, and specialized software for analyzing APT data may help in promoting the use of this tool.

The food-related lifestyle approach has been used for more than 30 years. This demonstrates its usefulness but also raises the question whether the instrument is ripe for some rejuvenation. The meaning of food in life has changed during these years, most notably regarding the role of sustainability and ethical aspects in food production, which are not covered in the FRL instrument. Likewise, newer aspects of shopping for food, like online sales and the use of mobile devices, are not dealt with. A revised instrument incorporating these aspects would ensure its usefulness also for the coming decades.

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Part XII

Pathologies of Eating and Drinking

Global Trends in Obesity

58

Hyun Jung Lim, Hong Xue, and Youfa Wang

Contents

Abstract

This chapter describes the current prevalence and time trends of obesity in adults and children worldwide. The obesity epidemic has become a major public health problem in many countries, and the problem continues to grow. Obesity has many health consequences such as cardiovascular diseases, diabetes, musculoskeletal disorders, and some cancers. Worldwide obesity has nearly tripled since 1975. In 2016, 39% of adults aged 18 years and over were overweight, and 13% were obese. In just 40 years, the number of school-age children and adolescents with obesity has

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risen more than tenfold, from 11 million to 124 million. Childhood obesity has long-term effects on mortality and morbidity. Overweight and obese children are likely to maintain their status into adulthood and are at higher risks for developing chronic diseases. Moreover, a growing body of literature suggests that the socioeconomic status and obesity association is complex and varies by several demographic or environmental factors. With the progression of the obesity epidemic, it is possible that such associations (e.g., association between socioeconomic status and prevalence of obesity) may become weaker or even disappear in some industrialized countries or change direction in some developing countries in the future. The epidemic calls for timely and effective population-based approaches to prevent the condition. Obesity is largely preventable by having healthy lifestyles that include healthy eating and adequate physical activity. The development of national policies and population-based intervention programs is needed to combat the obesity epidemic and promote public health in many countries.

Introduction

The obesity epidemic has become a serious public health problem in many countries worldwide; and it is a major public health challenge of the twenty-first century. Overweight and obesity are defined as abnormal or excessive fat accumulation that presents a risk to health. According to World Health Organization (WHO), worldwide obesity has nearly tripled since 1975. In 2016, 39% of adults (more than 1.9 billion) aged 18 years and over were overweight, and 13% were obese (over 650 million). In just 40 years, the number of school-age children and adolescents with obesity has risen more than tenfold, from 11 million to 124 million (2016 estimates). In addition, an estimated 216 million were classified as overweight but not obese in 2016. The condition also affects younger children, with over 38 million children aged under 5 living with overweight or obesity in 2017 (WHO 2017).

Overweight and obesity have many health and social consequences. Raised body mass index (BMI) is a major risk factor for noncommunicable diseases such as cardiovascular diseases (mainly heart disease and stroke), which were the leading cause of death, diabetes, musculoskeletal disorders (especially osteoarthritis – a highly disabling degenerative disease of the joints), and some cancers including endometrial, breast, ovarian, prostate, liver, gallbladder, kidney, and colon (WHO 2018a).

Childhood obesity has long-term effects on mortality and morbidity. Overweight and obese children are likely to maintain their status into adulthood and are at higher risks for developing chronic diseases (WHO 2010). In addition to increased future risks, obese children experience breathing difficulties, increased risk of fractures, hypertension, early markers of cardiovascular disease, insulin resistance, and psychological effects (WHO 2018a).

The following sections describe the global epidemic in adults and children including trends over time based on recent research findings in the field. The disparities in overweight and obesity rates across world regions and among groups within countries' socioeconomic status (SES) are also discussed.

Obesity Trends in Adults

Obesity has become a global epidemic, but the prevalence has varied dramatically between world regions, countries, and population groups within counties. During the recent two decades, rates of overweight and obesity have been increasing dramatically in many countries, in particular, those with rapid economic development. In 2016, worldwide more than 1.9 billion adults aged $\geq$18 years were overweight, and 650 million adults were obese. Overall, 39% of adults aged 18 years and over (39% of men and 40% of women) were overweight. In addition, about 13% of the world's adult population (11% of men and 15% of women) were obese in 2016 (WHO 2017).

Over the past four decades, it has transitioned from a world in which underweight prevalence was more than double that of obesity, to one in which more people are obese than underweight, both globally and in all regions except parts of sub-Saharan Africa and Asia. The rate of increase in BMI since 2000 has been slower than in the preceding decades in high-income countries, where adiposity became an explicit public health concern around this time, (Bentham et al. 2016; Zhou et al. 2017) and in some middle-income countries. However, because the rate of BMI increase has accelerated in some other regions, the global increase in BMI has not slowed down. If post-2000 trends continue, not only will the world not meet the global target for halting the increase in obesity, but also severe obesity will surpass underweight in women by 2025.

In 1975, age-standardized mean BMI was less than 19 kg/m^2 in men in Timor-Leste, Burundi, India, Ethiopia, Vietnam, Rwanda, Eritrea, and Bangladesh (Fig. 1a) and 17–18 kg/m^2 in women in Bangladesh, Nepal, Timor-Leste, Burundi, Cambodia, and Vietnam (Fig. 1b). In the same year, men and women in Nauru and women in American Samoa already had a mean BMI of more than 30 kg/m^2 (Ahmad et al. 2001; Danaei et al. 2013). By 2014, age-standardized mean BMI was more than 20.0 kg/m^2 in men and more than 20.7 kg/m^2 in women in every country, with Ethiopia, Eritrea, and Timor-Leste having the lowest mean BMIs for both sexes. At the same time, in American Samoa, the age-standardized mean BMIs were 32.2 kg/m^2 (95% CrI 30.5–33.7) for men and 34.8 kg/m^2 (33.2–36.3) for women, with mean BMI also more than 30 kg/m^2 in both sexes in some other islands in Polynesia and Micronesia and in women in some countries in the Middle East and North Africa (e.g., Egypt and Kuwait) and the Caribbean (see Fig. 1).

A recent study used 1698 population-based data sources, with more than 19.2 million participants (9.9 million men and 9.3 million women) aged 18 years or older, and reported about obesity/overweight estimates in 186 of the 200 countries in the world (NCD-RisC 2016). This *Lancet* paper presented the trends in prevalence of obesity from 1975 to 2014. Prevalence of obesity (BMI $\geq$30 kg/m^2) increased by a larger amount – from 3.2% in 1975 to 10.8% in 2014 in men and from 6.4% to 14.9% in women. 2.3% of the world's men and 5.0% of women were severely obese in 2014. The global prevalence of morbid obesity (BMI $\geq$40 kg/m^2) was 0.64% in men and 1.6% in women in 2014 (NCD-RisC 2016).

Global age-standardized mean BMI in men increased from 21.7 kg/m^2 in 1975 to 24.2 kg/m^2 in 2014 and in women from 22.1 kg/m^2 in 1975 to 24.4 kg/m^2 in 2014 (Fig. 2). The mean increases of 0.63 kg/m^2 per decade for men and 0.59 kg/m^2 per

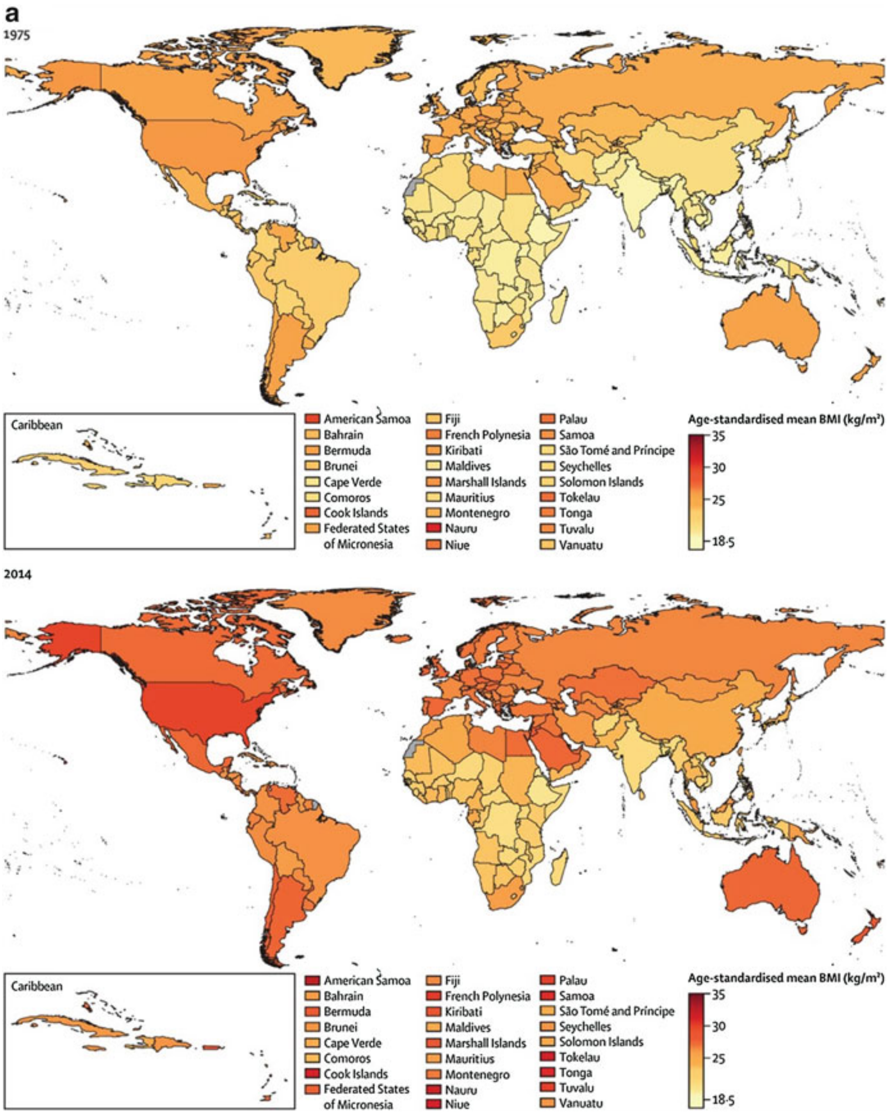


Fig. 1 (continued)

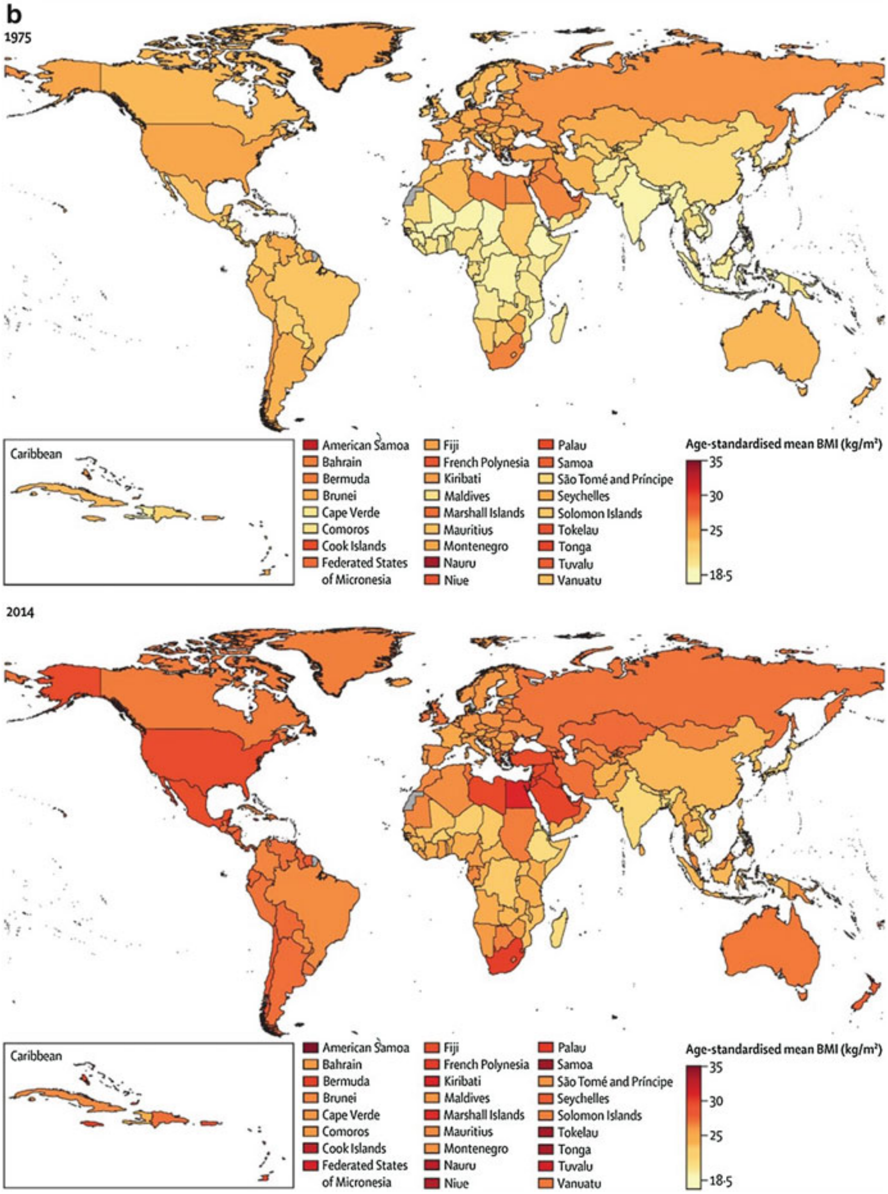


Fig. 1 Age-standardized mean BMI in adults, by sex and country in 1975 and 2014. (**a**) In men. (**b**) In women. (Adapted from NCD Risk Factor Collaboration (NCD-RisC) 2016)

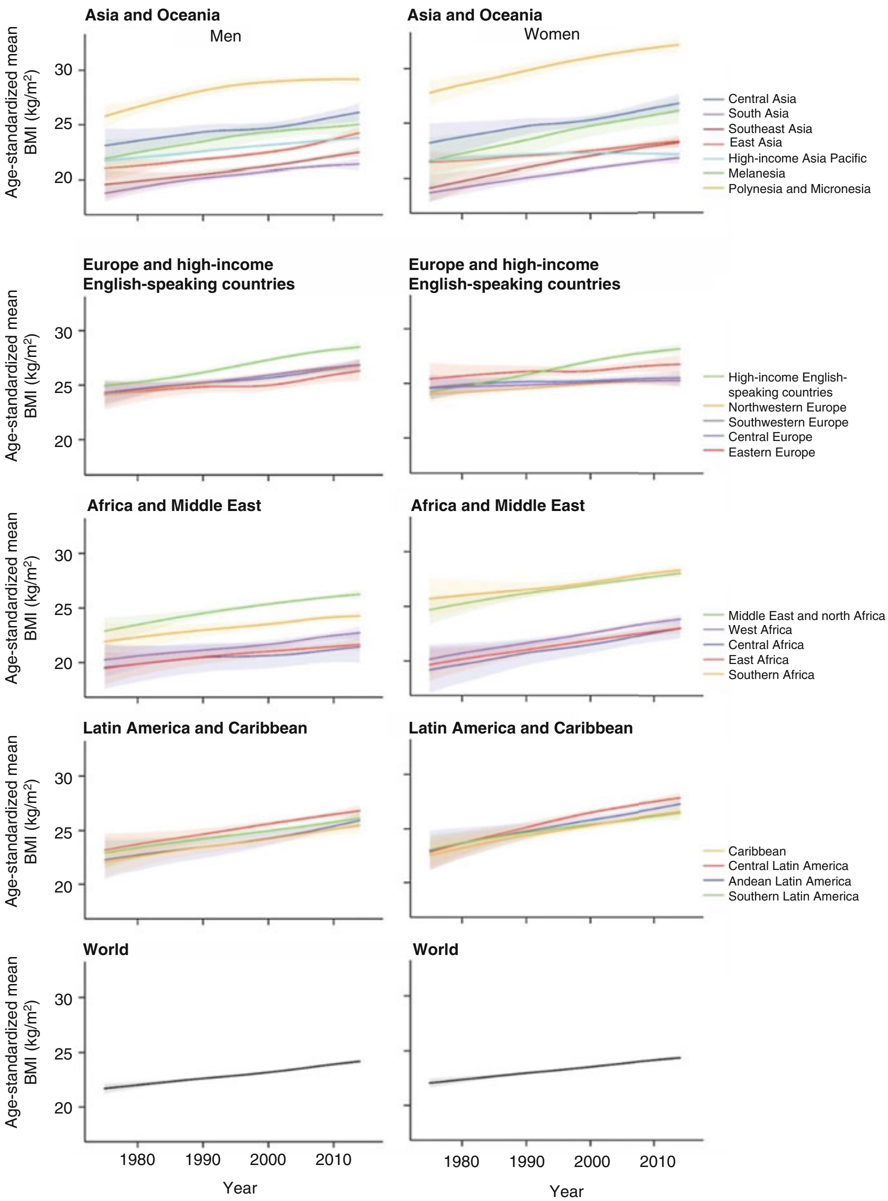


Fig. 2 Time trends in age-standardized mean BMI in adults, by sex and world region (lighter colors are 95% credible intervals): 1975–2016. (Adapted from NCD Risk Factor Collaboration (NCD-RisC 2016)

decade for women are equivalent. The world's population has become on average more than 1.5 kg heavier each decade (NCD-RisC 2016).

It is estimated 18.4% of obese adults (118 million) lived in high-income English-speaking countries, and these countries contained an even larger share of the world's severely obese people (27.1%; 50 million), followed by 13.9% (26 million) in the Middle East and North Africa. Countries with the largest number of obese and severely obese people changed over these four decades, with more middle-income countries joining the USA, especially for women. In 2014, slightly more obese men and women lived in China than in the USA, and even for severe obesity, China moved from the 60th place for men and 41st place for women in 1975, to the second highest in men and women in 2014 (NCD-RisC 2016).

Obesity Trends in Children

Childhood obesity is one of the most serious global public health challenges of the twenty-first century, affecting every country worldwide. The prevalence varied considerably across countries and is still growing in many parts of the world (Wang and Beydoun 2007; Wang and Lim 2012; Wang and Lobstein 2006). The prevalence is the highest in some Western and industrialized countries and is still low in some developing countries. The prevalence also varies by age and gender within and across countries. The rising trends in children's and adolescents' BMI have plateaued in many high-income countries, albeit at high levels, but have accelerated in parts of Asia, with trends no longer correlated with those of adults (Abarca-Gómez et al. 2017).

Although current understanding of the health consequences of overweight and obesity is predominately based on adult studies, increasing evidence suggest that childhood obesity has a number of immediate, intermediate, and long-term health consequences. Childhood obesity has long-term effects on mortality and morbidity. Overweight and obese children are likely to maintain their status into adulthood and are at higher risks for developing chronic diseases such as hypertension, dyslipidemia, type 2 diabetes, heart disease, stroke, gallbladder disease, osteoarthritis, sleep apnea and respiratory problems, and certain cancers (WHO 2010). For example, the estimated prevalence of childhood obesity and comorbidities were presented that over 0.5% have type 2 diabetes, while over 8.4% have impaired glucose tolerance, including 21.8% of hypertension and 22.1% of raised blood cholesterol levels and 23.9% of the metabolic syndrome among obese children aged 5–18 years in the EU (Tim Lobstein and Jackson-Leach 2006). Similar to, 22% of high LDL cholesterol, 14% of hypertension, and 15% of impaired glucose tolerance were reported from NHANES (1999–2008) in US adolescents aged 12–19 years. By weight categories, 49% of the overweight and 61% of the obese adolescents had $\geq$1 CVD risk factors such as hypertension, high LDL-C, and diabetes (May et al. 2012).

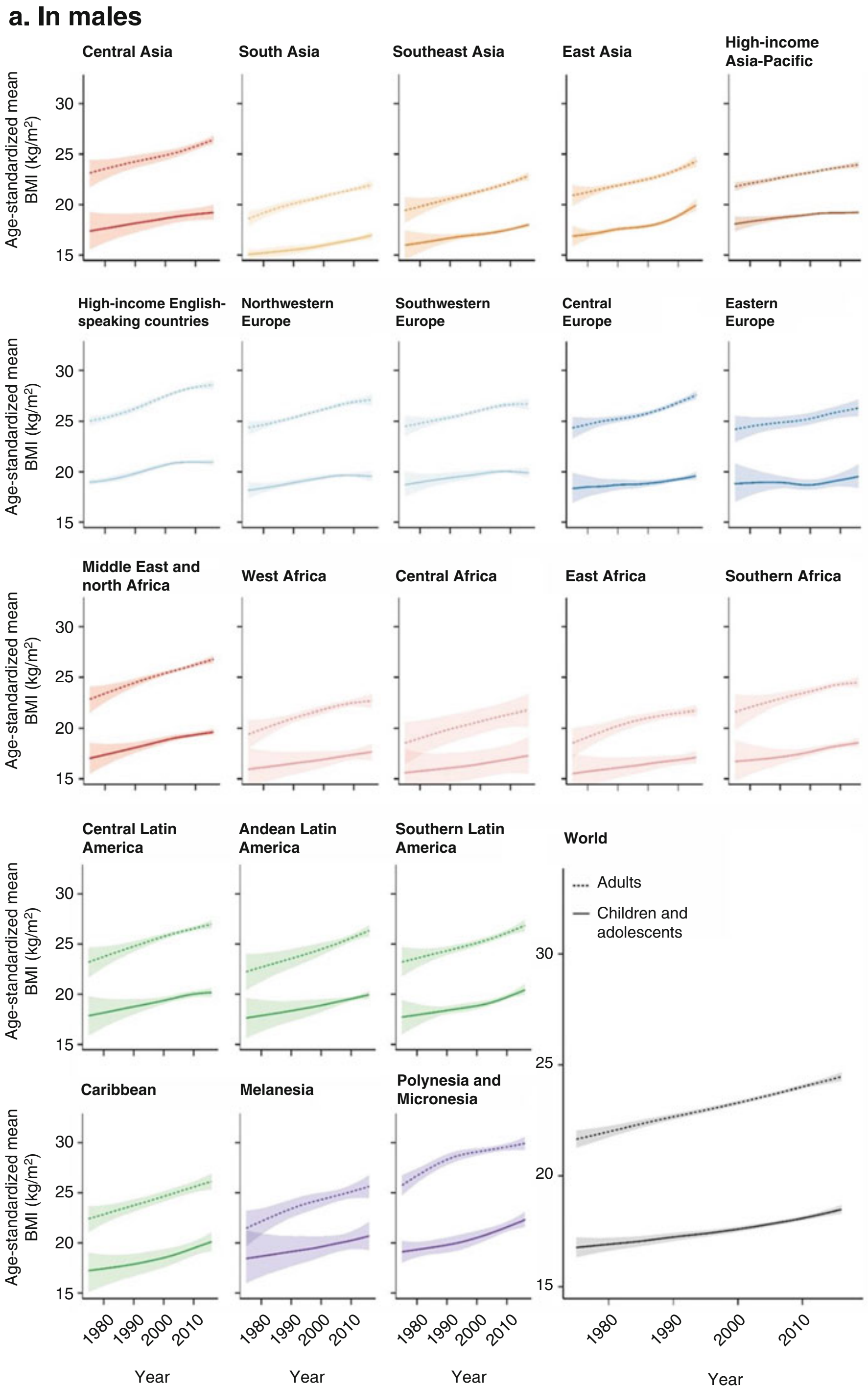
More broadly, in an unhealthy nutritional transition, an increase in nutrient-poor, energy-dense foods can lead to stunted growth along with weight gain in children, adolescents, and adults, resulting in higher BMI and worse health outcomes throughout the life-course (Abarca-Gómez et al. 2017).

In just 40 years, the number of school-age children and adolescents with obesity has risen more than tenfold, from 11 million to 124 million. In addition, an estimated 216 million were classified as overweight but not obese in 2016. The condition also affects younger children, with over 38 million children aged under 5 living with overweight or obesity in 2017 (WHO 2018b).

A recent comprehensive study pooled 2416 population-based data sources with measurement of height and weight on 128.9 million people aged > = 5 years from 1975 to 2016 (Abarca-Gómez et al. 2017). It reported that children's and adolescents' age-standardized mean BMI increased globally and in most regions (Fig. 3). In 1975, the global age-standardized mean BMI of children and adolescents aged 5–19 years was 16.8 kg/m2 (95% CrI 16.3–17.2) for boys and 17.2 kg/m2 (16.8–17.6) for girls. The global increase was 0.32 kg/m^2 per decade for girls and 0.40 kg/m^2 per decade for boys, leading to virtually identical age-standardized mean BMIs of 18.6 kg/m^2 for girls and 18.5 kg/m^2 for boys in 2016.

In the analysis of data collected over the 42 years, the global age-standardized prevalence of obesity in children and adolescents increased from 0.9% (95%CI: 0.5–1.3%) in 1975 to 7.8% (6.7–9.1%) in 2016 in boys and from 0.7% (0.4–1.2%) in 1975 to 5.6% (4.8–6.5%) in 2016 in girls. Prevalence of obesity was highest in Polynesia and Micronesia in both sexes, 25.4% (16.8–35.2%) in girls and 22.4% (13.4–32.9%) in boys, followed by the high-income English-speaking countries (Fig. 4). Obesity prevalence was more than 30% in girls in Nauru, the Cook Islands, and Palau and boys in the Cook Islands, Nauru, Palau, Niue, and American Samoa in 2016 and was also high, around or above 20%, in some countries in Polynesia and Micronesia, the Middle East and North Africa (e.g., Egypt, Kuwait, Qatar, and Saudi Arabia), the Caribbean (Bermuda and Puerto Rico), and the USA. In 1975, obesity prevalence was less than 10% in every country except Nauru and Bermuda, where it was still less than 20%. From 1975 to 2016, obesity prevalence increased in every country, although the increase was not statistically significant in some high-income countries (Abarca-Gómez et al. 2017).

Mean BMI and prevalence of obesity increased worldwide in children and adolescents from 1975 to 2016, with the rate of change in mean BMI moderately correlated with that of adults until around 2000, but only weakly correlated afterward. The trend in children's and adolescents' mean BMI has plateaued, albeit at high levels, in many high-income countries since around 2000 but has accelerated in East, South, and Southeast Asia. Despite this rise, more children and adolescents worldwide are moderately or severely underweight (75 million girls and 117 million boys) than obese. However, if post-2000 trends continue, child and adolescent obesity is expected to surpass moderate and severe underweight by 2022 (Abarca-Gómez et al. 2017).



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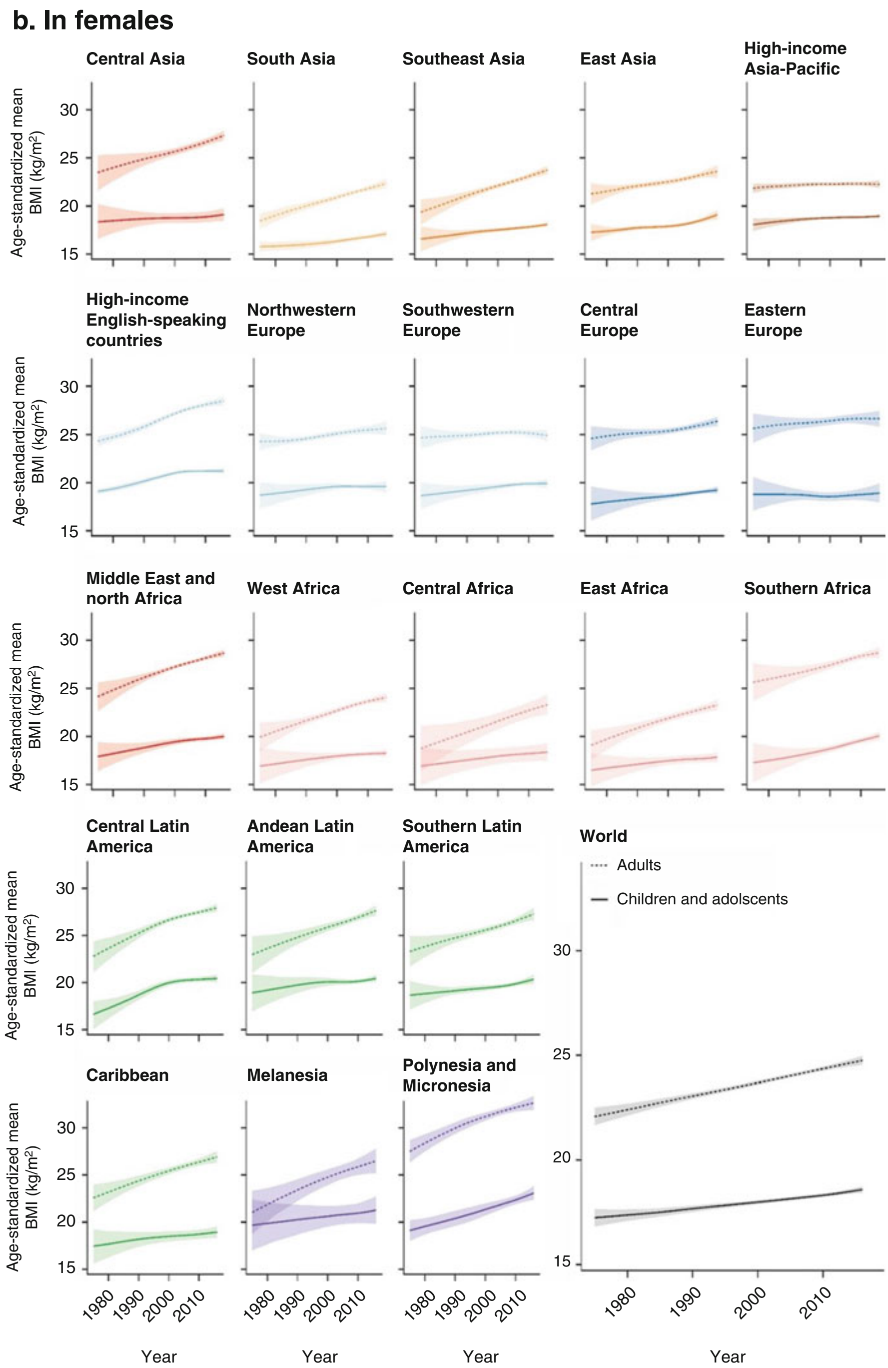

Fig. 3 Time trends in age-standardized mean BMI in adults and children, by sex and world region: 1975–2016. (**a**) In males. (**b**) In females. (Adapted from Abarca-Gómez et al. 2017)

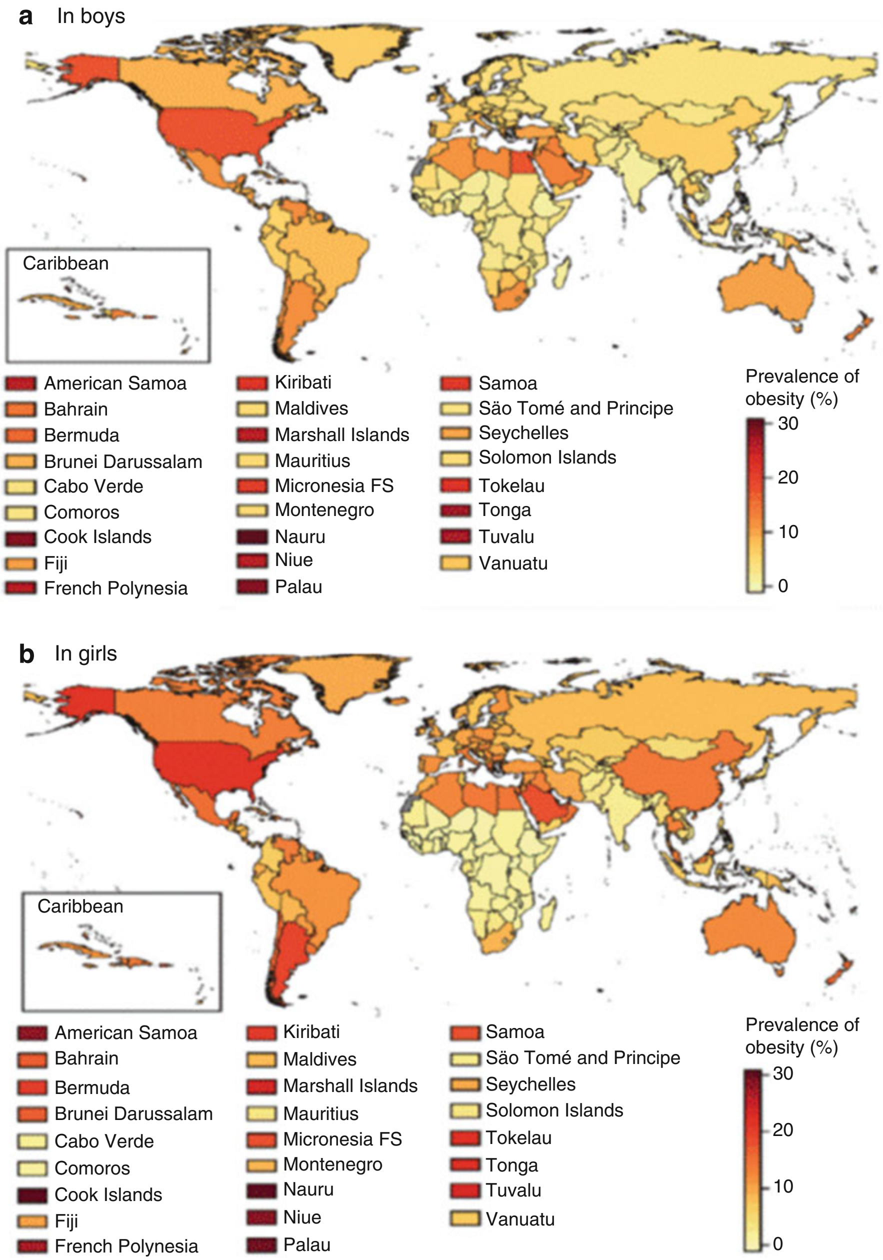

Fig. 4 Prevalence of obesity by sex in children and adolescents aged 5–19 years in 2016 (obesity was defined as $>$ SD above the median of the WHO growth reference). (**a**) In boys. (**b**) In girls. (Adapted from Abarca-Gómez et al. 2017)

Disparities in Obesity Across Population Groups

There are considerable disparities in the prevalence of overweight and obesity across world regions and countries (see above) and within countries, among the sex, SES, urban-rural resident, and ethnic groups. Rich research including ours has studied the complex obesity-SES association (e.g., McLaren 2007; Sobal and Stunkard 1989; Wang 2001; Wang et al. 2002; and Wang and Zhang 2006). It varies by several age, sex, ethnicity, or environmental factors (SES, countries, energy intake, physical activity) and is bidirectional; obesity can negatively affect people's SES by limiting educational and employment opportunities. We suspect that, with the growing epidemic of obesity, the association between SES and obesity in some industrialized countries may possibly become weaker or even disappear. Because the burden of obesity changes from high SES to low SES. In some developing countries, it may instead change direction (Wang and Lim 2012; Wang and Zhang 2006). For example, the past prevalence was higher in higher-SES group; however, it has become lower compared to lower-SES group according to changing environments in recent year in some developing countries.

Many studies in both industrialized and developing countries indicate that SES groups with greater access to energy-rich diets are more likely to be at increased risk for this condition. In general, low-SES groups in industrialized countries and high-SES groups in developing countries are more likely to become overweight or obese than their counterparts. The 1989 landmark comprehensive review (Sobal and Stunkard 1989) summarized findings from 144 studies and observed a different relationship between SES and obesity in developing and developed countries. It also noted some gender and age differences. Developed societies saw a consistently inverse association for women, while findings for men and children were inconsistent. In developing societies, a strong positive relationship was observed for women, men, and children; there is a tendency for urban children and children in high-income families to be at increased risk for excess weight gain. Often there are also marked gender differences. Another study showed that the prevalence of overweight was higher among children from less affluent families in 21 of 24 Western and 5 of 10 Central European countries compared to children from more affluent families. However, children from more affluent families were at higher risk of overweight in some countries (i.e., Croatia, Estonia, and Latvia). In Poland, Lithuania, Macedonia, and Finland, girls from less affluent families were more likely to be overweight, while the opposite was found for boys (Due et al. 2009).

Overall, the current literature shows that SES affects obesity. However, the association varies by gender, age, and country. Several comprehensive reviews have summarized findings from related studies (Bush et al. 2017; HaGani et al. 2019; Jia et al. 2019; Puolakka et al. 2016).

SES may affect lifestyle, including a population's access to food and patterns of physical activity, and, as a result, influence their energy balance. A large number of studies have attempted to study the impact of SES on obesity risk predominately using cross-sectional survey data collected in various population groups across different countries (Beydoun and Wang 2009; McLaren 2007; Puhl and Heuer

2009; Shrewsbury and Wardle 2008; Sobal and Stunkard 1989; Wang and Lobstein 2006; WHO 2004; Zhang and Wang 2004, 2007). Such studies can help us understand the population distribution and causes of obesity, as well as assist in the development of effective intervention programs for the prevention and management of obesity.

Figure 5 shows the association between prevalence of overweight and socioeconomic inequality in overweight for five countries. Opposite patterns (e.g., Macedonia and Germany) are observed (Due et al. 2009). For US children and adolescents, we found, based on NHANES data collected between 1971 and 2002, that patterns of SES disparities in overweight varied across age, race/ethnicity, and gender and also changed over time (Wang and Lobstein 2006). SES disparities in overweight have decreased since the early 1990s with the rise of the obesity epidemic. A reverse association between SES and overweight was only observed in white girls; African American children of high SES were at increased risk. The differences in the prevalence of overweight by SES across sex and age groups in the USA are shown in Fig. 6.

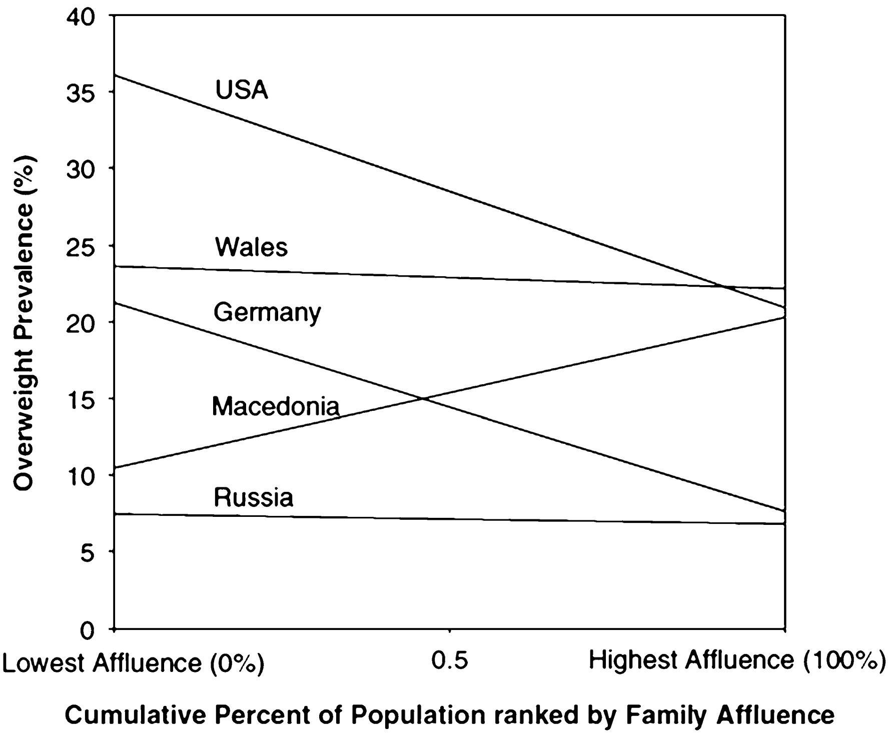

Fig. 5 Association between family affluence and obesity in adolescent boys aged 11, 13, and 15 years from five countries: Example of overweight inequality regression lines^*. ^Data were collected from the Health Behavior in School-Aged Children study. *Family affluence was measured as a function of family possessions (e.g., car ownership, number of computers, child had own bedroom) and number of family travels over the past year. (Adapted from Due et al. 2009)

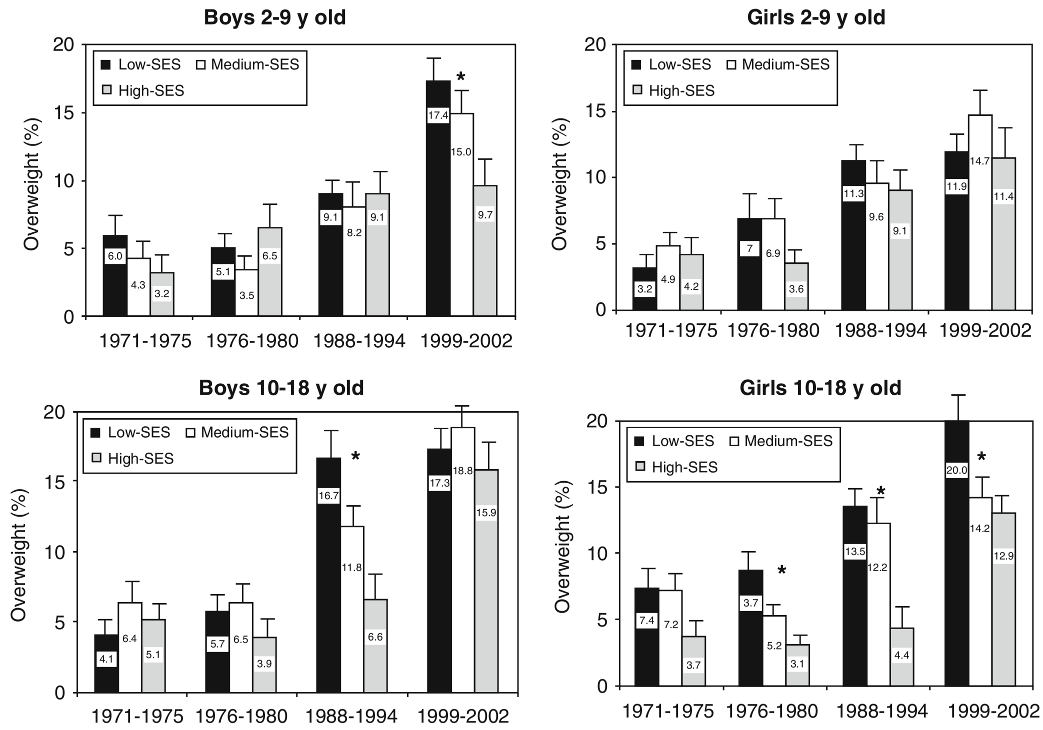

Fig. 6 Time trends in disparities of overweight prevalence by socioeconomic status (SES) in US children and adolescents: 1971–1975 to 1999–2002^. ^Obesity was defined as a BMI $\geq$ 95th percentile. The sample size in each National Health and Nutrition Examination Survey (NHANES) was NHANES I ($n = 6555$), NHANES II ($n = 6741$), NHANES III ($n = 9731$), and NHANES 1999–2002 ($n = 7390$). *Significant between-group differences, $P < 0.05$ (chi-square tests). (Adapted from Wang and Zhang 2006)

Overall, the prevalence of obesity in all groups has increased since the 1970s. However, there are distinct patterns across age, sex, and ethnic groups. Among boys aged 2–9 years between 1999 and 2002, a significant reverse association appeared between family income and overweight; no associations were significant among girls aged 2–9 years. A strong reverse association was also observed in adolescent boys aged 10–18 using NHANES III (1988–1994) data, although this pattern became statistically nonsignificant by 1999–2002. In adolescent girls, a reverse association between family income and overweight remained significant. But, the ratio in the prevalence of overweight in the low-SES group compared with the high-SES group decreased from 3.1 in NHANES III (1988–1994) to 1.6 in NHANES (1999–2002).

In summary, there remain many controversies regarding the relationship between SES measures and obesity. A growing body of literature suggests that the SES-obesity association is complex and varies by several demographic (e.g., age, gender, ethnicity) or environmental (e.g., countries, SES) factors. With the progression of the obesity epidemic, it is possible that such associations may become weaker or even disappear in some populations (e.g., industrialized countries) or change direction in some populations (e.g., some developing countries) in the future (Jones-Smith et al. 2011; Wang and Lobstein 2006). For example, in Brazil, the past prevalence was higher in women of higher SES but has become lower compared to women of lower SES in recent years. The burden of obesity is shifting toward the poor from the rich (Monteiro et al. 2007).

Discussion

Obesity and related noncommunicable chronic diseases have become one of the most serious public health problems globally. The prevalence of obesity (BMI $\geq$ 30 kg/m^2) has about tripled in many countries worldwide since 1975; and the number of people affected is expected to continue to rise for the future. This epidemic has been growing rapidly in some low- and middle-income countries, particularly in China, the Middle East, and the Pacific Islands. Obesity has many short- and long-term health and financial consequences for individuals, families, and society. Obesity in adulthood is a major risk factor for the world's leading causes of poor health and early death including cardiovascular disease, several common cancers, diabetes, and osteoarthritis.

Obesity, as well as other lifestyle-related chronic diseases, is largely preventable. However, once developed, it is difficult to cure. Supportive environments and communities are fundamental in shaping people's choices, by making the choice of healthier foods and regular physical activity the easiest choice (the choice that is the most accessible, available, and affordable) and therefore preventing overweight and obesity. At the individual level, people can limit energy intake from total fats and sugars; increase consumption of fruit and vegetables, as well as legumes, whole grains, and nuts; and engage in regular physical activity.

Childhood obesity is a serious public threat in many industrialized and developing countries worldwide. Actions to reverse the epidemic are the focus of the recommendations made by the WHO *Commission on Ending Childhood Obesity* and are one of the main objectives of the Decade of Action on Nutrition. Investing in children's health will help meet the global health targets and substantially reduce the predicted health and economic costs of obesity (WHO 2017). While most countries are still off-track to meet the target for controlling the prevalence of obesity, many are taking actions, and some have achieved a leveling off in childhood obesity rates.

Obesity prevention should start in early life stages. Developmental Origins of Health and Disease (DOHaD), a concept about exposure to certain environmental influences during critical periods of development and growth, emphasizes the importance of early human development on the risk of chronic diseases in later life (Gha 2006; Lobstein et al. 2004). Gestational weight gain, maternal nutrition, feeding practice, and parenting style all have a significant impact on later obesity and chronic diseases. Moreover, infancy and early childhood produce additional programming and are characterized by high metabolic and behavioral plasticity which shapes life-long energy balance-related behaviors and risk of subsequent obesity (Birch 1998; Cooke et al. 2004; Davis et al. 2007; Mikkilä et al. 2005; Skinner et al. 2002). While early life has been gaining traction for a few years, our understanding of risk factors during the first years of life remains limited. Funding resources should be allocated more in this area to support longitudinal etiology and intervention research. Investing in early life health will help meet the global health targets and substantially reduce the predicted health and economic costs of obesity.

The WHO has developed the "Global Action Plan for the Prevention and Control of Noncommunicable Diseases 2013–2020" which aims to achieve the commitments of the UN Political Declaration on noncommunicable diseases (NCDs) which was endorsed by Heads of State and Government in September 2011. The "Global Action Plan" will contribute to progress on nine global NCD targets to be attained by 2025, including a 25% relative reduction in premature mortality from NCDs by 2025 and a halt in the rise of global obesity to match the rates of 2010.

The World Health Assembly welcomed the report of the Commission on Ending Childhood Obesity (2016) and its six recommendations to address the obesogenic environment and critical periods in the life course to tackle childhood obesity. The implementation plan to guide countries in taking action to implement the recommendations of the Commission was welcomed by the World Health Assembly in 2017.

Present interventions and policies have not been able to curb the rise in BMI in most countries. Governments should urgently review their progress to meeting the 2025 targets and implement the recommendations of the Commission on Ending Childhood Obesity (WHO 2017). These include:

(1) Improve the environments in which children live, play, and learn.
(2) Implement policies to support healthy food environments, for mothers, infants, and children.
(3) Increase policy priority to ensure safe and accessible environments for physical activity for children of all ages.
(4) Strengthen the measurement of food and physical activity environments and policy implementation.

(5) Work toward Universal Health Coverage for all people to ensure children, adolescents, and their families have access to the obesity prevention and treatment services they need (NCD-RisC 2016).

The United Nations' Sustainable Development Goals, which address poverty, education, nutrition, and universal health coverage, provide an opportunity for integrating policies that coherently address underweight and overweight in children and adolescents and their health consequences, effectively and equitably. Doing so would require commitment from national and international agencies and donors for replacing the fragmented focus with an integrated approach (Abarca-Gómez et al. 2017).

Despite the significant attention and substantial investment in obesity prevention and control over the past three decades, the prevalence of obesity remains high and keeps increasing. This has led many in the scientific community to call for a reevaluation of the traditional ways in which we study obesity and to find new ways to address this pandemic. Systems science approach is one example. As the US National Academy of Medicine advocates, a systems approach should be adopted to address the obesity problem from all dimensions.

Conclusion

Obesity is a serious public health challenge in many industrialized and developing countries worldwide and the problem continues to grow. The epidemic calls for timely and effective population-based approaches to prevent the condition. Meanwhile, treatment is also important as a large number of people have developed the condition. Obesity is largely preventable by having healthy lifestyles that include healthy eating and adequate physical activity. However, once developed, obesity is difficult to reverse. Therefore, prevention of obesity, especially in early life stages, in children and young adults should be a priority. The development of new national and regional policies along with effective population-based intervention programs to promote healthy living environment and lifestyles is crucial to combat the epidemic and promote public health around the world. A good understanding of the obesity epidemic will help guide intervention efforts and develop effective population-based programs and policies. Vigorous efforts including national policies and programs are needed to combat the epidemic.

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Dieting and Overeating

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Abstract

Purpose: After a calorie-restricted diet, most people regain most of their lost body weight. The present chapter focuses on two possible psychological explanations for this weight regain (1) as caused by possible side effects of dieting, specifically the disinhibition effect (the overeating by dieters after they abandoned their dietary restraint), and (2) as caused by the fact that most treatments do not address possible causes of *emotional eating* (EE).

Findings: The disinhibition effect, though a robust phenomenon when dietary restraint was measured with the Restraint Scale, could not be replicated with other measures for restraint. This generated a discussion *i*) how restraint should best be measured and conceptualized and (*ii*) whether the disinhibition effect holds true for all dieters or whether it is only found in a subgroup of dieters, the so-called unsuccessful dieters. Unsuccessful dieters combine high dietary restraint with high overeating tendencies. It is further noted that the disinhibitor "ego threat" elicits EE. However, disinhibition requires prior inhibition (i.e., restraint) by definition. Because restrained eating may be both cause and consequence of EE, also evidence on possible causes of EE (independent from dieting) is presented, in addition to evidence on EE as marker of atypical depression (the subtype of depression associated with increased appetite and weight gain).

Implications for treatment: Side effects of dieting and associations of EE with alexithymia (difficulty in identifying and describing emotions) and atypical depression suggest that treatment of obesity should not automatically consist of prescribing calorie-restricted diets. Instead treatments should match with an individual's eating style. The DEBQ (Dutch Eating Behavior Questionnaire) enables such matched treatment of obesity.

Keywords

Disinhibition effect · Measures of dietary restraint · Successful dieters · Emotional eating · Atypical depression · DEBQ · Matched treatment of obesity

Introduction

Obesity is generally conceived as the outcome of eating too much and exercising too little. Treatment therefore focuses on creating a negative energy balance through a change in lifestyle involving restricting food intake and increasing physical activity (so-called *Big Two* treatments). In the short term, Big Two treatments result for most people in weight loss. In the long term, however, most of the lost body weight is regained, with some people even ending up weighing more than before the diet (Langeveld and DeVries 2015; Mann et al. 2007). Also in community samples, weight loss dieting has predicted future weight gain (references in Siahpush et al. 2015). The present chapter focuses on two possible psychological explanations for the weight regain of most dieters: (1) as caused by possible side effects of dieting, specifically the disinhibition effect, the overeating by dieters when their cognitive resolve to eat less than desired is abandoned, and (2) as caused by the fact that Big Two treatments do not address the possible *causes* of emotional eating (the tendency to eat in response to *negative* emotions or stress). The psychological explanations for the weight regain of dieters have implications for the treatment of obesity; therefore also a framework for matched treatment of obesity will be briefly presented.

Side Effects of Dieting

Dieting has biological and psychological side effects. Though this section focuses on psychological side effects of weight loss dieting, specifically the disinhibition effect, first some biological side effects of weight loss after a weight loss diet will be briefly discussed, specifically, *anabolism*, the reduction of the resting metabolic rate, and *increased hunger and appetite*, the physiological need and desire to eat food.

Biological Effects of Weight Loss

Already in the 1970s of the last century, some investigators (e.g., Cabanac et al. 1971; Nisbett 1972) had observed that adult body weight is relatively stable over time and that lost body weight is ultimately regained. This gave rise to the idea that someone's body weight is "defended" by a so-called ponderostat, a regulatory system that homeostatically controls body weight (Cabanac et al. 1971), within a range of predetermined values, the so-called set point of body weight (Nisbett 1972). This idea of a homeostatically defended set point of body weight has since accumulated increasing empirical evidence (Rogge and Gautam 2017). After having lost body weight as a result of a weight loss diet, the body acts as if in the starvation mode: hunger and appetite are increased and the resting metabolic rate is slowed down (see the Sidebar 1) (Goldsmith et al. 2010). Slowed metabolism and increased hunger are considered evolutionary adaptive responses to weight loss that allow living beings to survive in periods of food shortages (Polivy and Herman 2006).

Sidebar 1: Slowed Metabolism
The reduction in resting metabolic rate after weight loss is greater than can be expected from the loss of body mass or fat-free mass. This means for practice that formerly obese persons who lost 10% of their body weight will require between "\. . ..300 and 400 fewer calories per day to maintain the same body weight and physical activity level. . ." as never-obese individuals of the same body weight and composition (Rosenbaum and Leibel 2010, p. 2). Controlled studies in obesity-prone rats showed that an enhanced metabolic efficiency contributed to rapid weight regain after a weight loss diet (MacLean et al. 2004, 2006). There is also evidence that this enhanced metabolic efficiency does not resolve with time after a weight loss (Maclean et al. 2017, pp. S12–S13).

Psychological Effects of Dieting: The Disinhibition Effect

When people are deprived from the types of food that they like to eat ("the forbidden fruit"), for example, when observant Jews are forbidden to eat food that rises when mixed with water during the Jewish holiday of Passover, they tend to develop an increased desire (craving) to eat this type of food and tend to overconsume it "at the earliest opportunity" (Polivy et al. 2005, p. 303). Also dieters may feel deprived and develop cravings for "forbidden" foods which enhance their risk for abandoning their diet (Herman et al. 2008). Indeed, people with high scores on the *Restraint Scale* (Herman et al. 1978) – a scale meant to operationalize dieting – showed in a series of experiments elevated food intake when their self-control in regard to their dietary restraint was undermined by forcing them to eat a forbidden amount or type of food (Herman and Polivy 1980). This elevated food intake is the so-called disinhibition effect, the *dis*inhibition (disruption) of the *in*hibited food intake of dieters. This is also called the *rebound effect* or, more colloquially, *the what the hell effect* – once the dietary rule is broken, the rest of the day is written off: "what the hell, I might as well enjoy my food" (see Sidebar 2 for the classic preload-taste test study by Herman and Mack 1975, the so-called milkshake-ice cream study). On the basis of these and similar findings (Herman and Polivy 1980), *restraint theory* was formulated. According to this theory, dietary restraint or dieting (i.e., attempted restriction of food intake in order to maintain or lose body weight) contributes to overeating and even eating disorders, such as bulimia nervosa (Herman et al. 2005; Polivy and Herman 1985, 1993).

Sidebar 2: The Classic Preload-Taste Test Study by Herman and Mack (1975): The Milkshake-Ice Cream Study
Female students at the University of Toronto who had been classified as dieter or non-dieter on the bases of their scores on the Restraint Scale (median split-procedure) were required to consume 0, 1, or 2 milkshakes (preload) and then to "sample" some ice cream (vanilla, strawberry, and chocolate) under the guise of a taste test. The results showed that non-dieters ate less following a preload of 1 or 2 milkshakes. They showed "regulation" of their food intake. In contrast, the dieters ate more ice cream after having consumed 1 or 2 milkshakes. They showed "counterregulation" instead of regulation of food intake.

Herman and Mack suggested that the milkshake served to break down or to disinhibit the cognitive restraint (inhibition) that dieters normally exhibit in the face of tempting stimuli. "… without a realistic hope of staying within the caloric confines imposed to herself, the dieters was left without a sufficient reason for dieting" (Herman and Polivy 1980, p. 245). The dieters gave in to their hunger, with an outcome of overconsumption of the ice cream.

Implications for Current Treatment Practices

Current guidelines for treatment of obesity still mainly focus on Big Two (eat less, move more) managements. See, for example, the European guidelines for obesity management in adults (Yumuk et al. 2015) or the Dutch guidelines for management of obesity (Medisch Wetenschappelijke Raad van het Kwaliteitsinstituut voor de Gezondheidszorg CBO 2008). The physiological and psychological side effects of dieting, briefly mentioned above, seriously call into question the feasibility of these Big Two obesity management approaches (see, e.g., Rogge and Gautam 2017, p. 528; Polivy and Herman 1983; Bacon and Aphramor 2011). They well explain why diets are ineffective in spite of the participants' treatment compliance (Howard et al. 2006a, b) and why dieters may even end up weighing more than before their diet (see the review by Mann et al. 2007). The side effects also undercut the prevalent opinion of primary care physicians that the inability of overweight persons to sustain their weight loss simply reflects their lack of motivation, will power, and noncompliance with treatment recommendation (Puhl et al. 2009; Rosenbaum and Leibel 2010, p. 1).

The current Big Two guidelines for obesity management not only are ineffective but also may have adverse effects, such as weight cycling, eating disorders, and weight discrimination (Bacon and Aphramor 2011). Bacon and Aphramor (2011) remark "obesity research seems to enjoy special immunity from accepted standards in clinical practice and publishing ethics" (Bacon and Aphramor, p. 1) and suggest ". . . this draws attention to the ethical implications of recommending treatment that may be ineffective or damaging" (Bacon and Aphramor, p. 1). They advocate a paradigm shift from promoting weight loss and dieting behavior to promoting health behaviors for people at all sizes: Health at Every Size.

The Disinhibition Effect and Measures of Dietary Restraint

Disinhibited food intake in restrained eaters is a relative robust phenomenon when dietary restraint was assessed with the Restraint Scale (Herman and Polivy 1980) (but see the studies by Dritschel et al. 1993; Ouwens et al. 2003a, b; Van Strien et al. 2000, where the disinhibition effect was not observed even with the Restraint Scale). In striking contrast, the disinhibition effect was never found when participants were classified into restrained versus unrestrained eater based on the restraint scores of two other measures of dietary restraint: the 10-item Restraint Scale of the *Dutch Eating Behavior Questionnaire* (*DEBQ*; van Strien et al. 1986a, b) or the 21-item Restraint Scale of the *Three-Factor Eating Questionnaire* (*TFEQ*: Stunkard and Messick 1985) (see the studies by Dritschel et al. 1993; Jansen et al. 1988; Lowe and Kleifield 1988; Morgan and Jeffrey 1999; Ouwens et al. 2003a, b; Van Strien et al. 2000; Wardle and Beales 1987). Moreover, overweight restrained eaters never displayed disinhibited eating in preload-taste test studies in the laboratory (references in Van Strien et al. 2007, p. 110), even when the RS was used as a measure of restraint (McCann et al. 1992; Ruderman and Christensen 1983; Ruderman and Wilson 1979).

The finding that the disinhibition effect was not always replicated with the Restraint Scale and could not be replicated with the other scales of dietary restraint has generated a discussion on how restraint should best be measured and conceptualized. It also gave rise to the question whether restraint theory holds true for all dieters or whether it is only valid for a subgroup of dieters, the so-called unsuccessful dieters.

Success and Failure in the Measurement of Dietary Restraint

It has been suggested that the restraint scales of the DEBQ and the TFEQ select a broad range of dieters, successful dieters and unsuccessful dieters, whereas the Restraint Scale tends to select dieters who combine dieting with a tendency to overeat – unsuccessful dieters (e.g., Allison et al. 1992; Heatherton et al. 1988; Laessle et al. 1989a; Lowe 1993; Van Strien 1999; Van Strien et al. 2002).

The restraint scales of the DEBQ and the TFEQ showed predictive validity for restriction of food intake when using a time window of food intake of 24 h or more (e.g., Van Strien et al. 2006, further references in Van Strien et al. 2007). (see Sidebar 3 for the predictive validity of the Dutch Restrained Eating Scale). A further characteristic of the DEBQ and the TFEQ is that both questionnaires measure dietary restraint with a scale separate from scales on tendencies to overeat (such as, in the DEBQ, emotional eating, eating in response to negative emotions: *Do you have a desire to eat when you are irritated* or, in the TFEQ, disinhibited eating – *While on a diet, if I eat a food that is not allowed, I often then splurge and eat other high-calorie foods*).

Sidebar 3: The Predictive Validity of the Dutch Restrained Eating Scale

Restraint eating is defined as eating less than desired to maintain or to loose body weight. See, for example, the items on dietary restraint of the DEBQ: *Do you try to eat less at mealtimes than you would like to eat; Do you deliberately eat less in order not to become heavier?* Hence, the ultimate criterion of dietary restraint is the degree to which individuals eat less than they would like to eat. However "... how can one determine the quantity of food not eaten by the individual but which the individual would have eaten without self-imposed inhibition?" (van Strien et al. 2006). In the study on the predictive validity of the restraint scale of the DEBQ, a derivative, or indirect way for assessing the difference between desired and actual intake, was used, namely, the difference between required energy (estimated from body weight and physical activity) and actual intake of energy across three separate days. On 3 widely separate days (April, June, September), trained dieticians visited 110 female participants on unannounced home visits to obtain 24-h food recalls of the previous day. Energy intake was obtained by calculating for each of the participants the mean intake of energy and nutrients over the three 24-h food recalls. In addition to deviation from energy requirement, also relations with intake of fat and sugar were calculated, because restriction in intake of fat and/or sugar may also reflect dietary restraint. About 20% of the variance of scores on the restraint scale of the DEBQ was explained by the various measures for food intake. This suggests that the Dutch Restrained Eating Scale has moderate to good predictive validity (Van Strien et al. 1986).

The Restraint Scale was less clearly associated with a lower intake of energy (French et al. 1994; Klesges et al. 1989, 1992; Laessle et al. 1989a; Leassle et al. 1989b; Wardle 1987) but, instead, associated with more binge eating (Hawkins and Clement 1980; Laessle et al. 1989a; Stice et al. 1997; Wardle 1980). A further important difference with the DEBQ and the TFEQ is that the Restraint Scale does not have separate subscales with items on dietary restraint and items on overeating (e.g., *Do you eat sensibly in front of others and splurge alone*) but include them all in one scale.

The latest version of the Restraint Scale has ten items, including items on restriction of food intake, weight

Table 1 Subscale structure in the restraint scale

CD	1. How often are you dieting?
	Never-always
WF	2. What is the maximum amount of weight (in kilos) you have ever lost within 1 month?
	(0–2.5; 2.5–5; 5–7.5; 7.5–10; 10+)
WF	3. What is the maximum amount of weight gain (in kilos) within a week?
	(0–0.5; 0.5–1; 1–1.5; 1.5–2.5; 2.5+)
WF	4. In a typical week, how much does your weight fluctuate?
	(0–0.5; 0.5–1; 1–1.5; 1.5–2.5; 2.5+)
CD	5. Would a weight fluctuation of 2.5 kilos affect the way you live your life?
	Not at all-very much
CD	6. Do you eat sensibly in front of others and splurge alone?
	Never-always
CD	7. Do you give too much time and thought to food?
	Never-always
CD	8. Do you have feelings of guilt after overeating?
	Never-always
CD	9. How conscious are you what you are eating?
	Not at all-extremely
WF	10. How many kilos over your desired weight were you at your maximum weight?
	(0–0.5; 0.5–3; 3–5; 5–10; 10+)

Note: *CD* concern for dieting, *WF* weight fluctuation. Factor loadings differ across the publications (e.g., Blanchard and Frost 1983; Lowe 1984)

fluctuation over time, and overeating (see Table 1). Studies of the factor structure *on the level of the items* (Blanchard and Frost 1983; Lowe 1984; Overduin and Jansen 1996) showed that the RS was multifactorial, with some items having high loading on the factor concern for dieting (CD) and others having high loadings on the factor weight fluctuation (WF) (see Table 1).

Success and Failure of Restraint in One Person

Items of a scale should ideally load on only one factor if the scale is presumed to measure a homogeneous construct. A construct is in test theory defined as *the set of ideas behind the trait that the scale should be measuring*. In the case of dietary restraint: eating less than desired to maintain or to loose body weight. In other words, if the construct of dietary restraint is presumed to be homogeneous, the scale for measuring dietary restraint should be one-factorial, and multifactoriality of the scale is in this case considered to be a serious psychometric problem (Nunnally 1967). However, according to Heatherton et al. (1988), dietary restraint is not a homogeneous construct but instead involves “both a propensity to restrict food intake as well as a tendency to splurge” (Heatherton et al. 1988, p. 20). Successful restraint is followed by failure of restraint in one person. The simultaneous presence of both poles of restraint in one person is also thought to justify the multifactoriality of the RS: “. . . to argue that the restraint scale confounds true restraint with disinhibition betrays a mistaken view of the scales purpose, which is to identify dieters. Most dieters …. display both restraint and disinhibition and the disinhibition is not an arbitrary attribute, but a direct consequence of their restraint" (Heatherton et al. 1988, p. 20).

Not all researchers were convinced by the above argument of Heatherton et al. (1988) (e.g., Charnock 1989; Stice et al. 1997; Wardle and Beales 1987). They, instead, criticized the RS for "criterion confounding": people with high RS scores are more likely to show in the laboratory overeating (the criterion) because the RS (the predictor) itself contains items that measure the tendency toward overeating (see Table 1, item 6, and item 8). Furthermore, the items on weight fluctuation in the RS were considered problematic for measurement of dietary restraint in people with overweight (Rodin 1981a; Van Strien et al. 2007). Because the body weight of overweight people tends to show more fluctuation than does the body weight of people with a normal body weight (Field et al. 2004), overweight people may have high scores on the RS simply on the basis of large weight fluctuations, even if they do not restrain their eating or watch their body weight (Rodin 1981a).

Support for the suggestion that the RS measures a different type of dieter than the DEBQ-R and the TFEQ-R was found in two studies using factor analyses of the RS in relation to other measures of dieting, overeating, and body dissatisfaction (Laessle et al. 1989a; Van Strien et al. 2007). Using exploratory factor analysis in a study on 60 normal weight college women, Laessle et al. (1989a) found that neither the DEBQ-R nor the TFEQ-R loaded on the same factor as the RS and that the RS was closely associated with disinhibited eating and weight fluctuation but not with restriction of calories. The multifactorial structure of the RS was also confirmed in a sample of 349 normal weight and 409 overweight women using confirmatory factor analysis (Van Strien et al. 2007). The results were, however, different from those by Laessle et al. (1989a). In both the sample of normal weight women and the sample of overweight women, the RS was found to significantly load on three factors, namely, dieting, overeating, and body dissatisfaction. The finding by van Strien et al. (2007) that the RS was associated with dieting, in addition to overeating and body dissatisfaction, suggests that the RS tends to select dieters with tendency toward overeating (i.e., unsuccessful dieters). The DEBQ-R and the TFEQ-R, in contrast, seem to be unidimensional, because they both showed a satisfactory fit when loading on the dieting factor only in the study by van Strien et al. (2007).

The differences between the restraint scales in the type of dieter they select may well explain the inconsistent support for the restraint/disinhibition effects in the experimental research literature.

Are Most Dieters Unsuccessful?

The inconsistent support for restraint/disinhibition in the laboratory also calls into question that lapses in restraint are a central component of dieting. The observation that there also exist dieters who do not show counterregulatory behavior in the laboratory suggests that there may exist also "successful dieters," dieters with a low tendency toward disinhibition (for empirical support, see Lowe and Kleifield 1988; Pudel and Westenhoefer 1989; and Westenhoefer 1991). Westenhoefer (1991) even found that dietary restraint with a high tendency toward disinhibition was less common than dietary restraint with a low tendency toward disinhibition. This means that the population of restrained eaters can be assumed to exist of two subpopulations: (1) a subpopulation that combines high dietary restraint with a low tendency toward overeating and therefore low susceptibility toward failure of restraint (so-called successful restrained eaters) and (2) a subpopulation with high dietary restraint and a high tendency toward overeating and therefore a high susceptibility toward failure of dietary restraint. These two subpopulations of restrained eaters with high or low failure of dietary restraint can be located by using a two-factorial classification using both scores on dietary restraint and tendency toward overeating (Van Strien 1997) (Sidebar 4).

Sidebar 4: Successful and Unsuccessful Dieters

Experimental support for the two-factorial classification was obtained by Westenhoefer et al. (1994), using the Restraint Scale and the disinhibition scale of the TFEQ. Participants were invited to consume as much ice cream as they liked during a taste test following a 200 ml milkshake preload or without a preload. The results indicated that only participants who combined high dietary restraint with a high tendency toward disinhibition showed excessive consumption of the ice cream after the milkshake. In contrast, participants who combined high dietary restraint with a low tendency toward disinhibition not only did not overeat in the laboratory but also consumed the *least* amount of ice cream of all groups under both experimental conditions (i.e., following the preload or without the preload).

This finding means that the disinhibition effect does not hold true for all dieters but only for those dieters who combine high dietary restraint with high overeating tendencies.

The Disinhibition Effect Revisited

When using the RS as a measure of dietary restraint, the disinhibition effect does not always take the pattern of restrained eaters eating significantly more after a preload than without a preload (Van Strien et al. 2007, footnote 2). In some studies (e.g., Hibscher and Herman 1977; Jansen et al. 1988; Ruderman and Christensen 1983), the interaction effect in fact took the pattern that *un*restrained eaters ate significantly *less* after the preload than without the preload (they showed regulation of their subsequent food intake after having eaten a preload). On close inspection, only in three of the six preload studies of the last century, RS restrained eaters ate significantly more following the preload than in the absence of a preload (Herman and Mack 1975; Herman et al. 1987; Polivy et al. 1988). These varying outcomes have generated a discussion on the robustness of the disinhibition effect and the type of disinhibitors that most reliably elicit disinhibited eating in RS dieters (Van Strien et al. 2007, footnote 2).

The Disinhibitor "Ego Threat" Elicits Emotional Eating

One possible "reliable" disinhibitor of dietary restraint is a distress manipulation based on "ego threat," a distress manipulation where the participants anticipate having to give a speech in front of an evaluative audience (a variation of the Trier social stress test (Kirschbaum et al. 1993)). After such a stress manipulation, RS dieters showed higher food intake compared to non-dieters (Heatherton et al. 1991). Dieting was shown here to elicit emotional eating (eating in response to negative emotions or stress). Dieting may be a risk factor for the development of emotional eating because the continuous struggle against hunger sensations may have as outcome that dieters altogether lose contact with their feelings of hunger and satiety (Herman and Polivy 1980). The tendency to eat in response to negative emotions or stress is considered an atypical stress response. The typical stress response is not eating because the physiological stress reactions mimic the internal sensations associated with feeding-induced satiety (Gold and Chrousos 2002).

Disinhibition requires prior inhibition (i.e., restraint) by definition. However, it is as yet unresolved whether restrained eating is a cause or consequence of eating in response to distress or negative emotions (emotional eating), while this may also differ for various subgroups (Van Strien et al. 2005; Ouwens et al. 2009a).

Emotional Eating (As Independent of Dieting)

Emotional eating may also occur independent of dieting (Van Strien 2018).

Negative mood or distress is associated with both increased and decreased food intake (Greeno and Wing 1994), with a decreased intake of food being the typical and predominant response (Gold and Chrousos 2002). Distress is normally associated with activation of the hypothalamic pituitary adrenal (HPA) axis, with physiological reactions that prepare the individual for a fight or flight reaction. These physiological reactions include an increased release of the stress hormone cortisol, inhibition of gastric motility, and the release of sugar into the bloodstream, thereby suppressing hunger (Gold and Chrousos 2002). However, the so-called emotional eaters show an atypical stress response and eat the same amount or even more during distress (Oliver et al. 2000, Van Strien and Ouwens 2003, Van Strien et al. 2012).

As will be elaborated below, the atypical response of eating to negative emotions or distress may be the result of a poor interoceptive awareness, a low awareness of bodily arousal states related to hunger and satiety, and a difficulty in disentangling these states from the physiological arousal states related to different emotions. This may result in a pattern of responding to virtually any bodily arousal state by food intake: emotional overeating. Alternatively, emotional eating may also be the outcome of a reversed stress response of the HPA axis. Instead of the typical stress response of an elevated release of cortisol, the HPA axis reacts to distress with a diminished or blunted cortisol response. In this line of thought, emotional eaters do not react to stress with a reduction of hunger, but instead have similar feelings of hunger after stress.

Poor Interoceptive Awareness and Alexithymia

Poor awareness of hunger and satiety and a confusion with bodily symptoms associated with emotions may be a possible outcome of parenting practices that undermine the psychological and emotional development of the child (Snoek et al. 2007; Vandewalle et al. 2014, 2016). When the response of the caregiver toward the infant is characterized by low sensitivity, high degrees of rejection, or even of manipulative control, the outcome may be that the infant develops poor interoceptive awareness, high degrees of alexithymia (difficulty in identifying feelings and describing them to other people), and difficulty with adequately regulating emotions, in turn, predicting more emotional eating in childhood and adolescence (Van Strien 2018) (see Sidebar 5).

Sidebar 5: Parenting and Emotional Eating

In a cross-sectional study including 110 obese youngsters seeking treatment, Vandewalle et al. (2014) found that rejection by the mother was associated with emotional eating and that this association was mediated (explained) by maladaptive emotion regulation. In a further prospective study ($M = 71$ days between time moments) in a community sample of 81 adolescents, results went in the same direction, though the mediation effect of maladaptive emotion regulation was this time only marginally significant (Vandewalle et al. 2016).

In a different prospective Dutch study in adolescent children, it was found that the inadequate parenting practice of high psychological control (e.g., My father (mother) makes me feel guilty when I fail at school) interacted with a polymorphism in the dopamine D2 (reward sensitivity) receptor gene (DRD2) in predicting an increase in emotional eating after 4 years. Carrying the A1 allele of the DRD2 gene Taq1A polymorphism (rs1800497) is associated with reduced DRD2 receptor availability in the brain (Gluskin and Mickey 2016). Adolescent girls and boys showed an increase in emotional eating after 4 years only if they carried both at least one DRD2 A1 allele in combinations with a parent exercising a high degree of psychological control at baseline.

Reversed HPA Axis

As above indicated, emotional eating may also be the outcome of a reversed stress response of the HPA axis. Instead of the typical elevated release of cortisol in response to stress and the loss of appetite, the HPA axis reacts to stress with a diminished or blunted cortisol response and the atypical symptom of increased appetite and weight gain (Gold and Chrousos 2002). This reversed stress response of the HPA axis may be a possible outcome of chronic stress early in life, particularly when this stress involves a parent-child relationship (Cicchetti and Rogosch 2001; Yehuda et al. 2000). In this line of thought, emotional eaters do not have the typical post-stress reduction of hunger, but instead have similar or even higher feelings of hunger after stress (for support, see Fig. 2 in Van Strien et al. 2014).

When using as stressor the TSST (Trier social stress test), the highest food intake after stress was observed in the women who combined a high degree of self-reported emotional eating with a blunted HPA axis stress activity (blunted cortisol stress response) (Van Strien et al. 2013). A similar finding was found in the studies by Tryon et al. (2013) and Wingenfeld et al. (2017). It is, however, as yet unresolved whether a blunted cortisol stress response is indeed a cause or rather a response to emotional eating. A blunted cortisol stress response has also been conceived as being secondary to emotional eating, as possible outcome of adaptive downregulation of the HPA axis in response to frequent overeating (Dalman 2010).

Emotional and External Eating

Emotional eating tends to co-occur with external eating (overeating in response to food-related cues such as the sight and smell of attractive food) (Van Strien 2015). Heatherton and Baumeister (1991) explain this co-occurrence with the escape-of-self-awareness theory. According to this theory, some people (e.g., emotional eaters) shift their attention away from their negative affect by narrowing it to the immediate (food) environment, with, as outcome, external eating. In support, Slochower (1983) showed in an experiment that female students with obesity only overate in the high anxiety-high salience of food condition, but not when either the anxiety or the food salience was low. Similarly, in a functional neuro-imaging study in female chronic dieters, negative mood was associated with an increase in the reward value of appetizing food cues, as indicated by an increased activity in the orbital frontal cortex (OFC) (Wagner et al. 2012). In a subsequent study, it was found that this increase predicted weight gain 6 months later (Demos et al. 2012).

Although emotional and external eating as measured by self-report questionnaires often co-occur, they refer to different constructs. In both explorative and confirmatory factor analyses, items on emotional and external eating loaded on different factors (van Strien et al. 1986; Barrada et al. 2016). The scales for emotional and external eating also showed good discriminative validity in relation to other variables, such as depressive feelings (Van Strien et al. 1995; Ouwens et al. 2009b; Paans et al. 2018). In the study by Paans et al. (2018, p. 41), pure emotional eating and not pure external eating were associated with depression diagnosis and severity of depression (see Sidebar 6 for key differences between emotional and external eating).

Sidebar 6: Key Differences Between Emotional and External Eating
A key difference between emotional and external eating is that external eating is considered an evolutionary adaptive response (Rodin 1981, p. 361). Evolution favored genetic adaptations that allow humans to survive in periods of food shortages, including selective pressure to overeat whenever food is present. " ... when food becomes available, the individual would be prone to gorge on it, so as to store as many calories as possible to be drawn on during the next period of deprivation" (Polivy and Herman 2006, p. 32). A further difference between emotional and external eating is that external eating, in contrast to emotional eating, is not associated with overweight or obesity. Overweight women showed in various studies similar degrees of external eating as women with a normal body weight (references in Van Strien et al. 2009). In contrast, emotional eating was repeatedly shown to be associated with overweight and prospective weight gain (Koenders and Van Strien 2011; Sung et al. 2009; Van Strien et al. 2012), also in interaction with short sleep duration as a possible marker of stress (Van Strien and Koenders 2014).

Emotional Eating as Marker of Atypical Depression

Depression is normally associated with loss of appetite and weight loss. However there exists a subtype of depression that is characterized by the atypical features of increased appetite and subsequent weight gain (DSM-5; American Psychiatric Association 2013). Emotional eating shares with this atypical depression type the atypical feature of increased appetite in response to distress (Paans et al. 2018, 2019) and can therefore be considered a marker of atypical depression.

Depression was in a meta-analysis (Luppino et al. 2010) found to be associated with weight gain and obesity. In various other studies, emotional eating mediated the link between depression and obesity (Clum et al. 2014; Goldschmidt et al. 2014; Konttinen et al. 2010) and depression and weight gain (Van Strien et al. 2016; Vittengl 2018; Konttinen et al. 2019).

Though restrained eaters also reacted to depression with the atypical response of weight gain – a finding that Herman and Polivy (1980) explained in terms of "emotional turmoil" disrupting the dietary restraint of the restrained eaters (disinhibition effect) – restrained eating did not mediate the link between depression and body mass index (Clum et al. 2014) or between depression and weight gain after 5 years (van Strien et al. 2016).

The finding that emotional eating is a potential mediator between depression and obesity – both common conditions with high costs for society – suggests that emotional eating may be an important treatment target for both obesity *and* depression.

Matched Treatment of Obesity

Most weight reduction treatments do not result in permanent weight loss for most individuals (e.g., Mann et al. 2007). A possible reason for this may be that the treatments did not fit with the individuals' specific reasons for overeating. Some persons may overeat after a period of slimming, when their cognitive resolve to eat less than desired is abandoned (e.g., because they can no longer cope with their extreme feelings of hunger or their appetite for high caloric foods) (restrained eating). Other persons may have a tendency to overeat when experiencing negative emotions, specifically when seeing or smelling delicious food (tendency toward eating in response to negative emotions or stress predicts external eating). Each style of eating has its own etiology and therefore also requires its own treatment. Perhaps more permanent weight loss may be obtained when treatments better match with a person's eating style.

The DEBQ

The three eating styles can be measured with the DEBQ. Though the three eating styles can nowadays also be measured with other instruments (references in Barrada et al. 2016), the DEBQ was the very first theory-based instrument that covered the three eating styles with unidimensional scales that had been tested in representative Dutch community samples (e.g., Van Strien et al. 1986b).

The DEBQ is used by researchers all over the world (citations in Google Scholar are 2621 and in the Web of Science 1521 as per October 31, 2018). The original Dutch version of the DEBQ has been rated by the Dutch Committee on Tests and Testing (COTAN) as “up to the mark” or “good” on all European Federation of Psychologists’ Association criteria (COTAN 2013). Specifically, the three DEBQ scales had good internal consistency, dimensional validity, and predictive validity for, respectively, distress-induced food intake, greater responsiveness, and eating to food-related cues and eating less than desired (Barrada et al. 2016; Brignell et al. 2009; Nijs et al. 2009; Oliver et al. 2000; Van Strien et al. 2006, 2012a, b; Van Strien and Van de Laar 2008). In a representative Dutch community sample, the DEBQ showed measurement invariance with respect to sex, body mass index, age, and level of education (Barrada et al. 2016). The three-dimensional structure of the DEBQ was also confirmed in other languages and cultures, for example, China (Wu et al. 2017), Japan (Imada 1994), Germany (Nagl et al. 2016), and Spain (Cebolla et al. 2014), so it seems that the three eating styles have cross-cultural dimensional validity.

The DEBQ and Treatment

People with a high degree of emotional eating (scale scores above the mean or higher compared to the closest norm group) could be taught skills for better emotion regulation and tolerance to distress. Dialectical behavior therapy adapted for obese emotional eaters seemed effective at the 6-month follow-up in reducing body weight and (eating-related) pathology (emotional eating and depression). This group therapy had modules on mindfulness (a nonjudgmental state of awareness of one’s thoughts, feelings, or experiences in the here and now), emotion regulation, and distress tolerance (see further: Roosen et al. 2012). Enhancing mindfulness skills was also shown to enhance the cortisol (stress) response (Creswell et al. 2014; Daubenmier et al. 2011).

A high degree of external eating, unsupported by a high degree of emotional eating, points to sensitivity to food cues. Here, the treatment could best focus on the sensitivity to food cues by means of behavioral methods such as food go/no-go training or cue exposure with response prevention.

In people with low scores on emotional or external eating but with high scores on restrained eating, also the past history of body weight and weight fluctuation should be taken into account, in addition to tendency to binge. Severe dieting in combination with underweight may indicate anorexia nervosa, and a history of large weight fluctuation in combination with tendency to binge may point at bulimia nervosa. However, if a person has always been overweight, he or she may be better accepting of his or her heavy build than continuously starving him or herself. Approaches such as intuitive eating and health at every size focus on health, adaptation, and getting into contact with feelings of hunger and satiety again (Bacon and Aphramor 2011).

Conclusion

Most dieters regain their lost body weight. This may be *psychologically* explained by the disinhibition effect, the overeating of specifically *unsuccessful* dieters when their cognitive resolve to eat less than desired is abandoned. Unsuccessful dieters combine high dietary restraint with a high tendency toward overeating. The weight regain of dieters may also be explained by the fact that diets do not address the possible *causes* of emotional eating: poor interoceptive awareness, high alexithymia, or a blunted HPA axis stress response (as indicated by a blunted cortisol stress response). A matched treatment of obesity is presented, an approach where treatments match an individual's specific eating style.

Conflict of Interest Tatjana van Strien receives royalties for the DEBQ and its manual.

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The Neuroendocrinology of Anorexia Nervosa and Bulimia Nervosa

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Lindsay P. Bodell and K. Jean Forney

Contents

Abstract

Eating disorders are serious psychiatric conditions associated with severe medical complications and increased risk of death. Two of the most well-known eating disorders are anorexia nervosa (AN) and bulimia nervosa (BN). AN is primarily characterized by extreme dietary restriction that results in low body weight. BN is primarily characterized by the presence of out-of-control over-eating episodes (i.e., binge eating) coupled with extreme behaviors used to compensate for these binge-eating episodes such as self-induced vomiting, fasting, or excessive exercise. Given that these psychiatric illnesses are defined by disturbances in eating behaviors, research has focused on the potential role of appetite-regulating hormones on the development and maintenance of these disorders. The purpose of this chapter is to provide a review of studies on the

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neuroendocrinology of AN and BN, with a specific focus on gastrointestinal or adipose tissue hormones whose effects on eating have been well characterized and theorized to impact eating disorder symptoms. In general, findings support that disturbances in some specific hormones may contribute to the severity or maintenance of AN and BN. However, future longitudinal studies with larger sample sizes are still needed to better understand the role of feeding-related hormonal factors in the pathophysiology of these eating disorders.

Introduction

Eating disorders are serious psychiatric illnesses characterized by disturbances in eating or eating-related thoughts and behaviors (American Psychiatric Association 2013). Indeed, individuals with eating disorders are up to six times more likely to die prematurely compared to the general population, likely due to medical complications and elevated suicide associated with these illnesses (Arcelus et al. 2011). Two of the most well-known eating disorders are anorexia nervosa (AN) and bulimia nervosa (BN). AN is primarily defined by extreme restriction of food intake that leads to significantly low body weight (e.g., body mass index less than 18.5 kg/m^2) as well as an intense fear of gaining weight. BN is characterized by recurrent binge eating, defined as large out-of-control eating episodes, coupled with extreme behaviors to compensate for binge eating, including self-induced vomiting, laxative use, fasting, or excessive exercise. Individuals with BN also report an exaggerated importance of weight and shape on their self-evaluation. Both AN and BN occur most frequently in girls and women, but they also occur in boys and men. For example, in a nationally representative sample of adults in the United States, lifetime prevalence estimates for AN and BN were 1.42% and 0.46% for women, respectively, and 0.12% and 0.08% for men (Udo and Grilo 2018). Importantly, eating disorders do occur *globally* across racial, ethnic, and cultural backgrounds, and they are no longer considered to be problems only affecting young White affluent females (e.g., Pike and Dunne 2015).

Given that both AN and BN are primarily defined by disturbances in eating behaviors (e.g., extreme under- and/or over-eating), hormones impacting eating and weight regulation have been hypothesized to play a role in the etiology and persistence of these illnesses. The purpose of this chapter is to provide a review of studies on the neuroendocrinology of AN and BN, with a specific focus on gastrointestinal or adipose tissue hormones whose effects on eating have been well characterized. These include “orexigenic” hormones that have stimulating effects on appetite (i.e., ghrelin) as well as “anorexigenic” hormones that impact satiation, satiety, and/or reduce appetite and food intake (e.g., cholecystokinin, glucagon-like peptide-1, peptide YY, leptin, and insulin). As outlined below, we review literature investigating whether disruptions in these hormones exist in AN or BN in cross-sectional, case-controlled designs. Where possible, we also review longitudinal or experimental work that more directly assesses the impact of these hormones in the maintenance of AN and BN. Notably, the vast majority of studies reviewed

Table 1 Summary of findings on feeding-related hormone levels in individuals with anorexia Nervosa and bulimia nervosa compared to healthy control participants

Anorexia nervosa		
	Fasting levels	**Postprandial levels**
Ghrelin	Elevated	No differences
Cholecystokinin (CCK)	Mixed	Mixed
Glucagon-like peptide 1 (GLP-1)	Mixed	Inconclusive[a]
Peptide YY (PYY)	Elevated	Mixed
Leptin	Low	(not reviewed)
Insulin	Mixed	Mixed
Bulimia nervosa		
	Fasting levels	**Postprandial levels**
Ghrelin	Elevated[b]	Elevated[c]
Cholecystokinin (CCK)	No difference	Decreased
Glucagon-like peptide 1 (GLP-1)	Inconclusive[a]	Inconclusive[a]
Peptide YY (PYY)	No differences	Mixed
Leptin	Low	(not reviewed)
Insulin	Mixed	Mixed

Notes: [a]Too few studies to draw meaningful conclusions
[b]ghrelin is elevated in bulimia nervosa when examining active (acylated) form
[c]ghrelin normally decreases after eating, and individuals with bulimia nervosa demonstrate an attenuated decrease in ghrelin

below have been conducted in females in North America or Europe, unless otherwise noted. Thus, these samples are not representative of many individuals with AN or BN. Table 1 provides a general overview of findings across studies.

Anorexia Nervosa (AN)

Orexigenic Hormones

Ghrelin

Ghrelin is a gastrointestinal peptide hormone predominately produced by cells in the stomach and lower gastrointestinal tract (Cummings and Overduin 2007). Ghrelin increases prior to meals and in relation to fasting and stimulates appetite and food intake. To date, ghrelin remains the only known orexigenic gut peptide hormone. There are two main forms of ghrelin, acylated (active) and des-acyl (inactive). Although both forms have been measured in individuals with AN, the majority of studies have examined total ghrelin levels in this population.

With a few notable exceptions (e.g., Lawson et al. 2011; Terra et al. 2013), the majority of studies have documented higher fasting ghrelin levels in underweight females with AN compared to healthy controls (e.g., Atalayer et al. 2013; Ogiso et al. 2011). In contrast, ghrelin response to food consumption (i.e., postprandial response) does not appear to be altered in underweight individuals with AN compared to healthy controls (e.g., Prince et al. 2009).

Because increased ghrelin levels are a common consequence of weight loss (e.g., Cummings et al. 2002), it is important to understand if ghrelin dysregulation in AN is strictly due to low weight or reflects a greater dysregulation than may be expected. One way to address this question is to examine levels in individuals with AN who have recently gained weight during treatment or in individuals who have recovered from AN. Few studies have examined ghrelin levels in these samples, with those that have producing mixed results. For example, compared to healthy control participants, girls or women recently treated for AN have statistically similar (Nakahara et al. 2007), lower (Otto et al. 2001; Janas-Kozik et al. 2007), or higher (Tanaka et al. 2004) ghrelin levels than healthy control participants that suggest ranges outside of normal variation in ghrelin. Notably, Tanaka et al. (2004) found that such differences were dependent on the subtype of AN, with only those who engaged in binge eating and purging (AN-binge/purge subtype) showing higher ghrelin even after treatment. Similarly, a more recent study conducted by Holsen et al. (2014) found that individuals who were recovered from AN for an average of 3.7 years had higher ghrelin levels than healthy controls and similar levels as those with current AN, suggesting abnormalities in ghrelin levels may persist even after recovery.

Nevertheless, with a limited number of studies, small sample sizes (9 to 33 per group), and mixed findings in individuals weight-restored or recovered from AN, it is hard to disentangle whether elevated ghrelin represents a trait characteristic of AN or an adaptive response to starvation. Moreover, even with elevated ghrelin in acute AN, these individuals are still able to excessively restrict their food intake. Thus, it is possible that individuals with AN may be less sensitive to the appetite-stimulating effects of ghrelin. Consistent with this idea, Holsen et al. (2014) found that individuals recovered from and those with current AN failed to show the normative associations between ghrelin and hunger ratings as well as associations between ghrelin and brain responses to visual food cues. Taken together, underweight females with AN consistently demonstrate elevated fasting ghrelin levels; however, this does not appear to lead to increased food intake. Instead, ghrelin's appetitive signaling may be disrupted. Additional studies are needed to replicate the persistence of these disruptions in individuals weight-restored or recovered from AN.

Anorexigenic Hormones

Cholecystokinin

Cholecystokinin (CCK) is a meal-related hormone produced by intestinal I cells in response to food intake and contributes to satiation (Cummings and Overduin 2007) and decreased meal size (Lieverse et al. 1995). Given that individuals with AN often report excessive fullness while eating and generally consume small amounts of food in one sitting, the potential role of CCK in AN has been of interest to many researchers. Compared to healthy control participants, underweight individuals with AN have been found to have lower (Baranowska et al. 2000; Brambilla et al. 1996), higher (Fujimoto et al. 1997; Philipp et al. 1991; Tamai et al. 1993), or similar (Cuntz et al. 2013; Fernandez-Aranda et al. 2016; Geracioti et al. 1992; Paslakis et al. 2019) fasting levels of CCK. One explanation for these discrepant findings may be the different types of CCK analysis and the sensitivity of different assay techniques (Cuntz et al. 2013).

Given that CCK is released in response to food intake and contributes to satiation, studies also have examined postprandial CCK response in individuals with AN. Although several studies have noted enhanced CCK responses to test meals in female adolescents and adults with AN (Fujimoto et al. 1997; Philipp et al. 1991; Tomasik et al. 2004), other studies have failed to find postprandial differences in CCK in AN and controls (Geracioti et al. 1992; Pirke et al. 1994; Tamai et al. 1993). Somewhat surprising, Cuntz et al. (2013) did not find postprandial differences between healthy controls and patients with AN at treatment admission; however, they did find enhanced postprandial CCK response in individuals with AN after initial weight gain and just prior to discharge. Moreover, higher levels of CCK across pre- and post-meal assessment points were correlated with frequency of vomiting and worse gastrointestinal symptoms (Cuntz et al. 2013). These findings suggest that CCK dysregulation during weight restoration may contribute to increased fullness and gastrointestinal distress often seen in patients with AN, thereby increasing risk for treatment dropout.

Taken together, no firm conclusions can be drawn regarding whether or not individuals with AN have disturbances in CCK levels. More recent studies with larger samples ranging from 23 to 64 participants per group suggest individuals with AN do not differ from healthy controls on fasting levels of CCK (Cuntz et al. 2013; Fernandez-Aranda et al. 2016; Paslakis et al. 2019). There is some limited evidence that CCK release in response to food intake is enhanced, particularly during weight restoration (Cuntz et al. 2013); however, these findings need to be replicated in larger, mixed-sex samples. Indeed, all studies on CCK in AN have been in women with only one exception that included one male participant (Cuntz et al. 2013).

Glucagon-Like Peptide 1

Glucagon-like peptide 1 (GLP-1) is an anorexigenic hormone produced by L cells in the small intestine and colon (Cummings and Overduin 2007). It is stimulated by nutrients in the gut lumen and released later in the digestion process than CCK (Cummings and Overduin 2007). Food intake is reduced when GLP-1 acts on its receptors in the brain, so this hormone has been linked to meal termination (Verdich et al. 2001; Gutzwiller et al. 2004).

Few studies have examined GLP-1 levels in individuals with AN, with all focused on females. Initial studies on this topic suggested lower fasting concentrations of GLP-1 in adolescent females with AN compared to healthy controls (Tomasik et al. 2002, 2005). However, more recent studies have failed to find such differences (Germain et al. 2007; Heruc et al. 2018; Stengel et al. 2014). To our knowledge, only one study to date has examined postprandial GLP-1 response in AN and found lower mean GLP-1 output in this group compared to controls (Tomasik et al. 2005).

In sum, only a handful of studies have been conducted that examined pre- or postprandial GLP-1 levels in AN, and limited conclusions can be drawn from these studies. The majority has been conducted in very small samples (12 to 22 participants) of adolescent females, and results have been mixed. Studies with much larger sample sizes are needed to determine whether GLP-1 levels are disrupted in AN, and if they are, whether these disruptions impact illness maintenance or generalize to other samples of AN (e.g., males, adults).

Peptide-YY

Like GLP-1, peptide YY (PYY) is produced by L cells in the distal intestine (Cummings and Overduin 2007). PYY is released in response to food intake and infusions of PYY reduce food intake, supporting its role in satiation (Degen et al. 2005). However, unlike GLP-1, PYY levels are elevated for several hours after meals and likely contribute to satiety and the duration of intermeal intervals (Steinert et al. 2017). It is possible that higher levels of PYY both before and after meal consumption contribute to satiety and subsequent food restriction in individuals with AN. Consistent with this hypothesis, the majority of studies have found higher fasting plasma concentrations of PYY in underweight female patients with AN compared to healthy controls (e.g., Eddy et al. 2015; Heruc et al. 2018; Lawson et al. 2011; Misra et al. 2006; Nakahara et al. 2007; Pfluger et al. 2007). However, one study found lower levels of PYY in individuals with AN compared to controls (Germain et al. 2010) and others have failed to find significant differences across these groups (e.g., Germain et al. 2007; Paslakis et al. 2019; Sedláčková et al. 2012; Stock et al. 2005).

Elevated PYY in AN also has been linked to clinical features and consequences of AN. For example, higher PYY levels were negatively correlated with bone mineral density ($rs = -0.72$ to -0.82) in a small sample of adult women with AN ($N = 12$) (Utz et al. 2008) and were associated with poorer bone health in adolescent girls (Misra et al. 2006). Misra et al. (2006) also found elevated PYY to be associated with reduced fat intake in adolescents with AN. Consistent with this finding, higher levels of PYY in female adult AN samples have been linked to other eating disorder symptoms including drive for thinness, dietary restraint, eating concerns, and shape and weight concerns (Eddy et al. 2015; Lawson et al. 2011). These findings suggest that elevated PYY may be an indicator of severity of AN and may contribute to the maintenance of this illness by facilitating small meal size and longer intermeal intervals. Indeed, fasting levels of PYY seem to normalize after recovery as elevated PYY does not persist after treatment (Nakahara et al. 2007), and PYY levels in individuals recovered from AN are similar to levels in controls (Gendall et al. 1999).

In addition to examining fasting levels of PYY, studies also have examined PYY response to food consumption in women with AN. Results from studies examining postprandial levels of PYY are mixed with studies finding either greater PYY output (Nakahara et al. 2007; Sedláčková et al. 2012; Otto et al. 2007) or no differences (Heruc et al. 2018) compared to controls. Another study found overall postprandial PYY output to be the same, but the rate of change in PYY response to be different in females with AN and healthy controls (Stock et al. 2005). Finally, there is some evidence that postprandial PYY response in AN may be dependent on the type of food consumed as individuals with eating disorders have demonstrated elevated PYY response to a high-protein but not a high-carbohydrate breakfast, a pattern that was not observed in healthy controls (Sedláčková et al. 2012).

In sum, the majority of evidence suggests that fasting and postprandial PYY response is elevated in females with AN compared to healthy control participants, but that these disturbances may normalize with recovery. Thus, elevated PYY may be related to the current state of illness, rather than representing a trait contributing to the onset of the disorder. Indeed, unlike the pattern of disturbances in other hormones (e.g., ghrelin), elevated PYY represents a maladaptive response to starvation and may contribute to greater severity of eating disorder symptoms as well as poor bone health in this population.

Leptin

Compared to the other hormones described thus far, leptin is relatively stable throughout the day, representing a more long-term controller of appetite and weight. Leptin is an adipose tissue hormone that regulates eating, in part, through its involvement in satiety (Coll et al. 2007). Both animals and humans with genetic leptin deficiencies experience extremely increased appetite and significant weight gain, and exogenous administration of leptin causes suppression of food intake and weight loss (Friedman and Halaas 1998). Pertinent to AN, leptin is produced by adipose (fat) cells, so significant weight loss results in decreased production of leptin (Considine et al. 1996; Maffei et al. 1995). Thus, decreased leptin in AN would be an adaptive response to weight loss and starvation as reductions in leptin generally contribute to increased food intake overtime.

Indeed, cross-sectional studies in underweight patients with AN have consistently reported reduced leptin levels in individuals with AN compared to healthy controls (Monteleone and Maj 2013). Moreover, lower leptin in women with AN has been correlated with severity of clinical symptoms, including dietary restraint, vomiting, binge eating, shape and weight concerns, anxiety, and depression (Eddy et al. 2015).

In addition to cross-sectional studies, longitudinal studies have examined changes in leptin levels across inpatient treatment as well as the impact of leptin levels on clinical outcomes. Such studies generally have reported increasing leptin as patients gain weight (Bosy-Westphal et al. 2005; Seitz et al. 2016), with studies in weight-restored or recovered individuals suggesting either lower or normalized leptin levels in this population (e.g., Brown et al. 2003; Ehrlich et al. 2009, 2014; Lawson et al. 2012). Although an early small study found that higher leptin levels at treatment discharge predicted poorer outcomes at one-year follow-up (Holtkamp et al. 2004), this finding has not been replicated in more recent, larger longitudinal studies (Mayer et al. 2007; Seitz et al. 2016). Taken together, there is a clear disruption in leptin levels in underweight individuals with AN, but these reduced levels seem to be a consequence of reduced fat mass as they tend to normalize with long-term weight restoration and recovery.

Insulin

Similar to leptin, insulin seems to circulate in proportion to fat tissue and has been found to reduce food intake when administered into the brain (Schwartz et al. 2000). As might be expected based on associations with fat tissue, insulin levels have been found to be reduced in underweight individuals with AN (e.g., Nogueira et al. 2013; Oświęcimska et al. 2015; Misra et al. 2007). However, several additional studies have found either increased or normal insulin levels in AN (e.g., Terra et al. 2013; Heruc et al. 2018). Potential differences in methodology, including time of day blood was collected (e.g., morning vs. the afternoon) or length of fast (e.g., overnight vs. several hours), could contribute to mixed findings.

In addition to examining baseline insulin levels in underweight individuals with AN, several studies have examined whether individuals with AN have a disrupted insulin response to food intake. One recent study found that despite negligible differences in baseline insulin, postprandial insulin levels significantly differed between adolescents with and without AN (Heruc et al. 2018). In particular, the authors noted attenuated insulin response to a standardized test meal in individuals with AN and that this response did not normalize after 2 weeks of treatment. Kinzig et al. (2007) had similar results, finding delayed peak levels of insulin in underweight patients with AN compared to controls and that this delay continued even after short-term weight restoration. Other studies have noted continued reduced baseline and postprandial insulin response in adults recovered from AN (Brown et al. 2003), further suggesting that disruptions in insulin response to food consumption may represent a factor contributing to the eating disorder or a "scar" effect of having had this illness. Notably, however, effect sizes for differences in postprandial insulin response in individuals with AN and healthy controls have been small, and an early meta-analysis of ten studies did not find any significant difference in insulin response across these populations (Prince et al. 2009).

Although data have been mixed regarding fasting and postprandial insulin secretion in AN, a more consistent finding relates to the possibility of insulin sensitivity in individuals with AN. Insulin sensitivity refers to how sensitive one's body is to the effects of insulin, such that someone with high sensitivity would require less insulin to lower blood glucose levels. Indeed, a recent meta-analysis that included eight studies in women with AN found increased insulin sensitivity in underweight AN patients, with effect sizes ranging from medium ($g = 0.61$) to large ($g = 5.34$) (Ilyas et al. 2019). However, body mass index moderated associations between AN and insulin sensitivity, suggesting that weight loss may be driving these effects. Thus, future studies that include weight-restored or recovered individuals are needed to understand how and when insulin sensitivity may be disrupted in this population.

Bulimia Nervosa (BN)

Orexigenic Hormones

Ghrelin

As described previously, ghrelin is an orexigenic hormone produced in the stomach and small intestine that increases food intake (Cummings and Overduin 2007). Binge-eating episodes are a hallmark feature of BN that may be precipitated by increased hunger, particularly in response to extreme dietary restriction and/or fasting. Increased ghrelin levels may facilitate the consumption of large amounts of food by increasing hunger. Supporting this hypothesis, a number of studies have reported higher fasting ghrelin levels in women with BN relative to controls in primarily Japanese samples with sample sizes (n) ranging between 16 and 49 participants (Fassino et al. 2005; Kojima et al. 2005; Tanaka et al. 2003, 2006). However, five times as many studies have failed to find differences in fasting ghrelin levels between women with BN and controls (n range = 13–56) (Devlin et al. 2012; Dynesen et al. 2008; Monteleone et al. 2005a, b, 2008, 2010, 2012; Naessén et al. 2007; Nakazato et al. 2004; Nedvidkova et al. 2011; Sedláčková et al. 2011, 2012; Smitka et al. 2019; Troisi et al. 2005). The inconsistent findings may reflect differences in methodology, including the specific form of ghrelin that was assessed (i.e., acylated/active or total). Studies examining the active form of ghrelin suggest that ghrelin levels are elevated in women with BN, which may facilitate binge eating through increased hunger (Kojima and Kangawa 2010).

Blood plasma levels of both acylated (active) and total ghrelin decrease in response to a meal (Blom et al. 2006); failure to experience this normative decrease also could contribute to increased food intake and binge eating in BN. Indeed, multiple studies have found that the expected postprandial ghrelin decrease is attenuated in women with BN (Keel et al. 2018; Kojima et al. 2005; Monteleone et al. 2003, 2005b). However, other studies have failed to find a difference in postprandial ghrelin release (Devlin et al. 2012; Dynesen et al. 2008; Naessén et al. 2007; Sedláčková et al. 2011, 2012). Variability in methods likely contributed to these findings, as two of the studies that detected a difference examined the acylated (active) form of ghrelin, whereas studies with null findings assessed total ghrelin.

If differences in plasma ghrelin exist between BN and controls, it is important to understand if these disruptions are linked to disease state, potentially contributing to the maintenance of the disorder. One study of 24 women with BN found that fasting acylated (active) ghrelin decreased significantly after a 16-week treatment with paroxetine and cognitive-behavioral therapy, although levels were still elevated relative to controls (Tanaka et al. 2006). Notably, treatment also contributed to decreased binge-eating and purging behaviors, so it is unclear whether the change in ghrelin levels was due to changes in eating behaviors, due to psychological or pharmacological treatment, due to the passage of time, or due to a combination of the above. More longitudinal work examining acylated (active) ghrelin is needed to understand the relationship between ghrelin and maintenance of BN symptoms.

Anorexigenic Hormones

Cholecystokinin

Given the role of CCK in satiety and meal size, lower CCK concentrations or blunted CCK responses could contribute to binge eating in BN by failing to "put on the brakes." CCK concentrations in women with BN have been examined using cerebrospinal fluid (CSF), T-lymphocytes, and plasma. Although assessments of CCK derived from CSF and T-lymphocytes suggest that women with BN have unusually low concentrations of CCK relative to controls (n range = 27–52) (Brambilla et al. 1995; Lydiard et al. 1993), studies sampling plasma have not found differences in fasting CCK concentrations (n range = 14–70) (Devlin et al. 2012; Fujimoto et al. 1997; Geracioti and Liddle 1988; Keel et al. 2007; Naessén et al. 2007; Rigamonti et al. 2014).

Given that CCK is posited to facilitate meal termination (Lieverse et al. 1995), postprandial CCK response may be most relevant to binge eating in BN. A blunted postprandial CCK response has been observed in multiple studies of women with BN (n range = 18–70) (e.g., Devlin et al. 1997; Geracioti and Liddle 1988; Keel et al. 2007; Naessén et al. 2007). Devlin et al. (1997) further demonstrated that group differences in CCK response depend upon meal size. Women with BN had similar CCK response to controls when eating 200 and 400 g meals. A blunted CCK response in BN was only observed after a 600 g meal. This effect was driven by a more rapid increase in CCK response across meal sizes in controls relative to women with BN, suggesting the postprandial CCK response is less responsive to meal size in BN. In addition to being less sensitive to changes in meal size, women with BN may be less sensitive to the anorexigenic effects of CCK. Supporting this hypothesis, CCK administration did not reduce the size of binge episodes in women with BN (Mitchell et al. 1986). Of note, multiple studies have failed to replicate group differences in postprandial CCK response, which may be due to differences in methodology. For example, these studies used a radioimmunoassay with a lower sensitivity (Devlin et al. 2012; Fujimoto et al. 1997; Hannon-Engel et al. 2013; Rigamonti et al. 2014) compared to the bioassay used in other studies finding group differences in CKK (Devlin et al. 1997; Geracioti and Liddle 1988; Keel et al. 2007).

The available literature suggests disruption in postprandial CCK release in women with BN. It is important to understand if this disruption contributes to the maintenance of BN and/or if this disruption is malleable through treatment. Pharmacological manipulations appear to influence CCK release, regardless of illness status. For example, cholestyramine administration increased CCK responses in both women with BN and controls, with a higher response in controls (Rigamonti et al. 2014). These results are difficult to interpret, however, as there were no group differences in response to placebo administration. Treatment with erythromycin (Devlin et al. 2012) and oral contraceptives (Naessén et al. 2007) did not change CCK levels in women with BN; however, binge eating also remained stable across the 6- and 12-week follow-up, respectively. Thus, the existing literature cannot conclude whether changes in CCK precede or follow changes in eating disorder behaviors, and more controlled, longitudinal work is needed to understand if and how disruptions in CCK response are linked to illness state in BN.

Glucagon-Like Peptide 1

Given the function of GLP-1 on reducing food intake and link to meal termination, lower GLP-1 levels or a blunted GLP-1 response could facilitate binge eating. However, relative to other gut peptides, research on GLP-1 in BN is limited. One study found that fasting levels of GLP-1 are lower in women with BN relative to controls (Naessén et al. 2011), although this result has not been replicated (Brambilla et al. 2009). In examining GLP-1 across the day, GLP-1 levels were lower in women with BN compared to controls in the afternoon, but not in the morning, mid-day, or evening (Brambilla et al. 2009). Taken together, the available literature is inconclusive regarding preprandial GLP-1 levels. In contrast, lower postprandial levels of GLP-1 have been found in women with BN relative to controls across two studies (n range = 13–38) (Dossat et al. 2015; Naessén et al. 2011). However, a third study, larger study ($n = 40$), failed to replicate this finding (Brambilla et al. 2009). More work is needed to better understand the role of GLP-1 dysregulation in BN and whether or not it may contribute to binge eating.

Peptide-YY

As previously stated, PYY is an anorexigenic hormone that is released in response to food intake and remains elevated for several hours after meals, likely contributing to satiety and duration of intermeal intervals (Steinert et al. 2017). Thus, directional hypotheses for the role of PYY in BN are unclear. Elevated intermeal PYY could contribute to the alternating fasting and binge-eating pattern sometimes observed in BN (American Psychiatric Association 2013), or a blunted PYY response could contribute to binge eating in a manner similar to hypotheses regarding CCK and GLP-1. However, the vast majority of literature fails to support that fasting levels of PYY differ in women with BN relative to controls (n range = 14–56) (e.g., Devlin et al. 2012; Kojima et al. 2005; Monteleone et al. 2005b; Rigamonti et al. 2014; Smitka et al. 2019), with only one positive finding ($n = 29$) (Sedláčková et al. 2012). Thus, it appears unlikely that elevated PYY contributes to intermittent binge-eating episodes in BN.

Supporting the hypothesis that postprandial PYY response facilitates large binge-eating episodes, two research groups have found a blunted postprandial PYY response in women with BN relative to controls (n range = 14–22) (Kojima et al. 2005; Monteleone et al. 2005b; Rigamonti et al. 2014). In contrast, Sedláčková et al. (2012) found an elevated PYY response after a high-protein meal compared to controls but not after a high-carbohydrate meal. This latter finding is consistent with two other studies that failed to find evidence of a dysregulated PYY response in women with BN (Devlin et al. 2012; Keel et al. 2018). The studies that found a blunted postprandial PYY response tended to use high-fat meals (e.g., 75% fat) (Monteleone et al. 2005b; Rigamonti et al. 2014), whereas studies with null results tended to contain lower fat (e.g., 30% fat) (Devlin et al. 2012; Keel et al. 2018). As PYY response increases with higher fat content (Gibbons et al. 2013), results suggest that the PYY response in BN is characterized by a failure to respond to higher fat content. This may be a consequence of a blunted CCK response, given evidence that CCK release facilitates PYY release in response to fat intake (Lin et al. 2000).

Leptin

Although by definition individuals with BN are within or above an average healthy weight range, many are "weight suppressed" or maintaining a body weight lower than their lifetime highest weight (Bodell and Keel 2015; Lowe et al. 2007). It has been posited that individuals with BN may exhibit lower leptin levels due to being weight suppressed, and that reduced leptin may contribute to binge-eating episodes (Bodell and Keel 2015). Consistent with this hypothesis, several studies have found lower leptin levels in women with BN compared to healthy controls matched for body mass index (n range = 63–78) (e.g., Bodell and Keel 2015; Jimerson et al. 2010; Monteleone et al. 2002). Additionally, some studies have reported associations between lower leptin levels and greater frequency of binge-eating episodes (Jimerson et al. 2000; Monteleone et al. 2002) and longer duration of illness (Keel et al. 2017; Monteleone et al. 2002). However, not all studies have supported associations between leptin and binge frequency (e.g., Jimerson et al. 2010). These null findings may be due to differences in clinical severity and binge-eating frequency across studies.

Importantly, not all studies have found lower leptin levels in individuals with BN compared to healthy control participants (Ferron et al. 1997; Housova et al. 2005; Monteleone et al. 2003; Nakai et al. 2000). For example, Nakai et al. (2000) found higher leptin levels in Japanese women with BN compared to control participants. However, control participants in this study had lower fat mass compared to the women with BN and lower leptin concentrations (mean [SD] = 6.5 [0.5] ng/mL) than observed in control participants from other studies. Other studies that have failed to find differences in leptin levels between individuals with BN and controls, no information was provided for when or how samples were collected (e.g., samples were not collected in a fasting state in the morning) (Ferron et al. 1997) or whether menstrual cycle phase was controlled (Housova et al. 2005). Evidence suggests that blood leptin levels follow a diurnal pattern (e.g., Kalsbeek et al. 2001) and are subtly influenced by food intake (e.g., Monteleone et al. 2003) and phase of the menstrual cycle (e.g., Ludwig et al. 2000). Thus, inconsistent collection of blood samples may contribute to within group variance and null findings.

Insulin

As previously mentioned, insulin levels vary with adipose tissue and have been conceptualized as a signal for long-term fat storage (Schwartz et al. 2000). As women with BN tend to be weight suppressed, one might expect lower overall insulin levels, which would facilitate increased food intake and binge eating. One would not expect a dysregulated postprandial response, as insulin reflects a long-acting signal.

A small number of studies demonstrate lower insulin levels in women with BN (n range = 16–38) (Kojima et al. 2005; Naessén et al. 2011; Smitka et al. 2019;

Taniguchi et al. 1997), while three times as many studies have failed to detect a difference. A review of methods suggests that null results were more common when using a radioimmunoassay (Casper et al. 1988; Coiro et al. 1992; Dostálová et al. 2009; Fassino et al. 2005; Geracioti and Liddle 1988; Housova et al. 2005; Monteleone et al. 2005b; Raphael et al. 1995).

Numerous studies have looked at insulin in response to food intake in BN. Studies that have standardized food intake have observed no differences in postprandial insulin secretion at the group level (n range = 16–39) (Coiro et al. 1992; Dynesen et al. 2008; Geracioti and Liddle 1988; Kojima et al. 2005; Monteleone et al. 2005b; Naessén et al. 2011). Similarly, studies of glucose administration have failed to detect differences in insulin response in women with BN (n range = 16–41) (Blouin et al. 1993; Raphael et al. 1995; Taniguchi et al. 1997; Wollenhaupt et al. 2019). However, these group-level analyses may mask significant variability, as blunted, exaggerated, and normal responses have been observed at the person-level (Russell et al. 1996). The authors of this study attributed the different responses to symptom severity, with those who engaged in binge eating and purging less frequently and who had stable weights tended to have exaggerated insulin responses whereas those who engaged in binge eating and purging more frequently with unstable weights tended to have blunted insulin response. Moreover, self-induced vomiting, relative to other purging methods, has been linked to an increased insulin response (Yasuhara et al. 2004). Indeed, women with BN have elevated insulin levels after binge eating and vomiting compared to controls who eat meals (Kaye et al. 1989). However, a second study found that women with BN have lower insulin levels after vomiting compared to both controls and eating without vomiting (Johnson et al. 1994).

Taken together, the literature on insulin in BN is inconsistent. While there is some evidence for lower fasting insulin levels, these positive findings are limited to specific methods. Studies of postprandial response are largely null, but more nuanced analyses suggest differences in insulin response that is tightly linked to behaviors.

General Discussion and Conclusions

Over the past several decades, there has been much interest in the role of appetite-regulating hormones in the development and maintenance of eating disorders. As expected, the general profile of individuals with AN may represent an adaptive response to starvation, namely, elevated ghrelin and decreased leptin would both serve to facilitate appetite and stimulate food intake. One notable exception is the consistent finding of elevated levels of PYY in AN, which may play a particular role in the maintenance of this disorder. The profile in BN is more nuanced. Fasting ghrelin levels appear to be higher in BN, whereas leptin levels are lower, which would be consistent with elevated food intake. In addition, literature supports an attenuated postprandial decrease of ghrelin and blunted CCK response, which may facilitate the consumption of unusually large amounts food during binge-eating episodes.

Despite some consistent findings, the literature examining the neuroendocrinology of AN and BN is heterogeneous in regard to methodology, which has contributed to mixed findings in the literature. As reviewed above, the form of hormone assessed (e.g., acylated (active) vs. total ghrelin), type of assay (e.g., bioassay vs. radioimmunoassay of CCK), and macronutrient of test meals (e.g., fat or protein content and PYY) may contribute to the presence or absence of group differences between eating disorder and control participants. Additionally, the overwhelming majority of studies examining hormonal factors in AN and BN have used very small samples, with many underpowered to identify significant group differences. Indeed, of the studies examining BN, only 5 were appropriately powered to detect a large effect size (Devlin et al. 2012; Keel et al. 2007, 2018; Monteleone et al. 2005a; Tanaka et al. 2006).

Additionally, the ecological validity and generalizability of this literature is limited. Ecological validity refers to the extent to which a study design or findings map on to real-world settings. Although binge eating tends to occur in the late afternoon or evening, the majority of studies in BN have administered test meals in the morning, likely in order to more easily standardize fasting conditions and minimize diurnal changes in hormones. Thus, it is unclear if group differences in hormone levels and response (or lack thereof) actually mirror the dysregulations that occur when binge eating is most likely. Test meals also vary considerably in macronutrient content and often do not necessarily emulate the types of foods consumed during binge episodes (e.g., high-fat content). Additionally, the majority of studies of BN only included cases marked by self-induced vomiting. Although self-induced vomiting is a common presentation, individuals with BN may not self-induce vomiting and instead engage in laxative or diuretic abuse, excessive exercise, or extreme dietary restriction. As purging in the absence of binge eating has been associated with PYY dysregulation (Keel et al. 2018), it is possible that hormonal dysregulation varies by type of eating disorder behaviors. More work on various eating disorder presentations will help elucidate types of neuroendocrine dysregulation.

Moreover, the overwhelming majority of studies conducted on AN have used samples of individuals seeking treatment or those hospitalized for their eating disorder, which represents a group at the extreme end of severity. Thus, findings may not generalize to other individuals with AN. Relatedly, very few longitudinal studies have been conducted, which is vital to address questions related to the impact of starvation on neuroendocrine dysfunction as well as the role these processes have in the maintenance of these disorders. Finally, the available literature has almost exclusively studied women. Although less common in men, both AN and BN affect a significant minority of men, and how the neuroendocrine profiles may differ in men with eating disorders is unknown.

In sum, the current literature provides support for disturbances in some gastrointestinal and adipose tissue hormones in AN and BN. However, given extensive limitations of the studies to date, future studies with larger, mixed-sex samples are vital to improve our understanding of the neuroendocrinology of these illnesses.

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Causes of Smell, Taste, and Oral Somatosensory Disorders Affecting Eating and Drinking

61

Valerie B. Duffy

Contents

Abstract

Disorders of smell, taste, and oral somatosensation (irritation, touch, temperature, pain) challenge the ability to consume safe and healthy diets as well as enjoy eating and food-related behaviors. From nationally representative US health monitoring, these disorders are as prevalent as hearing or vision disorders. Olfactory dysfunction is most common among older adults, although aging itself may not be the cause. Primary causes of olfactory dysfunction are sensorineural (e.g., chronic nasal/sinus disease, head trauma, respiratory tract infections) and

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neurodegenerative (e.g., Alzheimer's disease). Less vulnerable to loss is taste, especially at levels experienced while eating. Individuals can suffer distorted or phantom sensations (i.e., dysgeusia) related to medications or conditions that disrupt normal interactions between cranial nerves that mediate taste sensation. Oral sensation (integrated taste, retronasal olfaction, and oral somatosensation) can be altered in systemic diseases (e.g., chronic kidney disease), especially if control is poor; by medications that treat and manage systemic diseases (e.g., cancer); and with poor oral health. Normal variation in taste associates with differences in food preferences and nutritional status, including obesity, while chemosensory disorders, if severe enough, can alter dietary patterns leading to weight gain or weight loss. Excessive alcohol consumption and chronic smoking increase the risk of chemosensory disorders directly or indirectly through exposures/conditions that, in turn, cause these disorders. Individuals with chemosensory disorders should have full medical evaluation, including assessment of the impact on eating behaviors, diet quality, and nutritional status. Access to healthcare and medical advances hold continued promise toward prevention and treatment of chemosensory disorders.

Introduction

Interest in the causes of chemosensory dysfunction was stimulated in the 1970s when the National Advisory Neurological and Communicative Disorders and Stroke Council estimated that two million adults suffered from taste or smell disorders, a figure that probably did not include the level of dysfunction seen in older adults (US Department of Health 1979). The first ever National Health and Nutrition Examination Survey (NHANES) chemosensory component estimates US prevalence of chemosensory disorders. From the home interview, 23% of adults self-reported a smell alteration (includes 6% with reported phantosmia) and 19% a taste alteration (includes 5% with dysgeusia) (Rawal et al. 2016). From the olfactory testing in the mobile examination center, 12.4% (13.3 million adults; 55% males/45% females) had olfactory dysfunction, including 3.2% with anosmia or severe hyposmia (3.4 million; 74% males/26% females) (Hoffman et al. 2016). The estimated prevalence rates of dysgeusia afflict approximately 7.6 million US adults aged $\geq$40 years, with 30.4% describing the quality as metallic, 22.8% bitter, and 9.9% sour (Hoffman et al. 2019). The reported qualities of bad/foul (at 24.2%) and burning/tingling (at 8.1%) may not be dysgeusia.

The purpose of this chapter is to review the cause of chemosensory disorders and the potential impact of these disorders on eating and drinking. As noted in the previous chapter, these disorders may be prevented through healthy behaviors and access to healthcare and preventive services such as vaccinations against infections that damage chemosensation. Population-based studies such as NHANES have shown us that there is higher risk of chemosensory disorders with lower income, lower educational access, and among individuals from racial/ethnic minority groups (Hoffman et al. 2016). Chemosensory disorders inhibit our ability to detect harmful through warning odors, to stimulate appetite, as well as prepare the body to process the foods we eat, experience pleasure from eating, from food-related activities and showing care through feeding others.

The most common causes of olfactory dysfunction in patients without major systemic diseases (e.g., chronic kidney disease) are upper respiratory tract infections, head trauma, inflammatory diseases (e.g., chronic nasal/sinus disease, allergic rhinitis), and neurodegenerative diseases (e.g., Alzheimer's disease and Parkinson's disease). These conditions/diseases diminish olfactory perception by (1) reducing transport of odors to the olfactory receptors; (2) damaging sensory receptors that receive and transduce the olfactory message; and (3) damaging the peripheral or central neurophysiologic systems. The first two can be labeled as sensorineural olfactory dysfunction. Less common causes of olfactory dysfunction are congenital disorders, toxic exposures, and medications. Compelling descriptions are available of what is it like to be born without a sense of smell (Tafalla 2013) as well as to lose the sense of smell suddenly (Boesveldt et al. 2017). These accounts and the prevalence of olfactory dysfunction, particular among older adults, highlight the need for routine screening and assessment of olfactory abilities, which are not usually part of routine medical care. Individuals with olfactory dysfunction should be advised to have functional detectors of smoke and natural gas and to pay attention to expiration dates of food. Treatments for olfactory dysfunction include olfactory training, medications, and surgical treatments as recently reviewed (Whitcroft and Hummel 2019). Research is underway in the development of strategies to promote neurogenesis of olfactory epithelial cells (Boesveldt et al. 2017) and stem cell-based therapies to replace olfactory neurons (Kurtenbach et al. 2019).

Taste disorders result from disruption of the transport of stimuli to the receptors (dry mouth or xerostomia), transduction pathways (certain medications), and neural pathways necessary for taste perception (taste damage to a specific cranial nerve). Usually unnoticed is taste loss to specific areas of nerve innervation (e.g., front of the tongue), except in the case that this loss results in dysgeusia (see also the companion chapter). Foul sensations perceived as from the mouth, but not salty, sweet, sour, or bitter in quality are a dysosmia or parosmia. Dysgeusia and altered oral sensations require correct evaluation and must not be mislabeled as psychiatric problems.

Aging

Olfaction: Older adults show a range of functioning from total loss (anosmia) to diminished ability (hyposmia) to a sense of smell equal to younger adults (normosmia). Aging per se is not the major cause of chemosensory dysfunction; the dysfunction results more from conditions or exposures that accrue with aging or are more frequent in older adults. Women consistently outperform men on olfactory tests (Hoffman et al. 2016), although this effect may not persist in those over 80 years of age (Doty et al. 1984; Larsson et al. 2004). Greater number of olfactory neurons in the olfactory bulb (Oliveira-Pinto et al. 2014) and sex hormone influence (Simsek et al. 2015) may explain superior olfactory ability in females. Frailty in older adults (e.g., experience weight loss, having poor grip strength, exhaustion, slow walking speed, and low physical activity) associates with diminished diversity of oral and nasal microbiota and increased susceptibility to infectious agents and environmental exposures that lead to chronic conditions that cause chemosensory disorders (Garcia-Pena et al. 2017). However, improvement of nutrient intake and lean body mass in frail older adults may not improve olfactory perception (de Jong et al. 2000).

Most studies support that olfaction declines with age, although healthy behaviors, preventive care, and access to healthy environments prevent declines that are usual with aging. From NHANES, the prevalence of self-reported chemosensory dysfunction were highest in those ≥80 years old (32% for smell, 27% for taste) (Rawal et al. 2016). Nearly 40% of ≥80-year-old adults had measured olfactory dysfunction (Hoffman et al. 2016), and 20–30% of ≥70-year-old adults were unable to identify warning odors. These prevalence are similar to 2400+ residents, ages 53–94 years, from Beaver Dam, Wisconsin (Murphy et al. 2002); the overall prevalence was 24.5% (62% in those >80 years old) and was greater in men and those reporting olfactory-related insults (e.g., nasal/sinus disease, smoking, upper respiratory tract infections).

Aging without specific insult associates with a gradual olfactory loss that often is unrecognized. Indeed, from the National Social Life, Health, and Aging Project (NSHAP), a nationally representative sample of adults to longitudinally assess sensory changes associated with aging (Schumm et al. 2009), 72% of older adults did not recognize having olfactory dysfunction (Adams et al. 2017). The highest rates of misrecognition were seen in older adults with cognitive deficit and those from groups with racial and social disparity. Olfactory loss associated with dementia disorders also may be gradual and parallel the decline in cognitive functioning. Although more precipitous olfactory loss associates with environmental insults (e.g., nasal/sinus disease, head trauma, upper respiratory tract infection), it is difficult to separate olfactory losses of aging from those caused by disease and these insults. Older adults with poor olfaction have higher risk of death according to the longitudinal analysis of the NSLAP, despite an overall self-reported good to excellent health at baseline (Liu et al. 2019). The olfaction-mortality association was explained by dementia and neurocognitive disorders.

Older adults have higher thresholds (less sensitivity) than younger adults (Schubert et al. 2017). Older adults require from 2- to 100-fold higher concentration to recognize the presence of an odor (recognition threshold) (Cain and Stevens 1989; Stevens and Dadarwala 1993) and may report less intensity from odor concentrations above the threshold level. Stevens and colleagues (Stevens et al. 1982) were the first to report lower odor intensities in older versus younger adults with differences greater for odor than taste intensity (Stevens et al. 1984). In comparing perceived intensities of six odors that varied in quality, Stevens and Cain (Stevens and Cain 1985) found age-related olfactory losses for weak and strong odors. A substantial elevation in threshold appears to parallel a reduced ability to perceive more concentrated olfactory stimuli.

Other sensory systems show quality-specific changes associated with aging, including age-related loss of high-frequency sounds and bitter taste quality. With the uniqueness of an individual's olfactory receptor fingerprint (Secundo et al. 2015), it is possible that subtle and gradual age-related changes in olfaction could be quality-specific as shown in the National Geographic Smell Survey (Wysocki and Gilbert 1989) and a more recent study comparing olfactory threshold between young and older adults (Seow et al. 2016). Age-related declines across odor groups (e.g., sweet vs. musky/spicy) may reflect differences in the trigeminal component of the odor as well as the pleasantness and familiarity of the odor. Severe olfactory dysfunction likely depresses the ability to perceive all odor qualities.

Defects to the olfactory system could impair orthonasal (via the nostrils) and retronasal (via the oral cavity) olfaction. Older adults show less ability than do young people to identify food based solely on olfactory cues in blended foods (Murphy 1985; Schiffman 1977) and readily available foods and condiments (Heilmann et al. 2002). One study showed that middle-aged and older individuals were equally unable to discriminate the presence of an olfactory seasoning (marjoram) in a food item (soup) (Cain et al. 1990). Clinical conditions can dissociate retronasal and orthonasal olfaction. Full retronasal olfactory perception requires sufficient mastication to release volatiles from foods as well as adequate mouth and swallowing movements to create enough intraoral pressure to pump the volatiles to the olfactory epithelium (Burdach and Doty 1987). Oral health problems can disrupt retronasal olfaction independent of orthonasal function. Regional taste damage also impairs retronasal olfaction independently from orthonasal perception (Bull 1965; MacCarthy-Leventhal 1959). Individuals can be able to identify odors retronasal even with olfactory impairment (Ganjaei et al. 2018) if the odor has a trigeminal component that helps to localize the odor to the mouth.

Taste: Most research suggests that aging is associated with elevated taste thresholds (Mojet et al. 2001; Murphy 1986). There are also compound-specific elevations in bitter threshold associated with aging (Cowart et al. 1994). Older individuals also show elevated taste thresholds within taste mixtures (e.g., elevated salt threshold in a mixture of citric acid or tomato soup) (Stevens and Cain 1993). Taste threshold may not correspond to how intensely concentrated tastes are perceived, such as those experienced during eating (Bartoshuk and Duffy 1995). Elevated taste thresholds have been associated with lower cognitive function, smoking, drinking alcohol, missing teeth, and lower stimulated salivary flow (Uota et al. 2016). Suprathreshold measures, if following evidence-based psychophysical procedures (Bartoshuk and Duffy 1995), likely provide the most information about taste in older adults. Bitter taste intensity shows great reductions than that for sour, sweet, and salty (Bartoshuk et al. 1986; Cowart et al. 1994; Mojet et al. 2003; Schiffman et al. 1994). Age-related differences in taste intensity are less pronounced during eating and when interactions between taste, smell, and oral somatosensation influence overall flavor intensity (Mojet et al. 2003). Aging can associate with loss of taste perception from individual regions of cranial nerve innervation that does not produce whole mouth taste loss (Bartoshuk 1989). Regional loss can alter oral somatosensory, retronasal, and even dietary-related behaviors. Taste can be damaged without changing the number of fungiform papillae. These papillae are formed early in gestation (Miller and Bartoshuk 1991) and remain intact unless the trigeminal and lingual nerves are damaged (Prutkin et al. 2000; Zuniga and Miller 1994).

A synthesis of cross-sectional data suggests that taste is upregulated in women during childbearing age and then declines across menopause (Prutkin et al. 2000). Hormone replacement has been hypothesized to reduce age-related olfactory declines in females. An observational study showed superior odor memory and discrimination in postmenopausal women with better estrogen status. This finding is consistent with maintenance of olfactory function among women who receive estrogen replacement and who have a genetic risk of early-onset Alzheimer's disease (ApoE-ε4 allele positive) (Sundermann et al. 2008).

Somatosensation: Perception of trigeminal sensations shows less age-related declines than of olfactory sensations (Pushpass et al. 2019). Although older adults are less able than young adults to tell which side of the nose an odor is presented (test of nasal trigeminal sensitivity) (Hummel et al. 2003; Wysocki et al. 2003) and report less intensity from menthol through the nostrils (Pushpass et al. 2019), they are still able to use trigeminal sensations for the perception and discrimination of odors (Laska 2001). Impaired nasal trigeminal sensations may be able to distinguish an older adult with idiopathic Parkinson's disease from an older adult without this neurodegenerative disease (Foguem et al. 2018). Aging likely does not associate with diminished oral somatosensory intensity, which is important for the swallowing reflex, as seen with thickened liquids (Weiffenbach et al. 1990), size of orally explored letters (Bangcuyo and Simons 2017), air pressure (Chamberlain et al. 2007), temperature perception (Calhoun et al. 1992; Weiffenbach et al. 1990), or burn of capsaicin (Pushpass et al. 2019). Differences in the number of fungiform papillae also explain differences in oral identity of letters (Bangcuyo and Simons 2017).

Oral burn and irritation may show age- and sex-specific differences. With menopause, there may be some loss of bitter perception, especially to the anterior tongue. The loss of taste on the anterior tongue (cranial nerve VII) could make the response to irritation (cranial nerve V) on the anterior tongue even more pronounced. Taste and pain interactions may play a role in the etiology of burning mouth syndrome (Grushka and Bartoshuk 2000). Individuals with this oral pain phantom were more likely than age-matched controls to have taste damage from the chorda tympani and the highest number of fungiform papilla (i.e., supertasters) or asymmetry between fungiform papilla on right and left sides of the tongue (Naud et al. 2018). Loss of taste on the anterior tongue could enhance the trigeminal sensations from high-fat foods and make them more pleasurable (Chapo 2002).

Chronic Nasal-Sinus Disease

Olfaction: Up to 12% of the population from industrialized countries suffer from chronic rhinosinusitis (CRS), which is persistent symptomatic inflammation of the nasal and sinus mucosa (Orlandi et al. 2016), with or without nasal polyps. From analysis of the NHANES 2013/2014 data, 2% of the US population has self-reported olfactory dysfunction along with the other symptoms of CRC including discolored nasal mucus, nasal blockage, and sinus pain (Bhattacharyya and Gilani 2018).

Comorbidities with CRC include asthma and other respiratory diseases, aspirin sensitivity, and chronic obstructive pulmonary disease. An animal model shows CRC-associated olfactory loss in three distinct phases: (1) olfactory neuron dysfunction due to the effects of cytokines (small molecules important to the immune system); (2) loss of olfactory receptor neurons and replacement with nonolfactory neurons; and (3) inflammation blocking the formation of new neurons (Lane et al. 2010). This model suggests that the olfactory impairment results more from changes to the olfactory epithelium and less from conductive causes (e.g., nasal/sinus obstruction of airflow, inflammation inhibiting odor-receptor binding), including novel signaling pathways (Victores et al. 2018). Thus, CRS may show more negative effects on olfactory thresholds than on than suprathreshold function. Odor discrimination may help track olfactory improvements with CRC treatment (Wu et al. 2018). Severe seasonal or perennial allergic rhinitis can cause hyposmia but not anosmia (Bosnic-Anticevich et al. 2019).

Nasal-sinus disease is one of the few treatable forms of olfactory dysfunction. Diagnosis of this condition by an otolaryngologist usually includes patient history, physical examination, and olfactory testing and imaging to assess blockage of the olfactory cleft (Boesveldt et al. 2017). Although there is a good correspondence between self-reported and measured olfactory dysfunction associated with chronic nasal-sinus disease (Murphy et al. 2003), olfactory testing should accompany self-reported measures (Haxel 2019). If patients notice fluctuations in their sense of smell with exacerbation of nasal-sinus conditions, they may benefit from aggressive therapy. Medical management of nasal-sinus disease includes nasal saline irrigation, antibiotics, and controlling the causes of the inflammation (e.g., allergens causing allergic rhinitis, nasal infections) and level of the inflammation (e.g., systemic or topical corticosteroids (Boesveldt et al. 2017)). From a meta-analysis (Banglawala et al. 2014), oral steroids, and less so for topical steroids, showed an improvement in self-reported olfactory function and less pronounced improvement in measured olfactory function. The lack of measured improvements may indicate the insensitivity of the olfactory measures to detect improvements (Doty 2007). A 16-week randomized control trial with nasal steroid spray plus a human monoclonal antibody (dupilumab), which inhibits cytokine signaling of T-helper cells involved in mediating inflammation, resulted in significant improvement in CRC, nasal polyps, and odor identification scores (Bachert et al. 2016). These results need replication with a larger trial but are promising (Haxel 2019). Some nasal-sinus diseases require surgical interventions (e.g., severe sinusitis and nasal polyposis) to achieve olfactory improvements, particularly in those with poorest sense of smell pre-surgery (Haxel 2019). Nasal polyps with CRS, olfactory dysfunction, and aspirin sensitivity (aspirin-exacerbated respiratory disease) require multilevel management (Graefe et al. 2012).

Taste: CRS may influence taste function if the pathogens and inflammation influence peripheral taste processing (Wolf et al. 2018). However, more interesting is the potential taste genetic relationship with the pathophysiology of this disease. Taste receptors uncoupled with taste nerves are throughout the body, including the upper respiratory tract, and may play a role in mucus quality and bacterial killing properties as well as the ability to form a biofilm (irreversible attachment of microorganisms for growth and replication) (Douglas and Cohen 2017). Individuals carrying both copies of the taster receptor for the *TAS2R38* gene (PAV/PAV) may be more protected than the heterozygote or homozygous nontaster (AVI/AVI) and have more positive outcomes from surgery for CRS without polyps (Adappa et al. 2016).

Upper Respiratory Tract Infection (URI)

Olfaction: URI can diminish olfactory perception through nasal obstruction and viral damage of the olfactory receptors and possibly the olfactory bulb. If sinus problems are ruled out, URI is the most common reason for olfactory dysfunction, with equal effects on orthonasal and retronasal function, more likely hyposmia than anosmia (Fonteyn et al. 2014), and more frequent in older women (Fonteyn et al. 2014; London et al. 2008). The URI virus primarily affects the peripheral olfactory processes, although viruses can invade the central nervous system via the olfactory receptor cells, especially with age-related degradation of the olfactory epithelium (Baker and Genter 2003). Individuals with post-URI olfactory dysfunction have reduced numbers of olfactory receptor cells with cilia (Moran et al. 1992). The olfactory bulb may play an important role in protecting the central nervous system from viruses and pathogens (Durrant et al. 2016).

Prevention of upper respiratory tract infections (or the flu) may be the best way to avoid the risk of olfactory dysfunction. Most patients with URI-related olfactory loss show olfactory improvement. Significant but incomplete improvement may occur in 25% of those with URI-related olfactory loss over 9 months (Rombaux et al. 2010). Patients with URI-related olfactory loss (and head trauma; see below) may exhibit dysosmia (distortion of an odor when an odor is present), which subsides over time. Antibiotics may improve olfactory function among individuals with URI and bacterial-related sinus inflammation (Wang et al. 2018b). Olfactory training also may be beneficial. In a pretest posttest design but without a control group, adults with URI-related olfactory dysfunction showed significant improvement in olfactory scores after 24 weeks of purposeful exposure to four odors in the morning and the evening (10 s smelling for each), with about 40% of adults recovering at 24 weeks (Qiao et al. 2019). Adults with shortest duration of olfactory dysfunction related to URI loss were 20% more likely to show improvement. More rigorous testing is required before a causal relationship can be concluded between olfactory training and improvement in URI-related olfactory loss.

Taste: The viruses that cause URI also damage taste from regional areas of cranial nerve innervation (e.g., loss of taste on the anterior tongue). Affected individuals likely would not report loss of ability to taste salty, sweet, sour, or bitter; whole mouth oral sensations remain intact due to interactions between cranial nerves innervating taste (Bartoshuk et al. 2006). However, severe regional loss could disrupt the balance of taste, oral somatosensory, and retronasal sensation to cause altered oral sensations.

Taste and Pathologies of the Middle Ear

A number of pathologies damage the chorda tympani nerve as it passes through the middle ear to influence taste and oral sensation. Otitis media (middle ear infection or OM) is common in children. Although the risk is lowered with vaccinations (pneumococcal and influenza) (Lieberthal et al. 2013), 23% of children suffer at least one acute OM by 1 year and 60% by 3 years of age (Kaur et al. 2017), with highest rates in males and those in day care, with family history, and not breastfed. Variation in chorda tympani taste (tongue tip) can explain differences in diet and nutrition outcomes (Fogel and Blissett 2019). Adults or children with lower chorda tympani nerve taste alone or relative to whole mouth report less preference/intake of vegetables (Dinehart et al. 2006; Peracchio et al. 2012), consume more alcoholic beverages (Duffy et al. 2004b), and have greater risk of elevated body weight (Fogel and Blissett 2019; Peracchio et al. 2012; Rawal et al. 2017).

Some surgeries also damage the chorda tympani nerve (e.g., acoustic neuroma surgery). Patients with pathological or surgical damage of the chorda tympani nerve show unilateral or bilateral taste impairment for one or all taste qualities, depending on the extent of the nerve damage (Bartoshuk et al. 1996; Kveton and Bartoshuk 1994). The surgery results in loss of fungiform papilla taste buds and altered taste and trigeminal sensations (Nishii et al. 2019). Although patients rarely report a whole mouth taste loss, taste damage to the chorda tympani nerve can result in altered trigeminal sensations and dysgeusia (Nishii et al. 2019) and changes in food preferences. Children may normalize oral sensations after the surgery more quickly than adults (Nishii et al. 2019). Taste buds on the tongue tip may take months to a year to recover (Saito et al. 2016).

Head Trauma

Olfaction: Head trauma can cause severe and sudden chemosensory losses. Rates of anosmia in those with head trauma range from as low as 0% to 16% among those with mild head injury and 25–30% among those with severe head injury (Howell et al. 2018); the rate of taste loss is very low (0.4–0.5%) (Costanzo and Zasler 1991). Head injury-related olfactory loss involves peripheral damage to the olfactory nerves and nose and central damage to the olfactory centers in the brain (Sumner 1964). The most common cause involves severing of olfactory nerves where they pass through the cribriform plate of the ethmoid bone from coup-contrecoup forces (impact causes the brain to bump to the opposite side of the skull) (Howell et al. 2018). Olfaction also is damaged with disruption to the sinonasal region or focal contusion/hemorrhage of the olfactory bulb and cortex (Howell et al. 2018). Via functional magnetic resonance imaging, patients with traumatic brain injury had impaired central nervous processing of odors (Han et al. 2018). Only a few patients (up to 35%) show slight improvements in olfactory perception over time (Duncan and Seiden 1995; Yousem et al. 1996).

Taste: Head, facial, and nose trauma has been associated with self-reported smell and taste disorders in the NHANES (Rawal et al. 2016) as well as measured taste alterations and increased risk of excessive adiposity (Rawal et al. 2016).

Olfaction and Neurodegenerative Disorders

Olfactory dysfunction is reported in many neurodegenerative disorders including Alzheimer's disease (AD), Parkinson's disease (PD) (and variants), Huntington's disease, and Down syndrome as shown in a meta-analysis of 43 studies (Mesholam et al. 1998). In a 15-year longitudinal aging study of dementia-free older adults, higher olfactory ability at baseline was associated with slower rate of cognitive decline over the study. Those with olfactory impairment scored poorer on many cognitive functions and had greater cognitive decline over the 15 years (Dintica et al. 2019). Olfactory dysfunction also appears an early marker in those at risk for developing AD (Bacon Moore et al. 1999) potentially explaining the conversion of mild cognitive impairment to AD (Jung et al. 2019). A simple probe with the ability to detect a common odor, unilaterally, may provide a simple screener for AD (Stamps et al. 2013). The rationale is that AD affects the left side of the brain more than the right and probable AD patients would show asymmetry and less ability to detect a common odor with the left than right nostril (Stamps et al. 2013). Most patients with AD are unaware of olfactory dysfunction (Nordin et al. 1995). The olfactory impairment parallels the progressive memory loss and dementia (Murphy 2019), and reductions in the ability to detect, discriminate, and identify an odor in AD likely involve neural networks beyond just olfactory networks (Lu et al. 2019). From a meta-analysis, AD was associated with significant impairments in olfactory identification and discrimination but not olfactory thresholds (Jung et al. 2019).

PD is viewed as a slowly progressing, multisystem neurodegenerative disorder with extensive involvement of the central nervous system, loss of dopaminergic neurons in the substantia nigra, and a host of motor deficits and non-motor disturbances (Kalia and Lang 2015). Olfactory dysfunction is seen in nine of ten individuals with PD (a rate that exceeds the presence of tremors, a hallmark sign of PD) (Doty et al. 1988). Patients with early-onset PD ($<$ 6 years) report olfactory loss and changes to food flavor as fifth out of the top five most bothersome side effects of the disease (Politis et al. 2010). In the later stages of PD, other symptoms overshadow the olfactory loss. The severity of PD does not correspond with the degree of olfactory dysfunction, and there may be a genetic variant of olfactory binding protein that associates with progression of PD to PD with olfactory dysfunction (Melis et al. 2019). Current research aims to determine if non-motor functions, such as olfactory function, are a diagnostic indicator before motor problems in early stages of PD (Sui et al. 2019). Individuals with hyposmia at PD diagnosis may have more rapid cognitive decline within the first 7 years of diagnosis (Gjerde et al. 2018). The evidence of taste alteration in PD is less clear. There may be regional taste differences in early PD (R. L. Doty et al. 2015) that like olfaction are not related to the level of dopamine.

Obesity

Obesity is defined as a body mass index >30 and characterized by a pro-growth, pro-inflammatory state that increases the risk of many additional chronic diseases and conditions. The World Health Organization estimates that obesity rates have tripled since the 1970s with 39% of the adults as overweight and 13% as obese (https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight). The rates in the USA are higher with nearly 40% of adults as obese (https://www.cdc.gov/obesity/data/adult.html). Poor diet plays a primary role in the development and fueling of obesity risk and has raised questions about chemosensory function, diet, and risk of obesity. Following the US Dietary Guidelines 2015, individuals can lower the risk of obesity by consuming a healthier dietary pattern [more whole fruits, a variety of vegetables, whole grains, low-fat dairy products, alcoholic beverages in moderation ($\leq$1 per day for women and $\leq$ 2 per day for men), lean proteins and less saturated/trans fats, sugar/sugary drinks, less fast foods, and less sodium (https://health.gov/dietaryguidelines/2015/guidelines/chapter-1/key-recommendations/].

Normal variation in taste: Despite the sense of smell holding primacy in the anticipation of eating, appetite, and flavor perception (Boesveldt and de Graaf 2017) and speculation on the role of olfaction and energy metabolism from animal work (Garrison and Knight 2017), more research has been reported on taste related to consuming a healthy diet and risk of overweight and obesity. Normal variation in taste has been associated with differences in sweetness and bitterness from vegetables, overall vegetable consumption (Dinehart et al. 2006; Duffy et al. 2010), and the need for condiments to improve the sensory appeal of vegetables among those who taste more bitterness (Fisher et al. 2012; Sharafi et al. 2013). Genetic variation in taste also has been associated with alcoholic beverage sensation (Allen et al. 2014; Nolden et al. 2016) and consumption (Dotson et al. 2012; Duffy et al. 2004a; Fischer et al. 2013; Hayes et al. 2011). Variation in taste has been associated with creamy and tactile sensations from fat, particularly among those who taste 6-n-propylthiouracil (PROP) as more bitter (Hayes and Duffy 2007; Tepper and Nurse 1998) and have more fungiform papillae (Essick et al. 2003; Hayes and Duffy 2007). Some variability in liking for fat is associated with the PROP taste phenotype (Hayes and Duffy 2007; Tepper and Nurse 1998).

In the 1960s, the psychologist Fischer concluded that “extremely sensitive tasters of both quinine and PROP can be classified as Kretschmerian leptosomes or Sheldonian ectomorphs, whereas the extremely insensitive tasters of both compounds conform to the Kretschmerian pyknic or Sheldonian endomorph type” (Fischer et al. 1966). Genetic variation in taste may interact with cognitive and metabolic controls of intake to influence food preferences, energy intake, and energy balance (Tepper et al. 2014). Studies of associations between taste genetics (PROP phenotype, *TAS2R38* expression) and weight in adults or children have been inconsistent. However, an epidemiological designed study (Mendelian randomization design) that evaluates genetic distributions independent of behavioral and environmental influences (Smith and Ebrahim 2004) has supported a causal relationship between PROP phenotype and body composition, with nontasters showing higher adiposity than tasters (Bouthoorn et al. 2014). Furthermore, from feeding studies, PROP nontasters consume less energy (Shafaie et al. 2015, 2013) and are the least responsive to a weight loss intervention to lower energy consumption (Coletta et al. 2013). Recently, we reported that markers of variation in taste were associated with risk factors of cardiovascular disease (blood pressure, serum lipids) through influences on food preferences (Sharafi et al. 2018). However, some of the relationship between taste and serum lipids was not associated with food preferences. The food environment also influences the expression of taste-related obesity risk. In an observational study of children (Burd et al. 2013), PROP nontasters living in areas with ready availability to less healthy foods had the highest adiposities.

There are new and emerging research on the role of taste and non-taste receptors throughout the body on metabolic responses to ingested foods, energy balance, and metabolic diseases such as diabetes and obesity (Karimian Azari et al. 2017).

Chemosensory dysfunction: Most adults with chemosensory disorders report changing their eating habits (Ferris and Duffy 1989; Mattes and Cowart 1994; Mattes et al. 1990). Some report improvements (Aschenbrenner et al. 2008; Ferris and Duffy 1989), no change, or consuming more in response to olfactory loss (Mattes and Cowart 1994), especially among females (Ferris and Duffy 1989). Individuals with anosmia report less enjoyment of eating and food-related activities (Boesveldt et al. 2017). Weight loss with a chemosensory disorder is reported more frequently in males and those with multiple chemosensory disorders (Mattes and Cowart 1994) and burning mouth syndrome (Deems et al. 1991a).

The association between olfactory dysfunction, diet, and obesity is also important to evaluate in nonclinical settings. Some research finds no significant association between olfactory dysfunction and nutritional risk (Toussaint et al. 2015). In a home-based evaluation, older with lower olfactory function reported less interest in food and food-related activities (e.g., cooking for themselves), more frequent intake of sweet foods, and a diet that increases risk of cardiovascular disease (Duffy et al. 1995). The women who had and rated a good sense of smell presented with the least nutritional risk and the highest intakes of fruits and vegetables as well as high-fiber grains and seeds and having a normal body mass index (Duffy 1992; Duffy and Ferris 1993). Those who perceived an olfactory dysfunction despite a normal measured function were significantly more likely to be obese and have a less healthy diet than those with measured dysfunction or those who did not believe that they had an olfactory problem. From the 2013/2014 NHANES (Gallo et al. 2019), middle-aged females with olfactory dysfunction showed elevated adiposity (BMI and waist circumference) and less favorable serum lipids. Males with olfactory dysfunction were thinner. In total, individuals with self-reported or measured chemosensory disorders should have a nutrition evaluation by a registered dietitian to support enjoyment of eating and a healthy diet and weight while managing the disorder.

Taste alteration: Environmental factors influence relationships between taste, diet, and adiposity. Altered taste perception associated with pathology-related insult to the chorda tympani (e.g., chronic otitis media exposure) is linked to risk for overweight and obesity in community-based (Bartoshuk et al. 2012) and laboratory-based (Rawal et al. 2017) studies.

Bariatric surgery: Bariatric surgery is a frequent treatment for morbid obesity (body mass index $\geq$40.0), and many patients after recovery from the surgery report changes to food tastes and food preferences. This surgery is growing in popularity for obesity treatment as one that can reverse type II diabetes and decrease cardiovascular disease risk (Panteliou and Miras 2017; Sjostrom 2013). Most bariatric patients are females (Young et al. 2016). The most common surgical procedures result in an excess weight loss of 60–80% for Roux-en-Y gastric bypass (RYGB) and 50% for sleeve gastrectomy. The weight loss results from restricting the stomach size and malabsorption with the RYGB (Panteliou and Miras 2017), which, in turn, suppresses appetite and hunger, enhances satiety, changes gut-derived signals and sensory mechanisms to lower reward and preference for palatable foods (Makaronidis and Batterham 2016), and alters the gut microbiota and bile acid (Mulla et al. 2018). Decreased liking or preference for energy-dense foods may result from changes in chemosensory function, gut-related hormones mediating food aversions (le Roux and Bueter 2014), neural activation in reward-related brain areas, motivation to consume, and hedonic hunger (Kapoor et al. 2017; Li et al. 2019; Schultes et al. 2010; Ullrich et al. 2013).

Bariatric surgery does not appear to change taste and smell function, yet because of the increased attention to eating and portion size required after survey, patients appear to self-report changes in taste and/or smell function. There are not consistent pre-post-surgery changes for taste threshold (Nance et al. 2017; Pepino et al. 2014) or perceived intensity (Hubert et al. 2019; Nance et al. 2017). Most patients after bariatric surgery report oral sensory alterations, including repulsive and aversive responses, and that these alterations were associated with better weight loss (Graham et al. 2014; Hubert et al. 2019; Makaronidis et al. 2016; Tichansky et al. 2006). Changes in smell perception are less frequently reported (Makaronidis et al. 2016), yet a pre-post bariatric surgery study found improvements in smell threshold and identification abilities (Holinski et al. 2015).

Several review articles have highlighted human studies of changes in preference for energy-dense foods following bariatric surgery (Gero et al. 2017; Kapoor et al. 2017; Primeaux et al. 2016). In response to sucrose solutions, post-bariatric surgery patients reported less preference for sweet and improved ability to control intake of sweets (Nance et al. 2017; Pepino et al. 2014), as well as reduction in reward from candy (Miras et al. 2012). Post-surgery patients who reported decreases in preference for energy-dense foods had the most success in total weight loss at 1 year (Hubert et al. 2019) and 18 months (Sondergaard Nielsen et al. 2018).

Liver and Kidney Diseases

The level of chemosensory impairment associated with systemic diseases may relate to the severity of the disease; impaired sensory processes due to disease complications, malnutrition, and the buildup of toxic by-products with metabolic alterations; as well as side effects of medications. Below is a review of some of these systemic diseases.

Liver Disease: Excessive alcohol consumption is associated with greater risk of chemosensory disorders (Hoffman et al. 2016). Individuals with liver disease (cirrhosis) show elevated thresholds (detection and recognition) for odors (Garrett-Laster et al. 1984) and tastes (Garrett-Laster et al. 1984; Madden et al. 1997) and impaired odor identification (Temmel et al. 2005). Recovery from the disease or correcting the nutrient deficiency (e.g., vitamin A (Garrett-Laster et al. 1984)) may improve function (Deems et al. 1991b). One study reported improved taste and smell sensitivity from pre- to post-liver transplantation; the changes may relate to improvements in health and nutritional status and reductions in medication usage (Bloomfeld et al. 1999). Hepatic encephalopathy is characterized by psychomotor problems including cognitive decline that advances with shaking of the extremities and slurred speech. This complication is difficult to diagnosis in early stage. As the severity of hepatic encephalopathy parallels the level of olfactory dysfunction, but not the severity of cirrhosis or other complications (e.g., portal vein hypertension, ascites), olfactory testing may assist the diagnosis of cirrhosis complications (Heiser et al. 2018).

Kidney Disease: The kidney helps to control blood pressure along with many important regulatory functions. Since olfactory and taste receptors have been located in the kidneys and may be part of blood pressure regulation, researchers examined the longitudinal association of self-reported chemosensory function and blood pressure in a large, population-based study of adults ($n = 5190$) who did not have high blood pressure or kidney disorders at the start of the study (Liu et al. 2018). In analysis adjusting for a range of sociodemographic, age, adiposity, salt consumption, and clinical covariates, those who reported altered chemosensation at baseline (approximately 3% of the sample) had greater increases in most blood pressure measures over a 2-year timeframe. Early research has supported that kidney disorders impair chemosensory functioning as seen in children (Armstrong et al. 2010) and adults (Griep et al. 1997). Recent research with a large clinical study also supports that most patients with chronic kidney disease and nearly all of patients with end-stage renal disease (ESRD) have impaired odor identification, which also was associated with poorer nutritional status, but lack of awareness of the olfactory deficit (Nigwekar et al. 2017). ESRD also impaired olfactory threshold (Nigwekar et al. 2017). Olfactory function improves with treatment of kidney disease (dialysis and transplantation) (Griep et al. 1997; Landis et al. 2011). Recent research also supports taste alterations and dysgeusia in chronic kidney disease. In a case-control study with careful sensory testing, patients on hemodialysis had elevated intensities of certain salt taste mixtures (Fitzgerald et al. 2019). Adherence to a specialized diet is critical to maintain health and functioning in chronic kidney disease and its treatments. Kidney patients complain about taste alterations (Pugh-Clarke et al. 2017) and challenges maintaining the sodium restriction and the potential that alterations in taste and preference contribute to these challenges (Kim et al. 2018; McMahon et al. 2014).

Diabetes Mellitus (DM): Subtle elevations in blood glucose may increase the risk of olfactory dysfunction (Guthoff et al. 2009). From the 2013/2014 NHANES, individuals with DM had a greater prevalence of olfactory dysfunction than matched controls (Rasmussen et al. 2018). Individuals with type II DM can show reduced taste thresholds (De Carli et al. 2018) and taste intensities (Gondivkar et al. 2009), particularly with less controlled DM (Naka et al. 2010), which could challenge adherence to a carbohydrate-controlled diet. Children with type I diabetes can show minor differences in olfactory function compared with matched controls (Yilmaz et al. 2019). Type II diabetes is characterized by excessive adiposity, and the combination of both diseases increases the risk of cognitive disorders and accompanying olfactory dysfunction from a case-control, imaging study (Zhang et al. 2019). Furthermore, treatment with agonists to the glucagon-like peptide 1 receptor is associated with cognitive and olfactory improvements (Zhang et al. 2019). These medications improve blood sugar control, promote weight loss, and may cross the blood-brain barrier to produce neuroprotective effects (Zhang et al. 2019). This observational study would need to be reproduced with randomized control trials to support a causal relationship.

Individuals with diabetes can suffer from oral health complications including periodontal disease, caries, xerostomia, oral lesions, and oral cancer, all of which can lead to alterations in taste and oral sensation (Verhulst et al. 2019). In type II DM, hedonic response to sweet beverages may be a function of dietary intake (Tepper et al. 1996) as well as level of blood sugar control (Tepper and Seldner 1999). Higher sweet preference was seen in those with greater intake of sweet foods and higher serum glucose. A population-based study found a link between preference for sweet and fatty foods and risk of diabetes (Zhao et al. 2019).

Cancer

According to US statistics, new cases of cancer will reach just over 1.7 million (https://www.cancer.gov/about-cancer/understanding/statistics), with the most common cases (descending order) as breast cancer, lung and bronchus cancer, prostate cancer, colon and rectal cancer, melanoma of the skin, bladder cancer, non-Hodgkin lymphoma, kidney and renal pelvis cancer, endometrial cancer, leukemia, pancreatic cancer, thyroid cancer, and liver cancer. These statistics parallel those worldwide. The overall death rate from cancer has declined with more people living and managing this disease. The key goal is to maintain health and quality of life throughout cancer treatment and to maintain and restore health while preventing cancer recurrence.

Patients with cancer frequently report changes in the taste of food and changes in appetite. In reviewing the older literature, we concluded that cancer itself does not appear to cause a reduction in taste or olfactory perception unless it directly interrupts receptor sites or neural transmission such as in head and neck cancers (Duffy et al. 2002). For example, there are no differences in taste or smell perception in breast cancer patients compared to normative data for healthy adults (Steinbach et al. 2010). Instead the therapies to treat and manage cancer are frequently the cause of smell, taste, and/or oral sensory alterations, although the published medical literature frequently confuses the labels for these alterations (e.g., dysgeusia to represent all taste changes). Changes in taste and smell challenge the ability to adhere to the treatment regimen and sustain hydration and nourishment, as well as maintain quality of life. Poor nutritional status prior to initiating therapy increases the chance of chemosensory alterations. For example, lung cancer patients with poor nutritional status and gastrointestinal disorders are likely to complain of dysgeusia (Turcott et al. 2019).

Chemotherapy: Seven of 10 patients report taste and smell alterations during chemotherapy for a variety of cancers (Gamper et al. 2012). The chemotherapy can have direct effects on chemosensation (e.g., tasting the chemotherapeutic agent, toxic effects on the chemotherapeutic agent on taste receptors) as well as indirect effects (chemotherapy causing a conditioned food aversion by eliciting nausea and vomiting (Chambers 2018)). Some cancers and their therapies involve mechanisms that also are involved in taste, which, in turn, could influence overall oral sensation. Cancers of the brain, gastrointestinal tract, lung, breast, and prostate as well as basal cell carcinomas dysregulate hedgehog signaling, and hedgehog signal blocking is a therapeutic strategy for cancer. Hedgehog signaling also is important to the maintenance of fungiform and circumvallate papillae function. Chemotherapy with hedgehog signal blocking can destroy taste receptor cells, which need to be replaced and innervated with taste sensory neurons and signaling from the sonic hedgehog pathway to recover taste function (Kumari et al. 2017; Mistretta and Kumari 2019). Another frequently used chemotherapeutic agent is protein kinases with taste changes and dysgeusia as a side effect (van der Werf et al. 2017). The mechanism could be through oral mucositis, xerostomia, and receptor transduction mechanisms (van der Werf et al. 2017). Changes in gene expression in taste receptor cells also may explain taste alterations with chemotherapy (Tsutsumi et al. 2016). Women treated with trastuzumab for herceptin receptor-positive breast cancer report prolonged taste and smell complaints after the chemotherapy treatment ends (de Vries et al. 2018).

Chemotherapy-related loss of taste can alter oral sensory integration including diminished retronasal olfaction, increased taste sensations from undamaged taste nerves, and heightened touch sensations, which can alter oral sensations from foods and beverages as well as mediate dysgeusia and phantom oral sensations (Mistretta and Kumari 2019). Reported taste changes typically occur around the second to third round of chemotherapy; however there is heterogeneity in the occurrence, frequency, severity, and distress from chemotherapy-related taste changes (A. Nolden et al. 2019). Some of the heterogeneity in taste changes involves the use of multimodal antiemetic regimens that are standard for treating nausea and vomiting associated with chemotherapy (Nolden et al. 2019). Patients can experience taste decreases, dysgeusia, and diminished retronasal olfaction if the chemotherapeutic agent causes oral health problems such as oral pain and xerostomia (dry mouth). Chemotherapy also may alter saliva composition, such as levels of reactive iron and salivary proteins, which could cause metallic oral sensations. A pilot study shows some benefit of an oral lactoferrin supplementation to counteract these salivary changes as well as taste and smell alterations (Wang et al. 2018a).

Radiation Therapy: Cancer and cancer therapies directed at the head and neck are the most disruptive to chemosensation and can be long-lasting. Radiation to the tongue for head and neck cancer results in dose-dependent decline in taste function (Kamprad et al. 2008), causing inability to identify tastes and changes in the taste bud number but not in the density of taste papilla (Mirza et al. 2008). Taste damage and complaints of dysgeusia and metallic sensations can occur with head and neck radiation even if it is not directed at the tongue and even if there is not a complaint of dry mouth (Barbosa da Silva et al. 2019). The peak compliant of taste alterations (dysgeusia) occurs after seven weekly therapies (Martini et al. 2019), and recovery is documented between 2 and 6 months after the radiation treatment ends (Kamprad et al. 2008; Mirza et al. 2008). The recovery may not be complete. Up to 33% of older patients report dry mouth and taste alteration as the top problems nearly 4 years after radiation therapy (Head et al. 2017). Over 40% of 5-year head and neck cancer survivors reported oral pain and dysgeusia; this may be due to peripheral damage to some taste nerves, resulting in intensification of taste and pain sensations in the central nervous system (Logan et al. 2008).

Patient's food and nutrition responses to cancer-related chemosensory are variable (Drareni et al. 2019). Registered dietitians can improve dietary intake and/or quality of life by providing practice advice to cancer patients (Peregrin 2006). A 12-week pilot, pre-post study with nutrition counseling as well as taste and smell training has shown some improvement in taste perception but no changes in quality of life and nutritional status (von Grundherr et al. 2019). Tailored nutrition recommendations can help the cancer survivor restore their enjoyment of food and eating as well as their nutritional status to prevent cancer recurrence.

Chronic Exposures

A number of airborne compounds, toxic metals, irritant gases, and solvents also are toxic to the olfactory system and impair olfactory perception indirectly (impeding the flow of odors to the olfactory receptors) or directly (damaging the olfactory epithelium and/or central olfactory processing) (Smith et al. 2009). Exposure to air pollution has been associated with lower olfactory function, affecting the olfactory epithelium, olfactory bulb, and paths to the olfactory cortex (Ajmani et al. 2016).

Chronic Smoking and Olfaction: Chronic cigarette smoking alters olfaction and oral sensation through direct and indirect mechanisms. Cigarette smoking can show a dose-response relationship with impaired olfaction (Frye et al. 1990). Young to middle-aged chronic smokers can show greater rates of hyposmia than age- and sex-matched non-smokers from NHANES (Duffy et al. 2019). Direct exposure to aqueous cigarette smoke diminishes functional olfactory receptors in animal models (Ueha et al. 2016) and overwhelms the capacity of the olfactory epithelium to regenerate with advancing age (Ueha et al. 2018). Indirectly, reported risk factors for olfactory disorders including sinonasal problems, serious head injury, tonsillectomy, and xerostomia explain some of the association between chronic smoking and self-reported olfactory dysfunction (Glennon et al. 2019). Cigarette smokers are more likely to suffer from risks of olfactory dysfunction including frequent nasal infections, allergies (Stuck and Hummel 2015), cranial/facial injury (Coelho and Costanzo 2016), and viral infections/tonsillectomy (Hoffman et al. 2016), respiratory infections (Bagaitkar et al. 2008; Cohen et al. 1993), acute and chronic rhinitis, nasal inflammation (Benninger 1999; Nicola et al. 2014), and traumatic brain injury (Ilie et al. 2015).

In small clinical studies, smokers require higher concentration to detect an odor (Hayes and Jinks 2012; Ozmen et al. 2016; Rosenblatt et al. 1998). The association between smoking and olfactory dysfunction in population-based studies can be unclear. The literature ranges from greater odds of olfactory dysfunction in chronic/heavy smokers (Murphy et al. 2002; Vennemann et al. 2008), no significant association (Bramerson et al. 2004; Schubert et al. 2011), and lower risk of olfactory dysfunction in chronic smokers (Mullol et al. 2012), including in the NHANES. The inconsistent association between smoking and olfactory dysfunction may have resulted from defining smoking status using just a single item, which can yield unreliable results (Glennon et al. 2019).

Chronic Smoking and Taste: Direct and indirect mechanisms may alter taste and oral sensations in chronic smokers. In animal models, long-term exposure to nicotine in rats decreases fungiform papillae size and changes their anatomical characteristics (Tomassini et al. 2007). This insult could explain lower density of fungiform papillae (Fischer et al. 2013) or difference in taste bud morphology and vascularization in fungiform papillae (Pavlidis et al. 2009) among chronic smokers. Altered taste and oral sensory alterations in chronic smokers could result from lower resting salivary flow rates and more frequent reports of xerostomia than non-smokers (Dyasanoor and Saddu 2014; Rad et al. 2010), as well as greater rates of respiratory infections (Bagaitkar et al. 2008; Cohen et al. 1993). With careful psychophysical testing, chronic smokers did not show impaired taste abilities (neither tongue tip nor whole mouth) and instead showed heighten intensities from 1 M NaCl at a concentration that elicits taste and irritation. Taste threshold responses are inconsistent in chronic smokers, with no significant difference compared with non-smokers (Gromysz-Kalkowska et al. 2002; McBurney and Moskat 1975; Sawada 2005), less sensitive to quinine (Krut et al. 1961), sucrose (Pepino and Mennella 2007), and sodium chloride (Jackson 1967), or electrogustometry (Cheruel et al. 2017; Khan et al. 2016; Pavlidis et al. 2014, 2009) of loci on the tongue tip, foliate papillae, and soft palate. Smoking cessation from 2 to 9 weeks is associated with improvements in taste threshold by electrogustometry (Cheruel et al. 2017) and perceived bitterness (Ahijevych et al. 2015). Obese smokers report less intensity of sweetness and creaminess in dessert-type sugar/fat mixtures independent of olfactory cues (Pepino and Mennella 2014).

Normal variation in taste also has been linked with smoking behaviors. For example, menthol smokers are more likely to be tasters identified by *TAS238* receptor genotype (Oncken et al. 2015) and supertasters of PROP bitterness (Duffy et al. 2019). Menthol in cigarettes blocks some of the negative oral sensations from cigarettes (Kreslake et al. 2008; Wickham 2015), producing a palatable cigarette even to PTC/PROP tasters.

Medications

Alterations of taste and smell are recognized as a potential side effect of prescription and over-the-counter medications, with clear implications for older adults who often have the highest medication usage and polypharmacy. However, this side effect is often overlooked by clinicians and toxicologists who look toward minimizing drug adverse effects (Wang et al. 2017). Medications that alter taste and olfactory perception have been reviewed elsewhere (Schiffman 2018). A description and a summary of some of the effects of medication on taste, smell, and oral sensation is highlighted below. Some drug effects are pronounced and well-documented (e.g., taste alterations with angiotensin-converting enzyme (ACE) inhibitors), while others are less clear due to inconsistent chemosensory assessment; the complexity of the medication dosing, polypharmacy, and drug-nutrient interactions; and isolating the effects of medications from the disease/condition. Clinicians should individually assess chemosensory complaints and identify alternative forms of treatment to support treatment compliance and avoid disrupting the patient's food intake and quality of life. Toxicologists should pay attention to chemosensory research in development of new drugs and during preclinical animal studies to avoid drug-induced chemosensory disorders and/or identify ways to mitigate these disorders (Wang et al. 2017).

Medications can directly alter chemosensory processes by impairing the transport of stimulus to the receptor and changing the peripheral structures and sensory transduction mechanisms. Medications are usually bitter (Schiffman 2018), which makes medication compliance a challenge, particularly for children and those with a genetic propensity to taste heightened bitterness (Mennella et al. 2015). Medications can be tasted orally when they are taken and/or as they enter the blood and saliva (Steele et al. 1979) as well as gingival fluid (Alfano 1974) to produce a dysgeusia and olfactory and other (e.g., metallic) sensations (Maruniak et al. 1983). These altered sensations can occur even if bypassing the oral route (Schiffman 2018). Different medication delivery forms with added sweetness and counterirritant (e.g., peppermint) may make the medications more tolerable (Cherian et al. 2018). Medications also can disrupt chemosensory signal transduction mechanisms. For example, some medications alter sodium channels to influence perception of sodium salts and some sweeteners, as well as affect G-protein and TRPM receptors (Schiffman 2018). Examples are provided in this chapter with cancer and chemotherapies. Individuals suffering from chemosensory disorders with medications can stop eating, become dehydrated, and suffer from malnutrition, which ultimately influences the effectiveness of pharmacotherapy and medical treatments (Wang et al. 2017).

Indirectly, medications with the side effect of xerostomia and/or drying of the nasal mucous membranes can hinder a taste or odor from reaching the receptors to alter functioning. Xerostomia also increases the risk of oral infections and periodontal disease, which can alter oral sensations (Ship 1999). Medications that induce nausea and vomiting also can condition a flavor aversion (learned association between nausea and vomiting and a specific flavor). Even a single occasion of this side effect can be sufficient to trigger severe revulsion when presented the flavor in the future (Chambers 2018). These aversions are reported frequently in the literature as one mechanism for loss of appetite and changes in food preference as the result of cancer and its therapies.

Careful interviewing of the patient will help the clinician determine if patient complaints are chemosensory or non-chemosensory (Schiffman 2018). Working with the healthcare team and changing medications might alleviate some of these complaints and lower the risk of drug-nutrition interactions. Furthermore, there may be counter-treatments that work to alleviate the chemosensory alterations associated with medication side effects (Wang et al. 2017). From a research perspective, thorough investigations are needed on the effect of medications on chemosensory mechanisms, including models of chemosensory toxicology, and clinical investigations that utilize valid psychophysical and behavioral measures (Wang et al. 2017).

Oral Health

Oral health is necessary for adequate oral sensations. Oral conditions that can alter oral sensations include oral hygiene, dental caries, infections, oral lesions, xerostomia, poorly fitting dental prostheses, and oral problems associated with systemic disease (Batisse et al. 2017). Changes to oral health in older adults are primarily due to diseases and their accompanying treatments rather than changes due to aging. In older adults, poor oral health is a sign of frailty (Ramsay et al. 2018). Likewise taste disturbances are reported by older adults with poorer health and oral health problems (Ekback and Ordell 2017).

According to WHO estimates, 60–90% of schoolchildren have dental cavities or caries (Organization 2012), with rates highest in poorer populations. Genetic variation in taste can influence risk of caries, including genetic variants in sweet [GLUT2, TAS1R2 (Izakovicova Holla et al. 2015)] and bitter [TAS2R38 (Yildiz et al. 2016)] taste receptors, additional genes that influence sweet sensitivity and preference (Eriksson et al. 2019) as well as the oral microbiota (Esberg et al. 2019). Significant dental caries influences the health of the mouth and the oral microbiota, which, in turn, can influence taste and oral sensations.

Since saliva is vital for tastes to reach the taste receptors and to maintain oral health, conditions that change the amount and composition of saliva can alter taste and retronasal olfactory sensations (Mese and Matsuo 2007). Individuals with taste disorders have different salivary composition than those without taste disorders (Walliczek-Dworschak et al. 2017). Likewise, some diseases decrease olfactory perception by changing the quantity and quality of mucus secretion. For example, patients with long-standing cystic fibrosis may exhibit reductions in olfactory thresholds but normal ability to identify odors, at least in cases without additional nasal sinus disease (Laing et al. 2010). Cystic fibrosis changes the chemical makeup and viscosity of mucus secretions, which impedes odors from reaching the olfactory receptors to accelerate olfactory dysfunction associated with older age. Individuals with Sjögren’s syndrome, which impairs salivary gland and mucus production, can show reductions in ability to identify tastes and odors (Kamel et al. 2009), including reductions in release and active transport of food volatiles to the olfactory receptors (i.e., retronasal olfaction). Retronasal olfactory perception can be reduced with dentures that cover the palate of the mouth, even with an intact olfactory system (Duffy et al. 1999).

Nutritional Interventions for Chemosensory Disorders

A chemosensory disorder may have a negative impact on nutritional health if the individual complains of a chemosensory problem and/or complains that the problem has influenced their eating habits (Mattes and Cowart 1994). Table 1 provides examples of questions to ask individual who complains of chemosensory disorders. The client may need to answer additional questions about the disorder and the nutritional outcomes to determine if the problem is sensory or non-sensory. These may include specific questions about feelings of health and happiness. Individuals may feel depressed because the chemosensory disorder has disrupted their eating and food behaviors. The person may feel less confident cooking or may stop entertaining friends and family because of decreased enjoyment in cooking. If the chemosensory dysfunction is disruptive enough to feelings of well-being, they may need to seek assistance in coping with emotional consequences of the disorder.

From a nutritional and chemosensory assessment, clinicians can create individualized nutritional care plans to help clients maintain their nutritional health and enjoyment of eating despite the chemosensory disorder. Individuals can utilize a number of strategies to compensate for loss. Since the ability to taste is rarely lost, the primary taste qualities of foods and beverages can be leveraged to support food enjoyment. Sweet or salty foods, especially those with healthy fats (e.g., olive oil, vegetable oils), may be particularly enjoyable to individuals with olfactory dysfunction. Greater use of salt with olfactory loss may challenge the ability to follow a

Table 1 Interview questions about nutrition related to chemosensory disorders

• *Have you changed your eating habits in response to the chemosensory problem? Are you avoiding any foods because of the problem? Have you changed the types of foods you eat since the problem started? Are you adding anything to your foods to make the foods and beverages more appealing?*
• *Are you taking any vitamin, mineral, or dietary supplements or using alternative therapies because of your disorder?*
Individuals may turn to supplements or complementary or alternative therapies as has been reported of individuals seeking evaluation of chemosensory disorders (Ferris and Duffy 1989)
• *How is your appetite? Has your appetite changed since the problem started?*
Clinicians can use a validated instrument – a longer and shorted version of the Council on Nutrition appetite questionnaire (Wilson et al. 2005) to identify risk of anorexia-related weight loss
• *Has your enjoyment of eating or activities such as cooking and food shopping changed since the problem started?*
• *Has your weight changed in response to the problem?*

low-sodium diet (Henkin 2014). Changes in oral sensation may blunt less pleasant flavors of some vegetables and fruits and increase their acceptance and intake. Acceptance of vegetables can also be enhanced by masking the bitterness with either sweet or salt to improve liking, especially among those who dislike vegetables (Sharafi et al. 2013). Somatosensory sensations can also provide another dimension to a meal. Texture complexity and eating more slowly with smaller bite sizes are vital to support satiety (James 2018). Differing the texture and temperature of foods also may provide enough variation to stimulate interest in eating in those with diminished or absent olfactory food flavor. The color and presentation of food, or "eating with the eyes," may stimulate appetite and food enjoyment, especially for those with olfactory dysfunction. Sauces help with oral manipulation and promote oral sensation in those with dry mouth.

The flavor and consumption of healthy foods can be enhanced with naturally occurring olfactory flavorings (Bartoshuk and Klee 2013) or added spices (Peters et al. 2018). Flavor components are complex and unique to the food (Regueiro et al. 2017). Older adults report liking olfactory flavorings added to common foods more than do younger adults (de Graaf et al. 1994), and the addition of flavorings to cooked foods may improve consumption and body weight in older adults living in a nursing home (Henry et al. 2003; Mathey et al. 2001). However, the positive effects of flavor enhancements appear to decline over time (Koskinen et al. 2003). Other methods to enhance flavor include culinary techniques to develop flavors and adding nonvolatile compounds that intensify existing odors such as monosodium glutamate (MSG) (Schiffman 2000). Adding umami has shown to increase retronasal sensations in a chicken soup (Nishimura et al. 2016) and improve the flavor of lower-sodium products (Manabe et al. 2014). Adding mushrooms (Myrdal Miller et al. 2014) as well as other natural ingredients (tomato, fermented soy products) (Dermiki et al. 2013) to low-sodium meat dishes maintains flavor profile and acceptance (Dermiki et al. 2013). In a study with healthy young adults, the combination of MSG and umami flavor enhancer nucleotide inosine 5′-monophosphate in a soup enhanced appetite for the immediate meal and supported healthy energy intake at the next meal (Masic and Yeomans 2014). Furthermore, seniors who participate in congregate meals reported increases in aroma, liking, and overall satisfaction during a 4-week period of flavor- and MSG-enhanced foods (entrees, soups, sauces, vegetables, pastas) as compared with the unenhanced period (Schiffman 1998). However, the addition of a celery powder or MSG had no influence on hedonic rating or intake of a soup in older individuals, including among those with measured olfactory or taste alterations (Essed et al. 2009a). Thus, use of flavor enhancers should be individualized to the older adult's preference palate to assure the desired increase in food consumption (Essed et al. 2009b).

For long-term care residents or seniors in a range of healthcare settings, clinicians and culinary professionals can employ a variety of tools to stimulate appetite and promote food enjoyment. A complete nutrition assessment and nutrition diagnosis by a qualified dietetics professional will identify appropriate dietary recommendations, balancing health needs, social needs, quality of life, and individual desires (Dorner and Friedrich 2018). Excessive dietary restrictions of sugars and salt may only serve to blunt appetite and intake, especially in seniors with chemosensory disorders. Liberalizing diet restrictions can assure nutritional health and support quality of life. Chewing and swallowing difficulties also limit the ability to use texture as a way to vary the sensory qualities of foods. Pureed food may not have the vibrant colors of fresh foods. Applying techniques of culinary arts will enhance the overall sensory appeal of foods and beverages including visual presentation and oral sensory appeal, especially for salt, sugar, and texture-modified diets. Increasing the socialization during mealtime results in improved intake, even in residents who do not report changes in food preference (McAlpine et al. 2003). Flavor-enhanced foods may prove most beneficial for older residents who live in long-term care facilities to improve intake, weight (Henry et al. 2003; Mathey et al. 2001), and nutritional status (Schiffman 2000; Schiffman and Warwick 1993).

The nutrient zinc requires special mention related to chemosensation. Zinc deficiency has been associated with taste loss. One salivary protein, important to taste perception, is gustin [carbonic anhydrase VI (CA6)], which is a zinc metalloprotein. Salivary zinc concentrations and a polymorphism in the gustin gene explain differences in the ability to taste the bitterness of propylthiouracil. The polymorphism may influence the ability to bind zinc and resulting taste ability (Padiglia et al. 2010). Zinc supplementation may improve taste perception with zinc deficiency related to chronic diseases, such as those with kidney failure managed by hemodialysis (Kim et al. 2016), and prevent taste disturbances in patients prior to radiation therapy for head and neck cancer (Najafizade et al. 2013).

Zinc supplementation for otherwise healthy individuals with chemosensory disorders appears to have no benefit (Kumbargere Nagraj et al. 2017). Most individuals who have taken zinc for chemosensory disorders report no improvement in their condition (Price 1986) and show no difference in sensory function from those not taking zinc (Deems et al. 1991a). The ineffectiveness of zinc supplementation for chemosensory functioning was demonstrated in two, double-blinded studies (Greger and Geissler 1978; Henkin et al. 1976). Evidence showing a benefit of zinc supplementation on taste acuity in older adults is conflicting. Lower zinc status was not associated with taste acuity in older subjects (Bales et al. 1986), and zinc supplementation at recommended daily amounts showed inconsistent effects on taste acuity (Stewart-Knox et al. 2008). The benefit of zinc supplementation to improve food flavor perception in older individuals is still not substantiated. It is unclear whether older adults would notice improved oral sensory functioning in response to zinc supplementation and if this improvement would have a positive impact on their dietary behaviors.

Conclusion

Attention to chemosensory disorders and their causes has grown exponentially since the 1970s with the first US national estimation of the prevalence of these disorders. Since that time, there has been a more accurate estimation of the prevalence of chemosensory disorders, with rates equivalent to that for hearing and vision problems. Population-based studies have uncovered socioeconomic disparities associated with greater risk of these disorders as well as healthy lifestyle behaviors and access to medical and dental care as preventive measures. Greater rates of olfactory dysfunction in older adults, particularly connected with sensorineural and neurodegenerative diseases, support the need for screening olfactory dysfunction with full medical evaluation if a disorder is suspected. Treatment options for chemosensory disorders today are focused on correcting nasal/sinus diseases, better control of systemic diseases, as well as the use of alternative medications and treatments that are not toxic to chemosensation. Increasing the understanding of who is at risk for chemosensory disorders, how chemosensory systems undergo regeneration, gene therapies, and sensory transplantation will likely expand prevention and treatment options in the future. At the present, individuals with chemosensory disorders need guidance on how to be safe without sensory signals of danger in the environment and in food; on how to have a high-quality diet and maintain a healthy weight; and how to maintain enjoyment of eating and food-related activities.

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Part XIII

Cross-Cultural Differences in Eating and Drinking

Eating and Drinking in Four Nordic Countries: Recent Changes

62

Lotte Holm, Unni Kjærnes, and Mari Niva

Contents

Abstract

This chapter addresses social and cultural aspects of eating and drinking in Denmark, Finland, Norway, and Sweden and how this has changed in the period between 1997 and 2012. Public and scholarly debate have raised questions about whether traditional and ordinary eating patterns and the role of meals are changing in modern postindustrial societies, with nibbling, individualization, de-traditionalization, disruption, gastronomy, globalization, meal erosion, and commercialization replacing shared rhythms, social meals, and national food cultures. To address this, comprehensive data are needed

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which track micro changes in daily life and acknowledge the multidimensionality of eating. Results are presented from two empirical studies conducted 15 years apart, both of which included large national samples of the adult populations in the four countries. The studies were based on a model of *the eating system*, which combines physical, organizational, and sociocultural aspects of eating by focusing on three elements: the time structure of eating patterns, the meal formats, and the social organization of eating. Nationally distinct and socially shared eating patterns persist within each of the four countries, and there is little evidence of dissolution and individualization of traditional eating patterns in terms of the timing and number of eating events or of the social context of eating. In the Nordic countries, eating still primarily takes place in the home, and in the company of family members. The most striking changes relate to the conduct of meals, where informal codes of conduct appear to be spreading.

Introduction

This chapter presents changes in Nordic eating habits over the last decades. It builds on a sociological tradition in food research that treats food and eating mainly as social phenomena, linked to the overall organization of daily life in terms of time and place, social relations, and rules of conduct. The focus is on the mundane, or ordinary, aspects of eating and how these are transformed along with changes taking place in modern societies generally as well as more specific features of countries in the Nordic region: Denmark, Finland, Norway, and Sweden.

Historically, national and regional food cultures in different parts of the world were distinct and formed by specific geographical, economic, and political conditions (Johansen 1998; Mennel 2010). Today, simple and often mass-produced dishes are more dominant, promoted by an increasingly globalized, homogenizing food industry (see Ritzer's concept of "McDonaldization") (Warde 1997; Ritzer 1993). But there is also a revival and reinvention of local and regional food cultures which prioritize local provisioning, authenticity, fresh food, and traditional, culturally specific dishes (Counihan and Siniscalchi 2014).The question is to which extent local traits are still dominant in national food cultures.

How and what we eat within national food cultures are influenced by the rhythm and organization of work and family life. In Austria, Rotenberg (1981) observed a change from a five-meal to a three-meal pattern following industrialization in Vienna, involving a shift in the location of daily meals, which implied that also the social company at meals changed. This decline in the number of eating events has been observed in several industrialized countries (Prättälä and Helminen 1990).

Eating is an important operator of social life and has a primary social function. Meals in private households have been described as the medium by which families are created and re-created on a daily basis (DeVault 1991; Jackson et al. 2009; Julier 2013) and an important arena for the socialization of children into central cultural norms and values (Fischler 2011). For at least half a century, both mass media and scholars have claimed that traditional, regular eating patterns and meal formats have given way to a more irregular and de-structured style of eating (Mestdag 2005, Southerton et al. 2012). Regular meals eaten at home together with all, or most, family members are replaced, it is said, by individual snacking and fast food. Commercialization, globalization, and even "Americanization," as well as the changing social status of women, are often mentioned as the main developments lying behind this process of eroding meals. Market researchers use the term "grazing" (Caplan 1997) to describe this allegedly new, hurried way of eating, also characterized as "vagabond feeding" or "nibbling" (Poulain 2002, 2008) and, in Sweden, "frukostisering" (meaning *breakfastization*) (Ekström 1990). An increase in the total number of meals and a decrease in meals taken with family members would indicate changes toward erosion of traditional social eating in households. At the same time, it has been suggested that meals increasingly relocate from the home and the family context to commercial places such as restaurants, cafés, fast-food outlets, or canteens (Julier 2013).

This discussion draws attention to changes taking place when societies shift from industrial to postindustrial. Interesting questions are therefore how this societal shift affects eating as part of everyday life, to which extent people still share common eating times, whether we can identify typical national peaks in the timing of daily eating, and whether eating more and more takes place out of home.

Such shifts would also imply changes in the cultural norms around eating. All societies and cultural groups have models for good eating that dictate what foods should and should not be eaten, how foods should be ordered in terms of their combination and sequence (Douglas 1975; Fischler 1988; Murcott 1982), and what is the appropriate conduct while eating. Frequently applied in Nordic research is the concept of "the proper meal" – a notion originating in British studies about the meaning of meals in households (Douglas and Nicod 1974; Murcott 1982, Ekström 1990; Bugge and Døving 2000). Some claim that the meal is losing its significance as an event in its own right, since eating events increasingly take place simultaneously with other activities (Bugge and Døving 2000). Wouters (2004) has suggested that the rules of proper eating conduct, or table manners, are not as strict as they once were and allow for more individual variation and heterogeneity in behavior, thus expanding the cultural space of human action. The claims that traditional rules, norms, and standards applying to good food and the conduct of meals are dissolving have led to sociological literature raising the question of what comes in their place (Warde 1997). The concept of *gastro-anomie* (Fischler 1988, 2011) captures an extreme version of the idea that eating patterns have become irregular and individualized and that cultural eating norms are disappearing. This evolution is often associated with the fear of loss of social cohesion and order. Indications of de-structuration are the increasing use of convenience foods, the replacing of hot cooked meals with cold dishes, a more relaxed meal structure and rhythm, fewer shared meals, and less time spent eating than earlier (Mäkelä et al. 2001). However, meals may well become simpler and yet still be socially structured and regarded as "proper" by those who consume them (Marshall and Anderson 2002).

A typical shortcoming in existing research is that commensality, in terms of the temporal, social, and spatial setting of the meal, is usually studied separately from what is eaten. Moreover, normative expectations and actual activities are often mixed up in the debate. The very combination of these different aspects is crucial for an adequate understanding of the changes in eating habits. It is evident that across countries and cultures, there are differences in, for instance, what types of foods are eaten at mealtimes, whether the food is hot or cold, the number of ingredients and components, the sequences of different dishes, the meal venue, and those with whom meals are typically eaten.

This chapter will address the modernization of eating in the Nordic countries by focusing on three empirical questions: What does the contemporary Nordic menu look like; is it transformed in line with trends of "McDonaldization" or characterized by tradition and counteracting trends? What is the fate of regular social meals? Has eating away from home increased?

Researching De-traditionalization and Disruption of Eating Patterns

It is an empirical question whether today's daily eating habits resemble the more traditional, home-based, family-centered ideal or are increasingly characterized by individualization, grazing, and gastro-anomie (Jackson et al. 2009). Yet, with some exceptions (Poulain 2002; Mestdag 2005; Mandemakers and Roeters 2015), empirical studies to date looking into the matter are sparse. One reason for this may be that it is difficult to examine the issue in sufficient detail using typical questionnaire studies. This is because terms such as "grazing" and "vagabond feeding" point to simultaneous changes in several factors, including socially shared temporal rhythms and spatial coordination, sociability of meals, and the ability of cultures to impose norms on cuisine. In order to investigate all, or even most of these aspects of eating, rather comprehensive data sets are needed in which micro-behavioral aspects of everyday life are tracked.

Time-use studies have revealed some general trends such as a decline in the time devoted to cooking. They have also shown that trends in the time spent eating in the home and outside the home vary from country to country (Warde et al. 2007; Cheng et al. 2007; Mestdag 2005). However, time-use analyses address only a few aspects of eating. For a more comprehensive picture of daily eating patterns in populations, an analysis targeting a wider range of specific and micro-behavioral aspects of the organization of eating is necessary. To investigate how patterns of eating change, data are needed from more than one time point. This chapter presents an analysis of such data stemming from a study with two data collections made 15 years apart.

In the Nordic countries, Denmark, Finland, Norway, and Sweden, comprehensive population surveys were conducted in 1997 and in 2012. The surveys aimed at documenting and describing as richly as possible the state of eating practices paying special attention to their multidimensionality. Building on 24-h recall studies of the sort common in nutrition research, both surveys used a questionnaire which focused on details about one day of eating – the day before the interview. The two surveys included representative samples of the 4 populations, in all 4823 respondents in 1997 and 8248 respondents in 2012. In 1997, interviews were conducted by telephone; in 2012 they were web-based (Gronow and Holm 2019).

The analysis was guided by the concept of an *eating system*, which combines the physical, organizational, and sociocultural aspects of eating (Mäkelä et al. 1999; see also Kjærnes et al. 2009; Kjærnes 2001). The eating system consists of three elements: the eating pattern, the meal format, and the social organization of eating. The eating pattern refers to the rhythm and number and types of eating events. Meal format refers to the composition of the main course (center, staple, trimmings, gravy, dressings) and the sequence of the meal in terms of starter, main course, and dessert. The social organization of eating relates to the venue of the meal, commensal partners, the specific organization of the event, and who cooked the meal (see Mäkelä et al. 1999; Kjærnes 2001). In all these dimensions, eating events can be more or less complex or developed. At one end of the scale, there might be a snack consisting of a single food item, or perhaps a bite, eaten alone in a nonformal setting – say, driving the car. At the other end of the scale might be a three-course dinner eaten at a dinner table with the whole family and guests. The conceptual framework provided by the notion of an eating system is useful for understanding eating as a whole in which various dimensions operate together and are dependent on each other.

Survey questionnaires were designed to reflect the basic theoretical concept of the eating system. The main part of the questionnaire focused in chronological order on respondents' eating events the day before the interview (see Fig. 1). The maximum allowed was 10 events in 1997 and 13 in 2012, but no one had eaten so many times. The questions focused on the time of eating and the structure of meals (whether they were hot or cold, the number and types of courses) and on the foods and dishes eaten. Cold eating events were recorded on a list of food options, and hot eating events in terms of number of courses and the contents of the center, staples, vegetables, and trimmings in the main course. In both types of events, drinks were registered based on a list of options. In the analysis, meals were reconstructed on the basis of timing and character of events (breakfast the first event, lunch events taking place between 11 am and 2 pm, dinners between country-specific time spans). Foods eaten were registered at a generic level, not in specific detail. Thus, distinctions were made between "steak or roast meat," "minced meat," and "meat mixed with other ingredients," but not between beef, pork, or lamb. Neither were different species of fish registered, just as pasta was registered without distinction between "spaghetti" and "penne." Vegetables were recorded based on a list of options (e.g., tomato, lettuces, carrot, cabbages, "frozen/fresh green beans, peas"). Accordingly, the data is open for analysis of basic and underlying structures of the food culture, but do not allow for a detailed analysis of changes in relative positions or distinctions between specific products or brands.

The questionnaires also addressed the social context and conduct of the meal, including who cooked the meal, where the eating took place, the company present,

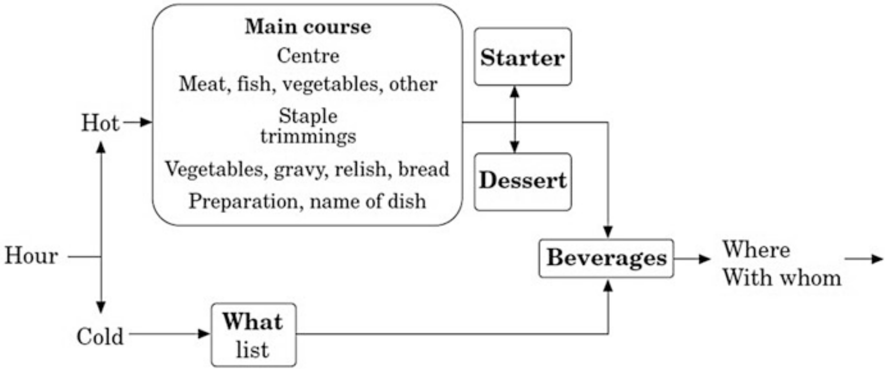

Fig. 1 The construction of meal formats

the duration, the seating arrangements for eating events, and finally whether other activities, like reading or watching the TV, took place while eating. In the 2012 study, respondents were also asked to categorize each eating event as a type of meal (breakfast, lunch, dinner, late evening meal, in-between, other). Questions about specific eating events on the previous day were followed by enquiries about the respondents' sociodemographic backgrounds and their attitudes to food and eating-related issues such as healthy eating habits, experiences of food deprivation, and sustainable food consumption. In both years, interviews were conducted within a fixed time frame at the end of April with no national holidays.

Changes in Everyday Eating in Nordic Countries

The Food: Underlying Traits Are Stable

When looking at the display of food products in supermarkets and various ready-to-eat outlets, the supply of foods in modern societies seems to represent enormous variation and rapid change. New products keep appearing, and new dietary regimes, fashions, and fads follow one after the other. But when looking over a period of 15 years, which changes are discernible in the kinds of foods Nordic populations eat? Are trends of globalization and de-traditionalization visible? Overall, looking at the kinds of foods eaten in the Nordic countries in the period from 1997 to 2012, there is both stability and change (Holm et al. 2015). The general frame is stable, with simple breakfasts, two distinctly different national lunch cultures, and simple hot meals. Between 50% and 80% of breakfasts contained only one food element, typically open sandwiches, bread with a simple topping, which were eaten by between 58% and 78% of populations. The next most typical food category, cereals, was eaten by 15–20%. Coffee or tea was drunk by between half and three quarters of populations.

Lunches appeared in two distinctly different versions in 1997, and this had not changed 15 years later. Whereas most Danish and Norwegian lunches were cold meals, typically consisting of open sandwiches (70–80% in both years), Finnish and Swedish lunches were quite frequently hot dishes (in both years more than 60% of the respondents in those countries had hot lunches). These markedly different lunch cultures are the result of historical trends which are upheld through quite different institutional arrangements around lunch. Whereas in Finland and Sweden, welfare policies are in place to ensure that children are served free hot school lunches every day and adults are given access to hot meals in workplace canteens or in commercial restaurants at affordable prices, provisioning of lunch for children and adults is a private matter in both Denmark and Norway. Children bring lunch packs prepared at home to school, and so do most adults. The typical and classical content of such lunch boxes is sandwiches.

Nordic hot meals remain quite simple, as "platefuls" (Murcott 1982). Dinners are one-course meals, typically, and meat is a dominant center, often minced meat, this is eaten by more than half of populations in both years. In all countries, dishes were recurrently eaten which belonged to Nordic and Scandinavian food traditions, such as an almost iconic comfort dish "Pyttipanna/biksemad" which is a bubble and squeak-type dish reportedly eaten in all four countries. Meatballs were another classic in all four countries and fish balls in Norway and Denmark. In each country, specific dishes were frequently eaten which belong to the typical culinary culture of the respective countries, such as mock hare meatloaf in Denmark, liver casserole in Finland, potato dumpling with sausage and salted meat in Norway, and pea soup with mustard in Sweden. Such stable elements suggest that the categories of foods eaten by Nordic populations have not changed much. They also demonstrate that nationally distinct patterns of eating persist and resist globalizing trends.

There are, though, discernable changes, which point toward other types of developments. In all types of meals, there were minor changes in terms of the relative significance of various food items (e.g., porridge for breakfast decreasing in Finland but slightly increasing in Sweden). The most prominent and systematic changes across the four countries were related to dairy products, drinks, and fruit and vegetables. Milk drinking decreased quite markedly in all countries. Thus, at breakfasts milk decreased in Norway and Sweden (from 48% to 28% and 26% to 15%, respectively), at lunches it decreased with 10% points in all countries, and for dinners it decreased from 16% to 10% in Denmark, 52% to 38% in Finland, 7% to 4% in Norway, and 28% to 17% in Sweden. Milk is thus no longer the core drink at Nordic meals. Instead, water has taken the dominant position and was in 2012 drunk with half or more of all lunches and dinners and increasingly also at breakfasts. Yet, at the same time, yoghurt became a more popular element of breakfasts and was in 2012 eaten at 20–30% of breakfasts. Another key change is the appearance in 2012 of vegetables and fruit at meals at which they would typically not be included in 1997. Thus, in Denmark, fruit was hardly ever eaten at breakfast in 1997 but was included in 14% of breakfasts in 2012. In all countries except Finland, there was a sharp increase in fruit eaten at "in-between" eating events. Further, in both Denmark and Norway, vegetables were increasingly part of the cold lunches, often in the form of a salad. Even though meat has continued to dominate at dinners, dishes with vegetables as the main component or center increased in all countries.

Taken together, the study shows that despite a constant flux of new products and brands on the market, the underlying traits of Nordic food culture remain relatively stable. Populations in the four countries continue to compose their meals according to the same basic principles of simple meals and platefuls. At the same time, though, a clear trend of shifts in how dairy products are consumed is evident, and there has been a marked increase in the place of fruit and vegetables in eating patterns. The emergence of these foods at breakfasts and in-betweens and as centers at hot meals may reflect an uptake of messages from public health authorities which in recent decades have promoted increasing the consumption of fruit and vegetables. Thus, while stability is a prevailing characteristic of the foods that make up the Nordic diets, new cultural trends are also emerging. It should be noted, however, that our data does not include information about spices or the origin of products. Thus, the minced meat dishes of 2012 may have different and more exotic flavors than earlier, and they may not have been produced from scratch in households and were perhaps instead purchased in more or less ready-to-eat versions. Burgers may have a flavor of globalization or McDonaldization but can also be seen as a slightly altered version of the traditional Nordic meatballs. These aspects of changing food patterns are not revealed by the study method.

The Rhythm: Distinct and Enduring National Patterns

At society level, eating at regular hours indicates social coordination and shared meal conventions. In contrast, an anomic situation with individualization and eroding meals would appear as a lack of distinct social patterns in the timing of eating. In order to get an overview of the daily patterns of eating, all eating events were compiled for each hour of the day.

Figure 2 shows the daily rhythms of eating events on weekdays in the four Nordic countries in 1997 and in 2012. The figure shows that in both 1997 and 2012 and in all four countries, there were clear and marked peak hours during which many people had eaten, and there were quieter hours when eating was rare. The first peak, which was assumed to be breakfast, occurred at 7–8 am in all four countries, with smaller peaks 1 h earlier (6–7 am) and 1 h later (8–9 am), and again at 9–10 am. The second major peak occurred around lunchtime and was more distinctive than the morning peaks of eating. The typical lunch hour in Finland and Norway was 11 am–12 pm; approximately 40% of respondents were found to have eaten during this time, while in Denmark and Sweden lunches were a bit later, typically at 12–1 pm, a time when approximately 50% in Denmark and in Sweden over 40% had eaten. The patterns of eating in the afternoon and evening show that eating was more spread out, and national patterns differed more. Still, in Denmark there was a very sharp peak at 6–7 pm, similar to the peak at lunchtime, when almost 50% of respondents in 1997, and over 40% in 2012, reported to have eaten something.

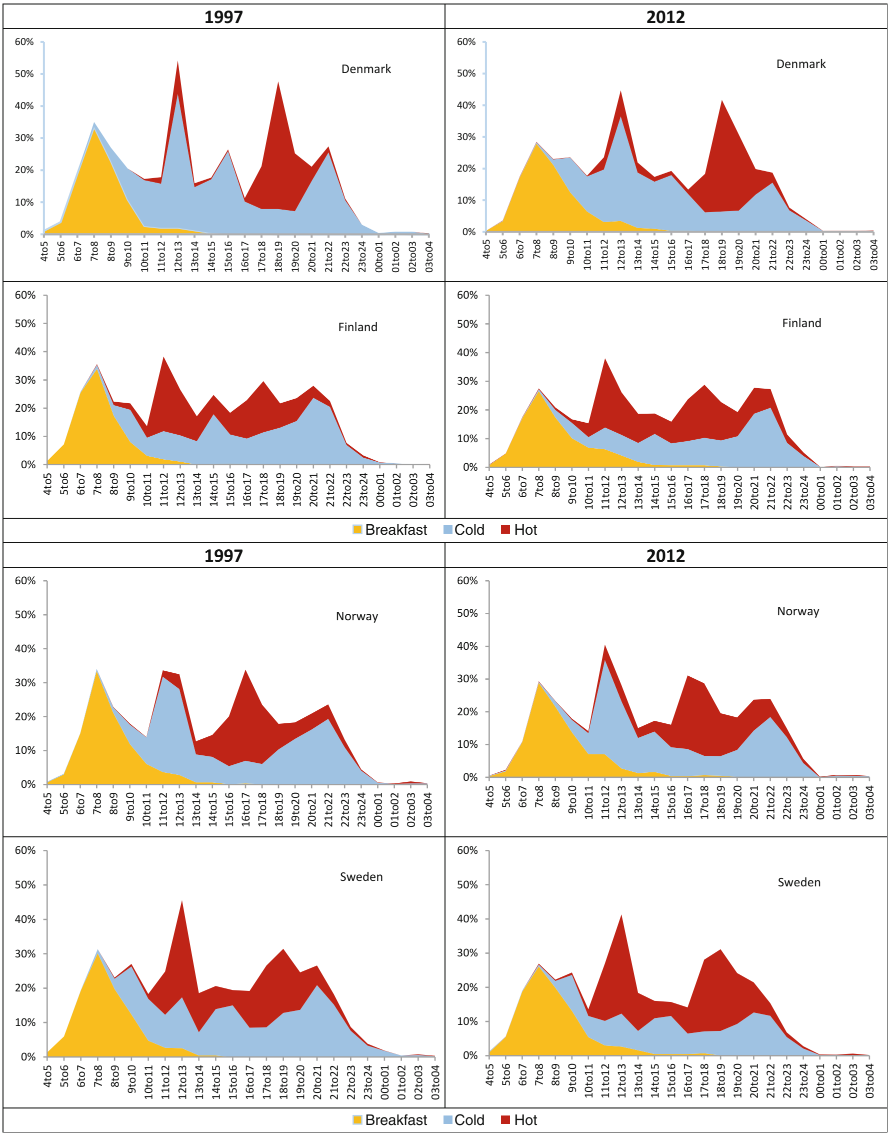

Fig. 2 The daily rhythm of eating in Denmark, Finland, Norway and Sweden. 1997 and 2012. Percent of population eating either breakfast (first eating event), cold or hot food at all hours of the day

In the other Nordic countries, peaks were less distinct from the midafternoon onward. One possible explanation for these patterns is that work hours most likely shape daily eating schedules substantially during the first part of the day, while they are less constraining later in the day and in the evening (cf. Rotenberg 1981; Southerton et al. 2012).

Figure 2 also shows marked differences between the countries in terms of the relationship between hot and cold eating events. In Finland and Sweden, there were two peak hours where many people ate hot food, a major peak in the middle of the day around lunchtime and one less distinct later in the day where in both countries hot eating events spread out from the late afternoon until the evening. In Denmark and Norway, on the other hand, there were only one peak hour with hot food, in Norway in the late afternoon (16–17 h) and in Denmark in the early evening (18–19 h). The two different patterns reflect the distinct traditions that were described above with cold lunches consisting of sandwiches in Denmark and Norway and hot lunches in Finland and Sweden with full hot meals.

In all countries, changes in the daily rhythms of eating between 1997 and 2012 were minor, but some were quite systematic. The early morning peaks between 7 and 8 am flattened somewhat out in all four countries and so did the lunch hour peaks between 12 pm and 1 pm in Denmark and in Sweden, while the lunch hour peak in Norway, between 11 am and 12 pm, rose a little. Other small changes were not systematic and differed between countries. This stability also showed in the almost negligible changes in the average number of eating events per day. In both 1997 and 2012, the most common pattern in all of the four countries was to eat three or four times a day (Lund and Gronow 2014). The patterns of eating displayed in Fig. 2 corresponded with the three-meal pattern (breakfast, lunch, dinner, with or without a snack break) identified as typical in industrial societies and found in recent European time-use studies (Rotenberg 1981; Mestdag 2005; Southerton et al. 2012). It seems then that this daily pattern is still a collective anchor point in this region – a pattern that most people adhere to and common even among those who are not in regular employment (see also below).

However, a deviant pattern was identified which was quite similar across the four countries but unsynchronized with each of the dominant national eating patterns. In this pattern, the eating day started later in the day, for many around lunchtime between 11 and 14 h, and the average number of meals was smaller than for the rest of the populations, only 2.9 (Lund and Gronow 2014). The study showed that there was a systematic increase in the unsynchronized patterns from 1997 to 2012. Thus, the shares rose with approximately 5% points in Denmark, Norway, and Sweden and almost doubled in Finland from 12% to 25%. Neither social class nor household income or education explained unsynchronized eating, but across all countries, this was systematically linked to life course and daily life organization, especially with respect to work. Thus, young people living alone more frequently ate in accordance with the unsynchronized pattern, and this pattern was more frequent on weekend days – or on weekdays for respondents who had a day off and among people who were unemployed (Lund and Gronow 2014). Based on the existing data, it is difficult to decide whether the rise in unsynchronized eating is indicative of a general change based on new eating patterns among young people, which will spread to the succeeding generations, or is, instead, linked to specific life situations and life phases that most likely will remain relatively constant over time. Still, the general influence of institutional time rhythms, such as that of the working day, suggests that collectively shared eating rhythms are likely to persist.

The Social Context: Stable but Changes in the Codes of Conduct

Commensality, i.e., the practice of eating together with other people at the same table, is regarded as one of the key characteristics of human sociability (Fischler 2011). While commensality is highly valued in all food cultures, the discourses around individualization and de-structuration have brought moral concerns about the demise of shared, social meals and about the loosening of social norms regarding the social conduct and context of eating (Murcott 1997; Sobal and Nelson 2003; Mestdag 2005; Mäkelä 2009; Giacoman 2016). These concerns are most prevalent in discussions about the alleged demise of family meals – typically eaten at home – as the archetype of commensality (e.g., Mestdag 2005; Julier 2013). Such worries have been accentuated by public health and nutrition studies suggesting that shared meals are important in socializing children and adolescents into healthy eating habits (e.g., Larson et al. 2013) and preventing them from adopting other unhealthy patterns, such as smoking or drinking alcohol. Consequently, also public health education today strongly encourages families to eat together.

Based on the results on Nordic eating patterns, however, concerns about the erosion of commensal eating in terms of home eating and eating with others seem to be somewhat overrated (Holm et al. 2016). Figure 3 shows three aspects of the social context of meals, namely, location, company, and duration. The figure suggests that the changes in social context and commensality from 1997 to 2012 were mostly moderate. In Denmark, Norway, and Sweden (Finland was not included in these analyses), the respondents ate more than two thirds of their meals at home. During the time period under study, the share of home meals declined by a few percentage points at most (from 75% to 71% in Denmark, from 74% to 72% in Norway, and from 73% to 72% in Sweden). When eating elsewhere, eating at work or in school dominated (12–15% of meals in 1997 and 14–16% in 2012). Only in Denmark did the share of work/school meals increase markedly (from 12% to 16% of all meals). At most 10% of meals were eaten in other places than this in both years; of these about half were eaten in someone else's home. Few meals were eaten in cafes/restaurants (2–5% in 1997 and 3–6% in 2012) on the day before the interview.

The share of meals eaten alone increased somewhat in Denmark (from 33% in 1997 to 38% in 2012) and Norway (from 36% to 41%), but not in Sweden (37% and 36%). In all countries, family members were in both years present in nearly half of all meals. In Denmark, the share of family meals declined somewhat (from 50% to 43%), while the share remained stable in Norway (43% and 42%) and increased in Sweden (from 41% to 46%). In both years, more meals were eaten with social company than alone in all three countries, although in Norway the difference between alone and shared meals was only 1% point. In total, around every fifth meal was eaten with colleagues, friends, or others in both years in all three countries.

While both the location and company at meals remained relatively stable over the 15-year time period, larger changes took place in meal duration, accompanying activities, and seating arrangements. Figure 3 shows that the proportion of very

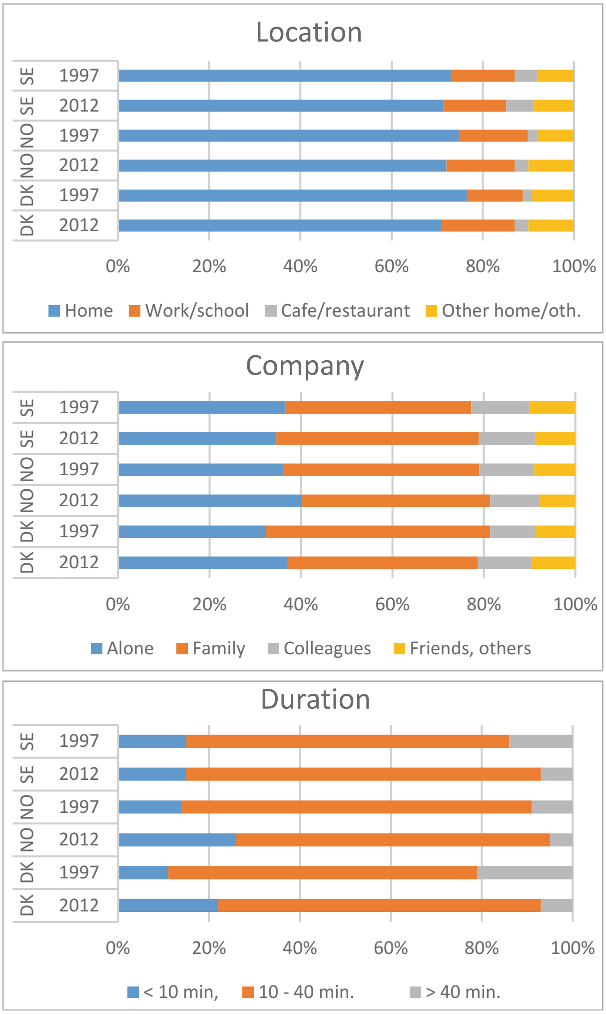

Fig. 3 The social context of eating during the day before: location, social company and duration of meals in 1997 and 2012

short meals, eaten in less than 10 min, increased considerably in both Denmark (from 11% to 22%) and Norway (from 14% to 26%). In Sweden, such short meals remained at a stable level (15% in both years). At the same time, very lengthy meals taking more than 40 min became less common in all three countries; only about 1 in 20 meals was that long in 2012. In addition, there were some indications of informalization, with more accompanying activities during meals (figures not shown). In all three countries, people increasingly watched the television while eating; in 2012, around one third of meals included television watching. Meanwhile, listening to the radio declined considerably from more than 20% to 10–14%, while reading remained at around 12–14%. Computers, tablets, or smartphones were not included in the 1997 study, but in 2012, they were used in a little less than one in seven meals (13–14% in all three countries). Furthermore, it seems that more often than earlier do Nordic people eat sitting at sofa or coffee tables rather than at kitchen or dining tables (no figure/table). The accustomed manner of eating at kitchen or dinner tables declined overall from around two thirds in 1997 to a little more than half of meals in 2012. At the same time, roughly a third of meals – with some country variation – were eaten at coffee or sofa tables (an increase from 23% to 30% in Denmark, from 31% to 40% in Norway, and from 19% to 28% in Sweden).

Such trends were to some extent associated with demographic factors, albeit somewhat differently so in the three countries (see Holm et al. 2016 for details). Here we report sociodemographic differences common in all three countries. First, regression analyses showed, not surprisingly, that eating meals alone was explained primarily by living alone. Living alone was also associated with eating meals elsewhere than kitchen or dining tables while watching television and using a computer, tablet, or smartphone. The younger the respondent, the more likely he or she was to eat very short meals, watch the television, and use a computer, tablet, or smartphone while eating. In addition, women were more likely than men to eat very short meals, and those with tertiary education were more prone to eat with computers, tablets, or smartphones than those with secondary education.

Logistic generalized estimating equations conducted for all four countries for the 2012 data (including Finland) showed that informal eating arrangements were in all countries more prevalent at breakfast and in-between meals and less so for dinners. Eating alone was quite usual for all types of meals except for dinner. Dinner thus seems to have most persistently kept its commensal character, while norms of commensality seem to be loosening for other meals.

Based on these observations, we conclude that hardly any delocalization took place, since most meals were eaten at home in both years. Individualizing tendencies were primarily related to the slightly increasing trend of eating alone. The most substantial transformation seems to have occurred in informalization. Compared to the late 1990s, Nordic people in the 2010s ate more quickly and engaged in other activities while eating – watched television, used the computer, etc. – and they more often enjoyed their meals informally on the sofa, for instance, instead of at kitchen or dining tables.

Eating Out: Modest with Remaining National Traits

The figures above indicate that eating out in cafés and restaurants does not have a prominent position in everyday eating in the Nordic countries. Yet, eating out may still be a regular phenomenon, and changes in such practices may inform us on the modernization of Nordic eating. The two surveys included not only questions about the venues of eating during the day before but also about the frequency of eating out in a restaurant or a café during the previous year.

The results on eating out add information on both similarities and differences between the four countries in the social organization of eating. In general, eating out seems quite infrequent. Figure 4 shows that in all four countries, only a small minority regularly ate out in terms of doing so weekly or more often. This was the case in all four countries. However, there was some disparity in the trends. Whereas eating out at least once a week in Denmark and Norway remained very low over the 15-year period, the figures were somewhat higher and showed an increasing trend in Finland and remained stable and somewhat higher in Sweden. In both years, a large majority (around 80%) had eaten out at least once during the previous year. However, while a trend of more people eating out once or several times a month was found in Finland and Sweden, this was not the case in Denmark and Norway. This means that in 2012, while 35% in Denmark and 45% in Norway ate out monthly or more often, the proportions were 55% in Finland and 61% in Sweden. Yet, the proportion of people eating out very rarely or never remained low, below 10%, in all four countries (Lund et al. 2017).

Further analyses of eating out in 2012 indicate that these divergences may, at least in part, be connected to different patterns of eating at work. In Finland and Sweden, a larger share of the meals eaten at a restaurant or a café on the day before the interview was eaten with colleagues (26% and 30%, respectively), while these proportions were lower in Denmark and Norway (12 and 20%, respectively) (see Lund et al. 2017). The difference can probably be explained by the different role of lunch in overall eating patterns in Finland and Sweden compared to Denmark and Norway. A hot meal away from home requires some kind of food service, either in a canteen or in a commercial venue. Meanwhile, in Denmark as many as 39% of the meals eaten at a restaurant or café were eaten with friends, a much larger share than in the other countries, in which the share was between 22% and 29%. In Finland, it was more typical than in the other countries

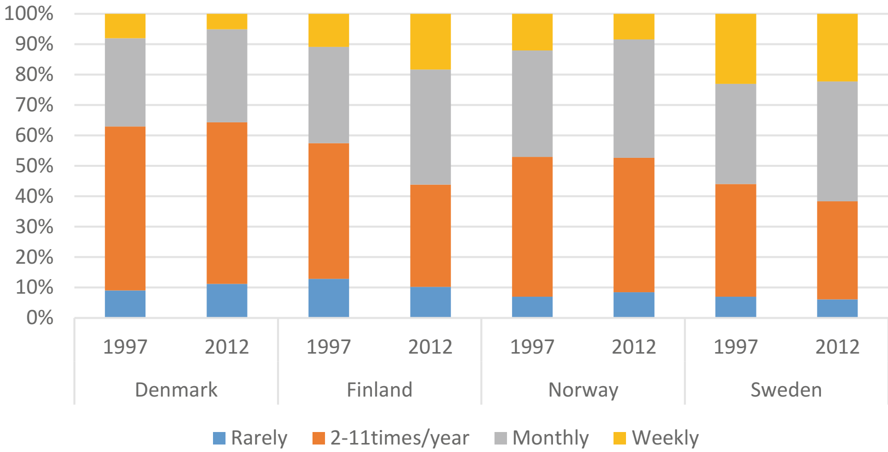

Fig. 4 The frequency of eating out in restaurants and cafés in four Nordic countries in 1997 and 2012

to eat alone in a restaurant or a café (21% in Finland compared to 7% in Denmark, 13% in Norway, and 14% in Sweden).

In all countries, living in urban surroundings increased the propensity to eat out. This is not very surprising, considering that while large cities offer easy access to a large variety of venues, this is much more limited in less densely populated areas. Eating out is a matter of social stratification, too. In Sweden and Norway, higher education was associated with the frequency of eating out, and in Sweden, Denmark, and Finland, the higher salariat, i.e., higher managers or professionals and large employers, more frequently ate out than others did. However, it should be noted that the analysis did not capture more fine-grained distinctions between different types of venues, which do range from top-end restaurants to fast-food outlets.

All in all, eating out in cafes and restaurants seems to represent an occasional element of Nordic eating patterns. It is hard to draw any strong conclusion when it comes to trends, but there are few signs of eating out increasingly replacing everyday eating at home. The limited increase is somewhat surprising, considering that income levels have increased in the Nordic countries during this 15-year period and emphasize the persistence of home-centered food cultures in this region.

Conclusion: No Strong Evidence of De-traditionalization and Dissolution

The empirical data from the two surveys clearly indicate socially shared eating patterns in each of the four Nordic countries. These patterns have remained surprisingly stable since the late 1990s. Therefore, in this region there is no strong evidence of the alleged dissolution and individualization of traditional meal patterns. Nor are there any strong trend of homogenization across countries in terms of how eating is organized. The general picture is one of stability in parallel with some elements of change.

Eating rhythms show clear national patterns. There were nation-specific collective daily time peaks at which meals were eaten by a great number of people in each of the four countries, with hardly any changes in the timing of eating over the 15 years. The pattern of having three to four meals per day, which corresponds well with the three-meal pattern identified as the predominant schedule of daily eating in industrialized societies, appears to have remained relatively unchanged. During the first part of the day, the rhythm of eating was quite similar in all four countries, including a morning meal (breakfast) and a midday meal (lunch). This corresponds well with Nordic work hours. After work – roughly speaking, when eating is less limited by the institutionalized structures of the working day – distinct national traditions emerged, even here remaining stable. Deviant practices, socially unsynchronized eating, were identified in all four countries, increasing slightly between 1997 and 2012. Judged from demographic variations, this pattern is most likely a transient phenomenon that reflects the life course of the respondents, and not an emerging de-structuring of eating rhythms.

The localization and social company of daily eating also remained relatively unchanged. Eating took place primarily in the home, plus in the workplace during work hours (for those employed). Accordingly, family and colleagues were the most frequent eating companions. In everyday life, eating rarely took place in restaurants, cafés, and the like, though this was very slightly increasing over the 15-year period. In the Nordic countries, visiting people in their homes or having guests over for meals appears to be the preferred way of socializing around meals with people who do not belong to the household. This is unlike, for example, British patterns, where eating out has been more widespread since the 1990s (Warde et al. 1999). Eating alone was frequent, too, with a modest increase over the 15 years, most likely reflecting the growing number of single-person households in the Nordic countries. The overall picture is then that while eating alone was quite common, social eating within the context of the home was still a stable and dominant part of contemporary eating patterns and the practice of family meals remained remarkably unchanged.

While supermarket shelves demonstrate considerable changes in the food items on offer in the Nordic countries, there was remarkable stability with respect to the categories of foods eaten in 1997 and 2012. Meat has a dominant position in dinner dishes, with some national variation. Our data do not, however, tell much about the character of the food items or the extent of home cooking. Meal formats of both hot lunches and dinners as “platefuls” are rather simple, very far from the complex meals presented as the ideal in, e.g., French studies Poulain (2017). Cold meals are even simpler. This was evident in both years. Despite these shared features, it seems that the core elements in traditional Nordic national food cultures persist. While Danes and Norwegians tend to eat their lunches cold, Finns and Swedes maintain a food culture with hot, cooked lunches. The institutional arrangements supporting the hot lunches in schools and workplaces in Finland and Sweden are probably strong stabilizing factors behind this finding and linked to normative expectations. In these two countries, more people eat out at cafés and restaurants during the day, and the timing of dinner is somewhat more flexible, compared to Denmark and Norway. Further, there is a higher frequency of skipping dinner in Finland and Sweden and a lower frequency of family meals among employed persons – one reason perhaps being that they already had a cooked meal at lunchtime.

Taken together, while we do see persistent and distinct national patterns, the picture is not uniform across social groups within each of the countries. Many of these variations are straightforward and relate to the evident impact of everyday life arrangements. Thus, people who were employed or undergoing education ate more often with colleagues or schoolmates, and people who lived alone ate alone more frequently and also tended to eat in a manner signaling informal codes of conduct. Many differences relate to life phase as reflected in age and household organization. Young people were the most likely to engage in brief eating events, eat in front of the TV or computer, and eat in an unsynchronized manner. It remains to be seen whether they will keep on doing so when they get older and have their own families and children.

Markers of social distinction were infrequent and somewhat scattered in our study. Fuller and more specific analyses of sociocultural differences in eating patterns are likely to demand different kinds of data: more detailed information on foods and dishes eaten, the prices of foods purchased, and more information on preferences. Considering the basic elements of eating patterns addressed in this study, social distinctions do not appear to be very important. Social and economic differences did, however, emerge clearly in issues directly related to economic resources, such as eating out (Lund et al. 2017) or being food insecure (Borch and Kjærnes 2016). Taken together, changes in eating patterns draw a double-sided picture: on the one hand, Nordic food cultures are evolving and becoming more similar in terms of what people eat and drink for daily meals as well as in terms of informalization of eating. On the other hand, the Nordic countries have hardly absorbed supposedly global developments in patterns of eating, such as more eating out and less eating at home. The stable number and composition of eating events indicates that frequent snacking is rarely replacing a pattern of ordinary meals. Contemporary Nordic meals are rapid and simple, but they are still "meals" in terms of timing and social organization.

The Nordic countries share many features of postindustrial societies in terms of everyday life as well as food provisioning; households are small, with most women and men being employed outside the home; welfare systems ensure a relatively low level of social and economic exclusion; and supermarket food distribution dominates completely, with high proportions of convenience food and ready-made dishes. Yet, as witnessed by this study, eating patterns have remained relatively stable, also retaining some key nationally characteristic features. Not only that, these national distinctions seem to be sustained by modern institutions, as demonstrated by the organization of lunch in the four countries. In most households, strong norms of eating together at home in the evening also seem to have survived the significant transformation of family and work life over the last decade.

Still, eating may change in ways that are not recorded in the type and level of data we have used here. Dilemmas of limited time for household chores seem, for example, to have been solved by a gradual transition from home cooking to industrial processing, as indicated by both sales data and time-use studies. This way, societal rules and norms of the social organization of eating seem to be upheld, to a certain extent, even in terms of the categories of foods and dishes. This does not preclude significant modifications at the food commodity level. Here, we have based our discussion on data, which allow us to conclude that in spite of the rapid changes, which are easily observable in supermarkets and in food marketing, the basic structures and patterns of eating change at a much slower pace and within specific local, normative, and institutional contexts.

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Traditional and Modern Eating in Japan

63

Sumio Imada and Isato Furumitsu

Contents

Abstract

In order to understand the Japanese food culture, the past and present eating behaviors of Japanese were discussed from the viewpoints of what and how they have eaten in their life. Although rice has not been a staple food in the nutritional sense, it has held a symbolically important role for almost all Japanese in the past and present. Fermentation by fungus specific to Japan, namely *Aspergillus oryzae*, characterizes Japanese food culture and its typical products *sake*, *miso*, and soy-sauce. Personalization of chopsticks and eating utensils, together with the

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ritualistic behavior before and after the meal, also characterizes Japanese eating behavior. Although saying "*Itadakimasu*" before a meal and "*Gochisosama*" when a meal ends are ordinary and common ritualistic behaviors today, these behaviors seem not to have traditional base. Focusing on Okinawa, where a modern diet characterized by high fat and high calorie was rapidly introduced after World War II, the possible relationship between a modern diet and health deterioration is discussed. Ever since the dawn of history, the Japanese diet has undergone three major changes: the period from prehistoric to ancient ages, the latter half of the nineteenth century, and after World War II. Despite such changes, the Japanese attitude and mentality toward food appears to have been relatively stable. Nevertheless, food globalization and denationalization are in progress in Japan and it is important to distinguish between the true tradition and the idealized and/or invented tradition.

Introduction

Just as in many other dietary cultures, the Japanese dietary culture has also been changing through conflicts and frictions with other dietary cultures. Through their history over a thousand years, Japanese positively accepted other cultures three major times. The first time such acceptance took place was when cultures were brought from China and the Korean Peninsula in the period from prehistoric to ancient ages. For instance, as for rice cultivation, it is said to have been stretched from China to northern *Kyushu* around 350 B.C. and reached the *Tohoku* area around A.D. 0. Thereafter, rice started to play a central role not only as food but also in Japanese politics and economy. Buddhism, which was brought from China to Japan via the Korean Peninsula in the sixth century, implanted the idea of the meat-eating taboo in Japan. Moreover, partly because of the influence of Shintoism, which is a native religion of Japan, many Japanese still do not like offal or variety meats and "bloody" steaks.

Chopsticks are also tableware introduced from China, although the period of their introduction is not identified. In Japanese history, it is known that Japanese ate with their hands in the third century and that chopsticks were used at formal events in the seventh century and became used also by common people by the early eighth century. Interestingly, although spoons were introduced with chopsticks since spoons were also used along with chopsticks in ancient China, the use of the spoon did not take root in Japan. While people in China and the Korean Peninsula today use both chopsticks and a spoon at meals, Japanese generally use only chopsticks. It is unknown why spoons did not take root in Japan.

The second time was when the Western culture was positively accepted in the latter half of the nineteenth century. In this period, a series of political incidents occurred to bring about a major transformation of Japanese politics, economy, and society (Meiji Restoration). Japan ended its national isolation policy which had continued for more than 200 years and started to adopt Western civilization and culture positively (civilization and enlightenment). Not only meat-eating but also

Western-style meals and table manners soon came to be accepted mainly by the ruling class. What is interesting is that an eclectic cuisine of Japanese and Western food was created by integrating the Western cuisine into the Japanese dietary culture instead of accepting the Western dietary culture as it is. *Sukiyaki*, which is now known as a typical Japanese dish, is one that was created in this period as a dish of the eclectic cuisine in which Western and Japanese dietary cultures were integrated. Over time, more dishes of the eclectic cuisine have been created to this day including *tonkatsu* (fried pork cutlet), Japanese curry, *omuraisu* (omelet containing fried rice), *nikujaga* (boiled meat and potatoes with soy sauce and sugar), *gyudon* (beef bowl), Japanese-style spaghetti, and ramen. The eclectic cuisine composed of those dishes is now called *yoshoku* (Western dishes).

The third time was when American and European cultures represented by American culture were positively accepted after World War II. In 1945, Japan was defeated in World War II and unconditionally surrendered. For the period from that year to 1951, which prolonged to 1972 in Okinawa, Japan had been placed under the rule of the Allied Forces mainly composed of the US forces. The United States supplied a large amount of food, typically wheat and skim milk powder, in assistance to Japan, which was suffering from postwar food shortage. At the same time, the Japanese government promoted the Nutrition Improvement Campaign which idealized a diet with foods such as breads, meats, milk, oil-based dishes, and dairy products. It is since this period that Western cuisine and Japanese–Western fusion cuisine have spread not only to the ruling class and the middle class but also to ordinary citizens. Japanese as a whole started to move toward an “affluent diet” and “the westernization of diet.”

Japan is an island country 75% of whose territory is covered with mountains and forests. Japan had never been invaded or occupied by other nations or ethnic groups for a long period of time. While, in 2013, the United Nations Educational, Scientific, and Cultural Organization (UNESCO) decided to inscribe “WASHOKU; Traditional Dietary Cultures of the Japanese” (Ministry of Agriculture, Forestry and Fisheries: MAFF 2019a) on the List of the Intangible Cultural Heritage of Humanity, it seems to have been against the backdrop that Japan has a relative stable political, economic, and cultural traditions. There are various opinions, however, as to whether *washoku* inscribed on the UNESCO’s list truly reflects the traditional dietary culture of Japanese.

First of all, per the conception of *washoku*, rice is regarded as traditional staple food for the Japanese from a historical perspective, but people who eat rice on a daily basis have been mainly in the ruling class. Most of farmers who produced rice ate miscellaneous grains and cereals as staple food, and rice was valuable food which they were able to eat only on special occasions such as national holidays. Second, although according to the conception of *washoku*, *ichiju-sansai* (three dishes and one soup) with rice as a staple food is regarded as the traditional meal structure, this is a meal style of samurai or warriors who were the ruling class from the middle to modern ages (*honzen-ryori*) and not that of ordinary people. The majority of Japanese were historically farmers, who were not able to afford to serve a meal of *ichiju-sansai* for daily meals. They might have eaten a bowl of hodgepodge. Third, it is problematic that, according to the conception of *washoku*, dishes of the Japanese-Western fusion cuisine mentioned above (*sukiyaki*, Japanese curry, fried pork cutlet, etc.) are called "the new traditions of WASHOKU." Numerous dishes of the Japanese-Western fusion cuisine have been created in Japan, including teriyaki hamburger, spaghetti with spicy salted cod roe sauce, pizza with dried seaweed and dried bonito shavings, and green tea ice cream, and they are common for many Japanese nowadays. This implies that the boundary line or definition that demarcates *washoku* is vague. The fourth problem is that the Chinese character "wa," the first letter of the word *washoku,* is used to refer to Japan itself and also associated with the Yamato court, the first unified state in Japan from the fourth to seventh centuries. While this regime was born in the Kansai area, its sphere of control did not include Hokkaido and Okinawa areas. In other words, for Japanese people indigenously inhabited in Hokkaido and Okinawa, "shoku" (food or eating) of "wa" is associated with "shoku" of an out-group. In particular, Okinawa is remote from the other four main islands in terms of distance, and many Okinawans regard "wa" as an out-group.

For the above reasons, it can hardly be said that *washoku* inscribed on the UNESCO's list reflects the traditional dietary culture of the entire Japanese people. *Washoku* promoted by the Japanese government is grounded on political and economical intentions and can hardly be said to be academically grounded. In other words, *washoku* can be said to be a notional dietary culture with political ornamentation (cf., Hobsbawm and Ranger 1983; Onuki-Tierney 1993; Cwiertka and Yasuhara 2016).

Now, there is an essay titled *Hojoki* by *Kamo no Chomei* (1212), which is said to be one of three great essays of Japan. One of its famous passage goes, "Ceaselessly the river flows, and yet the water is never the same. . .." Although the water of a river is always changing (not motionless), we perceive a river as such. Although it may vary how different persons perceive a river, the river should be perceived as something stable and almost unchanging.

A "tradition" may be compared to a stable and almost unchanging presence of a river in this sense. If you examine it closely, the water of a river is changing constantly and unstable. The "river" exists as such, however, as long as water flows. If a deluge occurs, the river water will overflow and the flow of the river itself may change. Still, it exists as a river. In the following discussion, a dietary tradition will be discussed as an unchanging stable river given above.

Now, when it comes to the historical transition of the Japanese dietary culture, numerous technical books have so far been published mainly in fields of cultural anthropology and history. This chapter refers to the following four books for historical details: *Nihon no shoku-bunkashi: kyu-sekki-jidai kara gendai made* [History of Japanese Dietary Culture: From the Old Stone Age to the Modern Era] (Ishige 2015), *Kouza shoku no bunka dai-2-kan: Nihon no shokuji bunka* [Lectures on the Dietary Culture Vol.2: Japanese Meal Culture] (Kumakura 1999), and *Nihon shoku-seikatsu-shi* [History of the Japanese Dietary Life] (Watanabe 1964). These are all written in Japanese.

What Japanese People Have Eaten in the Past and Eat at Present

Two Dimensions for Describing Traditional and Modern Eating

Sproesser et al. (2018) compiled and systematized characteristic elements regarding traditional and modern eating through an extensive review of relevant literature, and proposed two major dimensions for distinguishing between traditional and modern eating. These two dimensions, in other words, constitute traditional and modern eating. The first dimension is what people eat and has six subdimensions: ingredients, processing, preparation, temporal origin, spatial origin, and variety. The second dimension is how people eat and has six subdimensions: temporal aspects, spatial aspects, social aspects, meals, appreciation, and concerns. In what follows, distinctive features of the Japanese dietary culture are examined from the perspective of tradition and modernity generally in accordance with these two dimensions and several subdimensions. First of all, let us dwell on what Japanese people have eaten.

Rice

As stated above, rice has occupied a special position politically, economically, and culturally in the history of Japan. Paddy rice cultivation is thought to have been brought to Japan from China around 350 B.C. Until the transition to a modern state system in the wake of the Meiji Restoration in the latter half of the nineteenth century, farmers had delivered rice as tax. During the Edo period, the Daimyo, who were rulers of their territories, were ranked in accordance with rice production. Rice had been treated as a basic political and economic unit.

From a nutritional perspective, rice was not necessarily a staple food for many Japanese. Historically, it was a part of the ruling class and urban residents in the Edo period who ate white cooked rice as a staple food. Traditionally, for many Japanese, it was limited to special occasions such as holidays and festivities that they ate white cooked rice. Their ordinary staple food was miscellaneous grains (such as wheat and Japanese millet) with or without an addition of a little amount of rice. Even for Japanese today, according to the government statistics for recent years, the percentage of rice in the food calorie consumption is only 23.4% in 2014 (MAFF 2019b), far lower than other Southeast Asian countries such as Bangladesh, Cambodia, and Vietnam.

Particularly in recent years, there has been a consistent trend, “moving away from rice,” and, in terms of consumption expenditure, the amount of expenditure on bread has become greater than that on rice. In particular, for breakfast, those who eat mainly bread (48.6%) has become greater than those who eat mainly rice (36.1%), according to the survey conducted in 2002.

Although rice is said to be the staple food, it is not because rice is nutritionally important for the Japanese diet but because it has symbolic importance rooted in culture (Onuki-Tierney 1993). The Japanese word “gohan” means both meal and cooked rice. The word “rice” can be said to symbolize food as a whole. Furthermore,

Table 1 The frequency of occurrence of most free-associated words

Associated word	Korea	%	Japanese	%	Taiwanese	%
Rice[a]	40	13.6	68	9.6	47	7.6
Kimchi	26	8.8	0	0.0	1	0.2
Tasty	2	0.7	39	5.5	15	2.4
Noodles[b]	9	3.1	26	3.7	36	5.8
Total Num.	294	100.0	707	100.0	619	100.0

[a]Including "rice," "steamed rice," "steamed white rice," and other words related to rice
[b]Including "noodles," "ramen," "rice vermicelli," and other words related to noodles or noodle dishes

rice symbolizes both Japan and Japanese and has played a role as a metaphor whereby Japanese identify themselves. In 2019, the Emperor Akihito, who is stipulated to be "the symbol of the State and of the unity of the People" in the present Constitution, will abdicate and be succeeded by the Crown Prince. It is the *Daijosai* ceremony that is supposed to be the most important among events performed by the new emperor. This is a once-in-a-lifetime ceremony whereby a newly enthroned emperor not only celebrates the rice harvest of the year but also declares that the emperor is an entity linked to rice. It is for this reason that a special building dedicated to the *Daijosai* ceremony is constructed and removed immediately after the end of the event. Rice can be said to continue to be the symbol of Japan and of the unity of the Japanese people still today.

Imada (2013) had 236 Japanese, 97 Korean, and 209 Taiwanese college students to write down up to 3 words they freely associated with the word "food." The result was that the occurrence of "rice" and rice-related words was the highest among students of all three countries (Table 1). Distinctively, the occurrence of "kimchi" was higher among Korean college students than among students of other two countries. Likewise, the occurrence of "noodles (including related words)" was highest among Taiwanese college students. It is thus suggested that rice is a symbolic entity that represents meals for modern Japanese.

Rice Products: *Mochi, Sake*, and Others

Rice is eaten not only by boiling it but also by processing it for various uses. The most typical products of such processing are *sake* and *mochi* (rice cake). Sake is made by alcoholic fermentation using *koji* (*Aspergillus oryzae*), a fungus unique to Japan, and yeast. If *koji* only is used, saccharification only progresses, resulting in a sweet beverage. This is called *amazake* (literally, sweet sake).

While *mochi* is made by pounding steamed rice, it is kneaded by a machine these days. Fresh *mochi* is soft and stretches very well. Traditionally, *mochi* was eaten on special occasions such as local festivals. Even today, there are many Japanese who eat *mochi* on the New Year's Day, the most important holiday of the year.

Mochi is also used as an ingredient in confectionery. Numerous traditional confections have been made by combining *mochi* with sweetened beans, and modern

Japanese eat them regularly. Furthermore, rice cracker (*arare* or *okaki*), a typical Japanese snack, is made by drying thinly sliced *mochi* and grilling or frying them.

Nuka or rice bran is residue from rice polishing and used for making pickles. *Nukazuke*, which are called *dobuzuke* or *dobozuke*, are typical pickles of Japan made by pickling vegetables in *nukadoko* which is made by the lactic fermentation of *nuka*. Above all, *nukazuke* made of Japanese white radish is called *takuan* and often colored in yellow. Today it is served at Japanese restaurants here and abroad.

Fishery Products and Sushi

Japan is an island country composed of 6,852 islands. While its land area is the 62nd largest in the world, its total coastline distance is longer than those of the United States and Australia and the sixth longest in the world. Owing to such geographical conditions, Japanese have traditionally eaten fishery products. With a lack of active stock raising, fishery products had been valuable sources of animal protein for Japanese before modern times.

Sashimi, sliced raw fish, and sushi, sashimi placed on a bed of rice, are known as dishes representative of Japan. In the past when there was no refrigerating technology, however, raw fish dishes were available only to residents of fishing villages on the sea. Many fishery products were eaten by salting or drying them to improve their preservability. For fish for sushi, their preservability had been improved by soy sauce or vinegar historically.

Figure 1 shows what Japanese have eaten during the past century by kinds and Fig. 2 shows the amounts of protein calculated to have been supplied by those kinds of food (MAFF 2019c). It is shown that the major sources of protein were rice and soy beans about a hundred years ago (1911–1915) and that fish and shellfish were not an important source of protein then. They are foods whose intake increased after World War II (1945 and after), just like wheat, meat, milk, and dairy products.

Sushi developed as *narezushi*, *namanarezushi*, and *hayazushi* during the ancient and middle ages to become *nigirizushi*. *Narezushi* is made through the lactic fermentation of fish and rice for several years for the purpose of preserving fish, and it is still eaten in some areas today. *Namanarezushi* is made by simplifying the preparation method for *narezushi* with a short fermentation period of several days to 1 month. *Hayazushi* is a way of eating that spread in Edo in the beginning of the nineteenth century whereby fish and rice were eaten just by adding acidity with vinegar without waiting for lactic fermentation. It was called *nigirizushi* because rice was hand-pressed into a ball.

Nigirizushi started to be offered at stalls in Edo (present-day Tokyo) from the beginning of the nineteenth century and developed as stand-and-eat food. Edo at the time was a densely populated area and had a large male population, which caused the development of an eating-out culture. In the Meiji period and after, the sushi culture spread nationwide, and restaurants offering sushi became specialty restaurants. It is because sushi restaurants in the form called *kaitenzushi* (conveyor belt sushi restaurants) increased that sushi was popularized again.

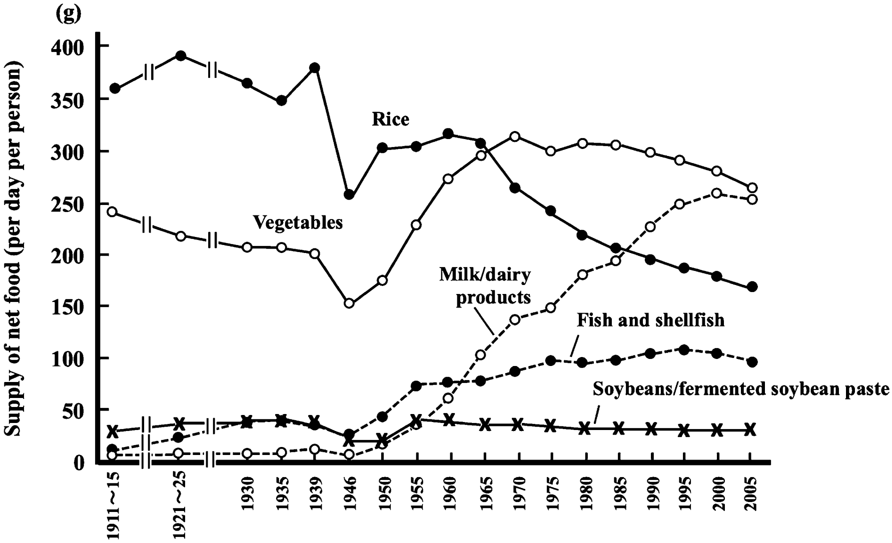

Fig. 1 The change of the dietary habits from 1910s to 2005 on an annual basis. Supply of net food is the amount of edible portion of food which is calculated by subtracting the amount of portions to be disposed from the amount of supply of food for commercial use, not including the amount of those for certain processed foods, livestock feed, or industrial use (gross food supply). Values of soybeans from 1930 exclude portions processed to make fermented soybean paste, soy sauce, and fats and oils. Values of wheat and rice include bread and thick white noodles which are not individually grouped, and portions processed to make rice crackers. From 1911 through 1925, values of fish and shellfish include whale and seaweed (1.0 g and 1.4 g in 1930, respectively). Since 1926, whale has been included in meat, and seaweed others. (Sources) "Food Balance Sheet" (in Japanese) and "Basic Statistics on Food Demand" (in Japanese), the Ministry of Agriculture, Forestry and Fisheries. "Revised Basic Statistics of Japanese Agriculture" (in Japanese), Association of Agriculture and Forestry Statistics (newly created based on Fig. 5 in MAFF 2019c)

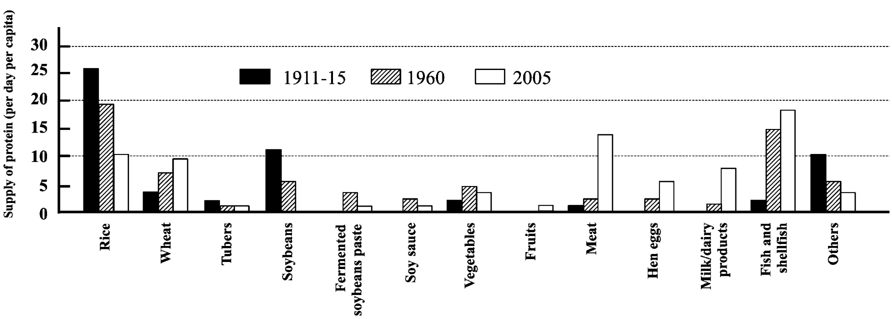

Fig. 2 Supply of protein per day per capita in 1911–1915, 1960, and 2005 on an annual basis. (Sources) "Food Balance Sheet" (in Japanese) and "Basic Statistics on Food Demand" (in Japanese), the Ministry of Agriculture, Forestry and Fisheries. "Revised Basic Statistics of Japanese Agriculture" (in Japanese), Association of Agriculture and Forestry Statistics. (Newly created based on Fig. 5 in MAFF 2019c)

Kaitenzushi is a form of sushi restaurant which lets customers eat whatever sushi they like freely by picking up sushi plates on the conveyor belt that run through the restaurant. The first *kaitenzushi* restaurant was opened in Osaka in 1958, and this type of sushi restaurant spread all over Japan during the 1970s and after with a rapid increase in their number. According to the survey conducted by Maruha Nichiro Corporation (of 250 each male and female individuals living in Kansai and Kanto areas, respectively, totaling 1,000, in 2018), Japanese today eat sushi more often at *kaitenzushi* restaurants than at dedicated sushi bars, and 37% of survey respondents answered that they use *kaitenzushi* restaurants "once or more per month" (Maruha Nichiro Corporation 2018). As for the amount of payment per customer (including the payment for desserts and alcoholic beverages), the survey result shows that the largest number of respondents (62.1%) answered "1,000 yen or greater and less than 2,000 yen." Compared with the fact that it is not uncommon that a guest at a dedicated sushi bar ends up spending 10,000 yen or more, it is found that *kaitenzushi* restaurants offer sushi at really inexpensive prices. In other words, *Nigirizushi* was born as fast food and became fine food in time but is now becoming popular food again. It can be said that a large percentage of fish and shellfish intake of Japanese today is supported by inexpensive sushi served at *kaitenzushi* restaurants.

Flavor Principles in Japanese Cuisine

According to Elizabeth Rozin (1983), three components of a dish of cuisine are staple foods, processing techniques, and flavor principles, and, among them, it is flavor principles that most characterize each ethnic cuisine of the world. Flavor principles that characterize Japanese cuisine are created by the combination of soy sauce, *miso* (fermented soybean paste), *sake*, *mirin*(sweet sake), and *dashi*, which are traditional condiments. *Dashi* is a soup stock mainly made from bonito flakes and *kombu* kelp. What is interesting is that almost all of them are fermented foods and that fungi unique to Japan are used in the fermentation of many of them. In particular, a fungus indigenous to Japan named *koji* is used in the production of soy sauce, *miso*, and *sake* to produce flavors unique to Japan. Furthermore, fermentation using other types of *koji* (*Aspergillus glaucus* and *Aspergillus repens*) is conducted at the final stage of the production of dried bonito. Many of the flavors characterizing Japanese cuisine can be said to be created by fermentation using *koji*.

An important psychological function of flavor principles is their role as a safety signal (Rozin 1982). Even if it is the first time to eat some food, one probably tries to eat it if it has a familiar flavor. Even if some food is familiar, one may hesitate to eat it if it has an unfamiliar smell. Just as it is case with rice, the flavors of soy sauce and *miso* enable most Japanese to identify themselves as Japanese.

This is manifested in cooking methods of meat, the eating of which came to be widely accepted by Japanese in the early Meiji period and after. At first, beef was cooked using a method of simmering chopped beef with *miso* in an iron pan (*gyunabe* or *ushinabe*). Beef, which was unfamiliar food, was eaten by providing a familiar flavor (*miso*). Figure 3 is an illustration in the novel, *Aguranabe* (by

Fig. 3 A student eating unfamiliar beef cooked in *miso* with having a familiar flavor, depicted in an illustration in the *Aguranabe*, a novel written in the early Meiji period (1871–1872) by Kanagaki Robun

Kanagaki Robun) published in 1871–1872 (Kanagaki 1871–1872). It depicts a student clad in Western clothes, rare for the time, eating beef boiled in *miso* broth. Officially, the meat-eating taboo was practically removed when Emperor Meiji ate meat on a formal occasion for the first time in 1872, which helped meat-eating to be prevalent. It is said that there were 558 beef houses in Tokyo by 1878.

Before long, *gyunabe* came to be called *sukiyaki*, and it became customary to use soy sauce, sugar, and sake for flavoring. The combination of these three is a basic seasoning combination in Japanese flavoring and used also in flavoring grilled chicken (*yakitori*) and eel (*kabayaki*). A *teriyaki* sauce, a hamburger sauce first used in Japan, is flavored in this way.

As mentioned above, *nukazuke* (vegetables pickled in a fermented medium) are fermented products. *Natto* (fermented soybeans), which causes many foreigner visiting Japan an aversive reaction to it but which many Japanese like to eat, is also a fermented product using *Bacillus subtilis* var. natto.

A flavor characteristic of the Japanese cuisine is said to be *umami. Umami* is chemically synthesized and is used as monosodium glutamate (MSG) in areas mainly in Asia. Today, chemically synthesized seasonings using nucleic acid substances such as sodium inosinate, sodium guanylate, and sodium ribonucleotide have been developed besides MSG, and many products combining them are used. A large amount of these seasonings are used in take-out food and at restaurants offering relatively inexpensive food.

Eclectic Fusion Cuisines

As stated above, Japan experienced dynamic cultural contacts three times in its history spanning one thousand and several hundred years. Any of them was neither the result of an invasion nor the consequence of coercion or pressure by other ethnic groups. Rather conversely, different cultures were positively introduced and accepted on the part of Japan.

What happened when another culture was positively accepted was its fusion or eclecticism with the home culture. Its most representative example is the Japanese language. While the written Japanese language today is composed of *kanji* (Chinese characters), *katakana*, and *hiragana*, they derive from Chinese, Western languages, and the indigenous Japanese aboriginal language or *Yamato-kotoba*, respectively. Because of the mixture of ideographs and phonograms, learning Japanese is not easy for foreigners.

It is the same with cuisine. You can enjoy almost all types of cuisine of the world in Tokyo today. Most of them, however, are adapted to Japanese taste. If you go out to eat steak, you will be asked whether to choose soy-sauce-based or others and to choose bread or rice to go with it. At *gyudon* (beef bowl) restaurants, a variety of toppings are offered including raw eggs, kimch, cheese, and so on. The same goes for pizza toppings.

The most typical fusion dish may be ramen. In Japan today, a variety of ramen restaurants are operating which are characterized by the thickness and shape of noodles, types of soup (mainly based on pork bone, chicken carcass, fish and shellfish, soy sauce, miso, or salt), and diverse toppings (sliced pork simmered in soy sauce, boiled fish paste, bean sprouts, vegetables, dried seaweed, kimch, shrimps, etc.).

The same is true of *karee raisu* (curry with rice, which was originally introduced from England around the late nineteenth century). At restaurants of the curry restaurant chain which has the greatest number of franchisees in Japan (1303; 2018 Dec.), you can choose whatever you like not only from 4 kinds of curry sauce, 8 different portion sizes of rice, 12 spice levels, and 5 mildness levels but also over 40 kinds of toppings (CoCo Ichibanya 2019). Their curry sauces are Japanese type sauces that have developed uniquely in Japan, and you can eat a curry dish based on one of them and combined with various kinds of meat, vegetable, cheese, and even kimchi.

While such eclectic cuisine may seem to decompose and dissect cuisines of the world and combine their elements in an apparently disorderly manner, this is the distinctive feature of the Japanese cuisine.

How Japanese People Have Eaten in the Past and Eat at Present

Dining Table

In a traditional Japanese house there was neither a room dedicated for dining nor a permanent dining table. At meal times, small individual tables called *hakozen* or *meimeizen* were brought into a living room, which temporarily served as a dining room. Figure 4 is an illustration in a book published in 1833, during the late Edo period. You can see that each family member is using their own individual table (Hata 1833).

While people continued to have meals in such an individual meal table style, dining tables changed gradually from *hakozen* or *meimeizen* to *chabudai* with the advent of the twentieth century. *Chabudai* is "a small group dining table customarily placed on the *tatami* mat flooring of a Japanese-style room. It may be either circular or rectangular in shape. Normally it is outfitted with four short legs which can often be folded to facilitate storage" (Inohe 1993). Figure 5 shows a replication of a

Fig. 4 A dining scene in a merchant's home in the latter half of the Edo period (the mid-nineteenth century): Small tables called *hakozen* or *meimeizen* were used individually

Fig. 5 Replication of a dining table using a chabudai: by courtesy of the Museum of Ehime History and Culture

family's dining table using a *chabudai*. In the latter half of the twentieth century, the family shared meal table style of *chabudai* further shifted to the current dining table style of having meals seated in a chair at a dining table.

Ishige (2005) and his coworkers conducted a detailed interview survey of 284 women on meals at home from 1983 to 1984. Those subject to the survey were mainly women aged 70 or older at the time of the survey. That is, they were people who actually experienced meals in the individual-dining-table style using a *hakozen* or *meimeizen* and the shared-dining-table style using a *chabudai* and, later, a dining table. As a result, it was revealed that meal tables used by Japanese until the early twentieth century were mainly of the individual meal table style using *hakozen* or *meimeizen* and later transitioned to the *chabudai* style and that the dining table style became common in the latter half of the twentieth century (around 1970 and after).

While, ever since the dawn of history, Japanese have taken meals seated on the floor or *tatami* at an individual meal table, meal tables shifted from the individual style to the shared style and then transitioned to the current dining table style of having meals seated in a chair. It can be said that the meal table style of Japanese transitioned to a Western style after about 100 years from the civilization and enlightenment.

Even today, however, the style of meal taking is not uncommon whereby you are seated on the floor (*tatami*) to have a meal. Meals and banquets at a Japanese inn are in the *hakozen* or *meimeizen* style, and, even among ordinary households, there are many where members take a meal at *kotatsu*, a floor table equipped with a heater covered wholly with a blanket to contain heat, particularly in the winter period. Furthermore, many restaurants, particularly those serving Japanese cuisine, are equipped not only with chair seats but also a space where you can take off your shoes to be seated on the tatami to have a meal (called *koagari* or *zashiki*).

Personalization of Chopsticks and Eating Utensils

One thing that characterizes Japanese meals is the personalization of chopsticks and other eating utensils. While the origin of such personalization is unknown, it is considered to have a long history as we found a warning notice of "50 whips if you take this away without permission" on an individual eating bowl excavated from remains of the eighth century.

Even today, in many households, it is common for each family member to use their own chopsticks and eating utensils to have meals. Imada et al. (2012) conducted a survey of 467 mothers (age range: 25 to 44) raising young children (0–5 years old) on the dietary life in each family. The summary of responses to questions on the personalization of chopsticks and eating utensils included in the survey questionnaire is shown in Table 2. You can see that, as regards chopsticks and a rice bowl, more than 80% of the total respondents answered that each family member has their own chopsticks and a rice bowl and that, the lower the age group of respondents was, the lower the percentage of those answering "yes" was (89.4% vs. 76.3%). It can be said that, although the tradition of personalizing chopsticks and rice bowls has been passed on today, the trend is gradually weakening.

Table 2 Result of the survey on the personalization of chopsticks, rice bowls, Japanese teacups, and tumblers. Subjects were asked to answer binary choice (yes/no) questions, and the percentage (%) of respondents answering "yes" is shown

Age	Number	Each family member has their own chopsticks (*meimei-bashi*)	Each family member has their own rice bowls (*meimei-wan*)	Each family member has their own Japanese teacup (*yunomi*)	Each family member has their own tumbler
25–29	160	76.3	71.9	37.5	40.0
30–34	105	82.9	84.8	37.1	49.5
35–39	98	87.8	86.7	45.9	60.2
40–44	104	89.4	88.5	64.4	57.7
TOTAL	467	83.1	81.6	45.2	50.3

It is common to use disposable wooden chopsticks called *waribashi* when eating out. This is thought to reflect the tradition of personalizing chopsticks based on the premise that each pair of chopsticks should be used by a particular individual even at places where people eat out. Furthermore, there are many people who use chopsticks even with Western-style meals, and it is not uncommon for popular Western restaurants to provide *waribashi* along with knives, forks, and spoons.

This survey had separate questions for *yunomi-chawan* (Japanese teacups) and tumblers. This is because it is common to use a *yunomi-chawan* as a dedicated beverage container for *sencha*, a kind of green tea which Japanese drink in their daily life. When it comes to the personalization of *yunomi-chawan*, however, the percentage of respondents of a younger age group (25–34) answering "yes" was considerably lower (37.5% vs. 64.4%) than that of respondents of an older age group (40–44). This is considered to reflect not only the weakening tendency to personalize *yunomi-chawan* but also the fact that the younger the age group one belongs to, the less one tends to drink *sencha*.

Conversation Over the Dining Table

Ishige (2005), referred to above, also conducted a hearing survey on conversations during a meal for each type of meal table (*hakozen*/*meimeizen*, *chabudai*, or dining table) used. The summary of responses are shown in Fig. 6. 83.3% of 108 respondents answered that "conversation was strictly prohibited" during meals when *hakozen* or *meimeizen* were used. On the other hand, when it comes to meals using a dining table, 62.5% of 80 respondents answered, "it is allowed to converse (during a meal)."

With regard to postures during meals, more than 80% of respondents answered they "sat in *seiza* (or straight)" during meals in days when *hakozen* or *meimeizen* were used and when a *chabudai* was used (see Fig. 7).

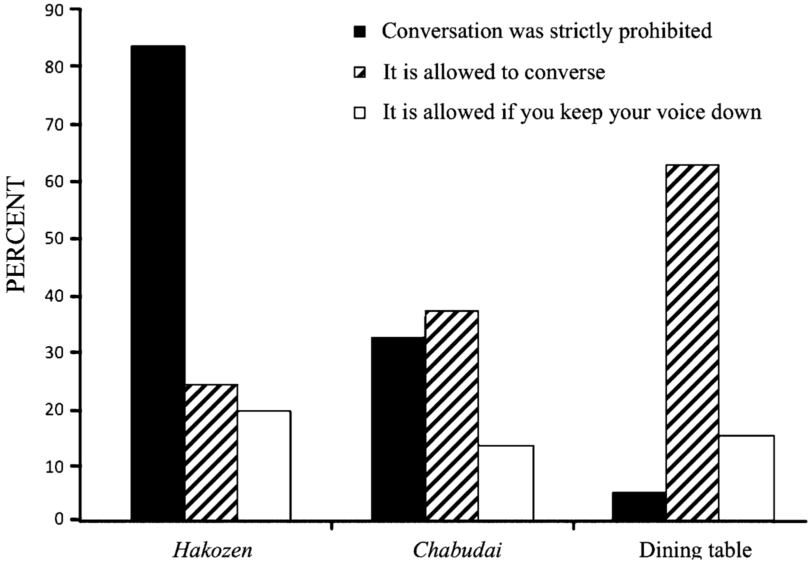

Fig. 6 Acceptability of conversation during meals by types of meal tables. Compiled by authors from Fig. 25 in Ishige (2005). Although the results of six question items are shown in the original figure, only the results of three typical items are shown here. As multiple answers were allowed, the total does not add up to 100%

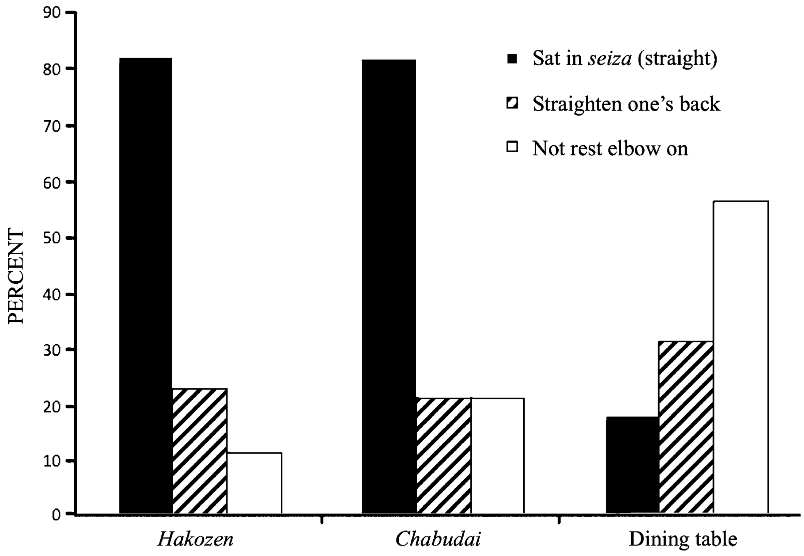

Fig. 7 Posture during meals by types of meal table. Compiled by authors from Fig. 23 in Ishige (2005). Although the results of eight question items are shown in the original figure, only the results of three typical items are shown here. As multiple answers were allowed, the total does not add up to 100%

In Japan today, there are many people who think that a meal where all family members are present is a place of communication where family members not merely enjoy a meal but also have an enjoyable conversation with each other. That is also what is taught in school education. In Japan, however, there is a tradition that regards meal taking as a solemn act, values various manners during a meal, and deprecates a lax way of eating. Such solemnness still partially remains today.

Ritualistic Behavior Before and After the Meal

Today, many Japanese say, "*Itadakimasu*" before a meal and "*Gochisosama*" when a meal ends. *Itadakimasu* means "I'll have this meal with gratitude," and, likewise, *Gochisosama* means "I finish this meal with gratitude."

Imada et al. (2012) asked mothers raising small children to rate the importance of each of multiple items given regarding "eating education" by a 4-point scale (1: important, 2: somewhat important, 3: not so important, 4: not important) and to indicate whether they practice those items. As a result, with regard to the importance of "saying '*Itadakimasu*' and '*Gochisosama*'" to children they are raising, 185 out of 427 respondents (43.3%) answered that they are "important," and 167 respondents (39.1%) answered they are "somewhat important." Furthermore, 400 respondents (93.6%) answered they "actually practice(d)" the item in question.

There are also many Japanese who make a *gassho* gesture (putting palms together upright) before saying "*Itadakimasu*" before a meal. According to a survey conducted by a private organization in 2015 of 1039 persons nationwide, 64.0% of respondents answered that they make a *gassho* gesture as they say "*Itadakimasu*" before a meal, and 28.8% of them answered that they say "*Itadakimasu*" without making a *gassho* gesture (J-Town Tokyo Prefecture 2015). Let us note that a *gassho* gesture is one whereby you put your hands together in front of your body, and, for ordinary Japanese, it is a special gesture that they perform on occasions such as praying at a Buddhist temple.

In contemporary Japan, the utterance of those routine words and the performance of a *gassho* gesture before and after a meal can be said to be extremely common behavior. It is not well known, however, since when such behavioral habits have spread. According to Kumakura (1991), in regard to meals in days when *meimeizen* were used, there were very numerous instances in which the utterance of such formulae and the performance of a *gassho* gesture were not reported. There are few examples reported in the survey of dietary habits in the early Showa period (1926–1989) by Seijo University Institute of Folklore Studies (1990). In other words, the utterance of the routine words and the performance of a *gassho* gesture before and after a meal are not necessarily traditional habits.

In Japan, the Basic Act on Dietary Education was enacted in 2005, and the Ministry of Education, Culture, Sports, Science and Technology (MEXT) asked educational institutions nationwide to promote dietary education in accordance with the law. The period of compulsory education in Japan is 9 years: 6 years of elementary school education and 3 years of junior high school education. School lunch is served at almost all public elementary and junior high schools. The MEXT asks schools to let students acquire “correct knowledge on eating and desirable dietary habits” through school lunch meals (MEXT 2019). There is no agreement, however, in views on what constitutes “correct knowledge” and what behavior constitutes “desirable dietary habits.” Judgments on relevant matters are often left to parties actually involved with school lunches, and, therefore, confusion has continued among them. For example, there are many schools which give instructions that prohibit students from not eating food they dislike, but there is no agreement in opinions as to whether it is a “desirable eating habit.”

What is accepted almost uniformly even under such a circumstance is the utterance of the said formulae (*itadakimasu* and *gochisosama*) and the performance of a *gassho* gesture before and after a meal. At school lunch time, students are instructed to eat the same menu served by themselves at the same, and it is customary for all students to say “*Itadakimasu*” simultaneously and perform a *gassho* gesture before eating. Such instructions for “desirable eating habits” at school lunch time is considered to have a great impact on the background for the wide acceptance of such eating habits by contemporary Japanese.

A *gassho* gesture is originally a religious gesture made in praying to a Buddha or Bodhisattva. In addition, a pious Buddhist chants a prayer to *Amida* Buddha before and after a meal to express gratitude to a wide range of objects. In Shintoism, which is a native religion of Japan, you are supposed to chant a Shinto prayer expressing gratitude to gods before and after a meal (instead of making a *gassho* gesture, you sit upright, bow once, and clap once). It can be said that the utterance of formulae (*itadakimasu* and *gochisosama*) and the performance of a *gassho* gesture before and after a meal, widely shared by contemporary Japanese, have such a religious root in both Buddhism and Shintoism.

Tradition and Modern Eating Conceived by Contemporary Japanese

It is not easy to describe the dietary tradition on the basis of historical facts. For the content of such description differs greatly by the age in which people subject to description lived, the area they lived, and the class they belonged to. Furthermore, the greatest problem is that there is little reliable historical material on what and how people ate, a matter related to their daily life. Sometimes, an “invention of the tradition” is made with a political intention, as was the case with *washoku* discussed in the introduction of this chapter.

How do Japanese lay persons perceive the “Japanese dietary tradition”? Sproesser et al. (2018) asked 340 Japanese (18–64 years old) to rate the degree of traditionality/modernness of 45 facets considered to reflect traditional and modern eating by 7-point scale. Table 3 lists facets rated as more traditional and facets rated more modern by what people have eaten and how they have eaten.

It can be said that contemporary Japanese regard eating grains, vegetables, and fruits grown in areas they live as traditional eating. Furthermore, it is found that they

Table 3 Characteristics of traditional and modem eating behavior. Facets rated to be "more traditional" or "more modern" are listed by what they have eaten (eat) and how they have eaten. (Source: Sproesser et al. 2018)

	What	How
Traditional	Eating food that has been eaten in this area for many years Eating grains Eating locally produced food Eating vegetables Eating vegetables and fruit of the season	Strictly complying to collective rules (e.g., of the family, community, society) Eating at home Eating breakfast, lunch, and dinner at predetermined times Having few food choices Eating with other people
Modern	Eating food that is industrially ultra-processed such as chips and ready-made meals Eating food that is only recently eaten Drinking soft drinks Eating food that has been imported from all over the world Eating food that has been mass-produced	Frequent use of mobile phone, internet, or reading a newspaper while eating Being able to buy food everywhere Eating while walking Eating out frequently Snacking frequently

conceive modern eating as eating foods mass-produced at food factories, many of which are imported and have recently come to be eaten.

If we take a look at how people eat, it is found that a traditional way of eating is perceived as eating at home at predetermined times in compliance with rules and customs of their family and local community, with little room of choice for what to eat and often with other people. In contrast, a modern way of eating is found to be perceived as being characterized by such a way of eating that you eat readily available foods frequently outside home and often perform eating and other actions (such as reading newspaper and/or watching TV) concurrently.

Food and Health: The Case of Okinawa

Japan is known as the advanced country with the least number of obese persons. According to OECD (2017), the obesity rate (BMI > =30.0) of Japanese is 3.7%, which is significantly below the average among all OECD countries at 19.5%. Japan is also known as one of countries where people live long lives. The Japanese life expectancy at birth is 84.2 years (81.1 years for males and 87.1 years for females), and the Japanese healthy life expectancy is 74.8 years (each according to 2016 statistics: WHO 2018). Traditional Japanese food is regarded as one of the elements that have led to such long lives and health (e.g., Yamori et al. 2001; Kurotani et al. 2016).

Westernized meals of recent years, namely, an excessive intake of calories and fat, however, have increasingly caused the excessive overweight and obesity of Japanese, which has been pointed out as one cause for an increase in the prevalence of lifestyle diseases (e.g., Kagawa 1978; Ministry of Health, Labour and Welfare:

MHLW 2019). What follows will focus on Okinawa, where the relation between the westernization of diet and health is most significantly observed to investigate the relation between them.

Okinawa Honto or Okinawa Main Island is an island with the fifth largest area in Japan and is located geographically remotely from the four main islands of Japan. The direct distance from Naha, the prefectural capital of Okinawa, to Tokyo is 1,554 km and that from Naha to Taipei is 630 km. Okinawa is located closer to Taiwan than to Mainland Japan (Hondo). As one can imagine from such geographical relations, Okinawa has been greatly influenced not only by Mainland Japan but also by surrounding areas including the minor islands of the South Pacific (primarily Micronesia), Southeast Asia, Mainland China, and the Korean Peninsula. Consequently, not only Okinawa's history but also its traditional diet differs greatly from those of Mainland Japan.

Okinawa was annexed by Japan during the early years of the Meiji period (1872), placed under US rule for 27 years after the Pacific War (1945–1972), and reverted to Japan in 1972, since which time it has remained a part of Japan. Active trade with Japan and China began during the Ryukyu Dynasty period and the distinctive culture of Okinawa was formed under their influence.

Okinawa has been known as a prefecture which has many people living long lives, people aged 100 or older, and people with a low risk of age-related diseases. The average life expectancy at birth of women in Okinawa prefecture ranked first among 47 prefectures in Japan, at 83.7 years (1985), 85.08 years (1995), and 86.88 years (2005). Many studies suggest that such high life expectancies are related to the traditional diet of Okinawa: namely, traditional diet whereby you eat a plenty of vegetables and fruits and do not take in much meat, refined grains, saturated fats, sugar, salt, and dairy products (Sho 2001; Willcox et al. 2007, 2009).

That has not been the case with Okinawa in recent years, however, a trend which is particularly prominent among men. The average life expectancy at birth of men in Okinawa prefecture was 77.22 years in 1995 (the national average: 76.70 years), ranking fourth among the 47 prefectures. Its rank fell to 26th in 2000, however (at 77.64 years, with the national average being 77.71 years). This extreme fall in rank drew a lot of attention from many people and was known as "26 shock!." The rank in the life expectancy of men in Okinawa prefecture subsequently continued to fall, ranked 30th in 2010 and 36th in 2015 (Ministry of Health, Labour and Welfare: MHLW 2017).

Why has the rank of the life expectancy of men in Okinawa being fallen? The most convincing argument about its causes cites drastic changes in the dietary environment after the war, namely the westernization of diet.

Meats, processed meats (ham, bacon, luncheon meat, etc.), butter, beer, etc. were imported duty free or at a low tariff rate to Okinawa under US rule. A low tariff rate was applied after it was returned to Japan in 1972 as a special measure following the reversion. In other words, high-fat and high-calorie foodstuffs came to be supplied at low cost after the war, and the dietary life of people in Okinawa prefecture drastically changed from a traditional diet mainly composed of miscellaneous grains and vegetables to a contemporary diet or high-fat and high-calorie diet.

Figure 8 compares percentages of fat energy in the total energy intake nationwide and in Okinawa. The Ministry of Health, Labour and Welfare notes that the percentage of fat energy in the total energy intake desirable for health is 20–25% for men and women over 30 years old. Assuming that 25% is the upper limit, the percentage of fat energy in the total energy intake gradually crossed the 25% line from the 1980s to the 1990s as a national average, as the figure shows. On the other hand, in Okinawa, it suddenly crossed the 25% line around 1970 and stayed at high values (around 30%) thereafter. According to a recent survey, two out of three adults in Okinawa prefecture take an excessive amount of fat (25% or greater). The diet of Okinawa people was rapidly "westernized" after the war.

With the progress of such westernization of diet, the degree of obesity of people (particularly men) in Okinawa increased and the prevalence of lifestyle diseases also rose. Figure 9 compares the percentages of obese persons (BMI > =25.0: the obesity criterion) by age in 2005 in Okinawa and national averages. It is found that the obesity rate is above the national average in almost all age groups of male and female adults in Okinawa. Figure 10 shows the transition of the mortality rate from diabetes nationwide and in Okinawa. It is found that the number of deaths from diabetes has been increasing since the latter half of the 1990s. According to Kuwae et al. (2006), the mortality rate of the male population of Okinawa (15–49) due to accidents and suicides, acute myocardial infarction, cerebral hemorrhage, diabetes, hepatopathy, etc. ranked within the worst five prefectures among the 47 prefectures of Japan in 2000 for each cause of death. Likewise with the female population of Okinawa

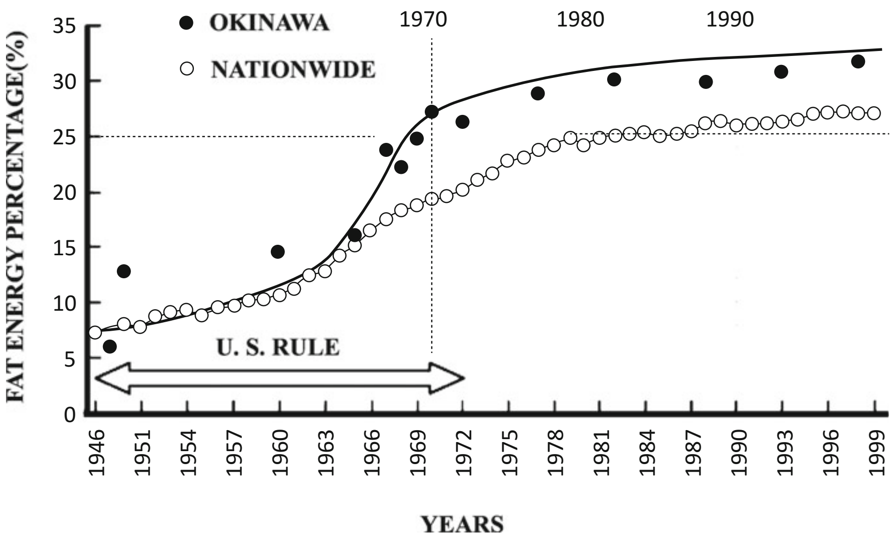

Fig. 8 Annual Changes in Average Fat Energy Percentage Nationwide and in Okinawa (newly created based on Fig. 1 in Todoroki 2008)

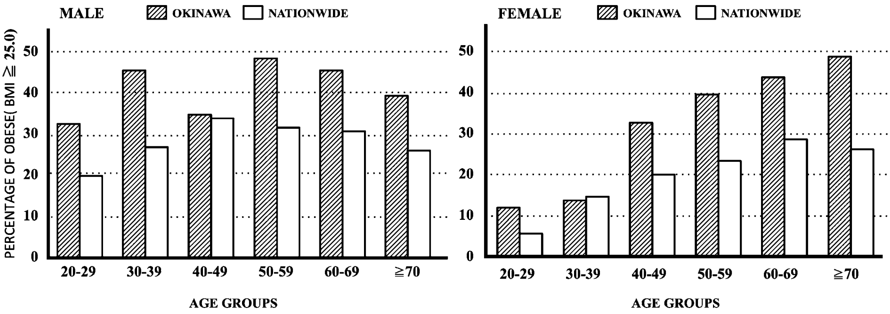

Fig. 9 Percentage of obese male (left) and female (right) in Okinawa, in comparison with the nationwide percentage of obese male and female in 2005. Source: Interim Evaluation Report of the "Kenko Okinawa 2010" Project. (Okinawa prefecture 2006)

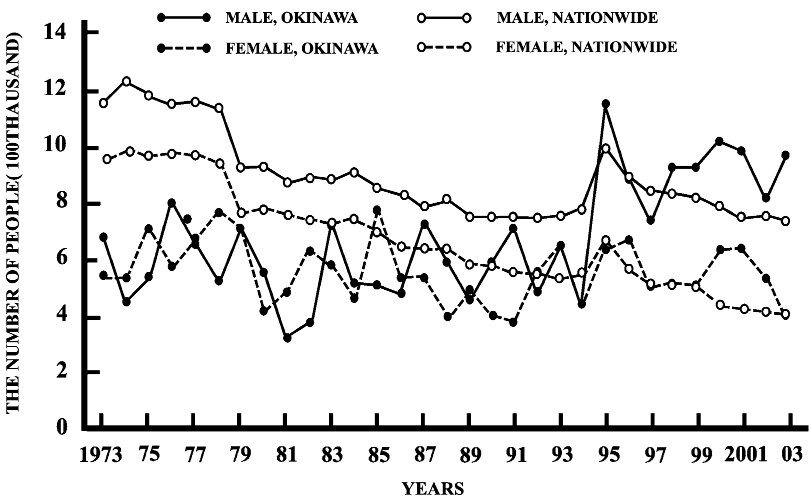

Fig. 10 Age-adjusted mortality rate from diabetes in Okinawa (comparison of the rate in Okinawa and nationwide, 1973–2003). In Okinawa, the male mortality rate from diabetes has approximately doubled since 1993. Source: Interim Evaluation Report of the "Kenko Okinawa 2010" Project. (Okinawa prefecture 2006)

(40–49), their mortality rate from cancer, liver failure, diabetes, etc. ranked within the worst five prefectures in 2000 for each cause of death.

Such a contrast in the relationship between health and diet as observed in Okinawa's diet may be said to be a scaled-down picture of Japan as a whole. Okinawa appears to be an area in Japan that provides us with various clues as to the relations between diet and health.

Conclusion

Words Americans associate with the term “Japanese food” are said to be such words as healthy, light, raw, simple, clean, and beautiful as well as names of dishes such as *tempura*, *sushi*, *teriyaki*, and *sashimi* (Ishige et al. 1985). As Japan came to be known as one of the countries with the longest life expectancy and a country with an extremely low percentage of obese persons, the perception is further spreading that the traditional Japanese diet provides healthy meals. “WASHOKU; Traditional Dietary Cultures of the Japanese,” publicized by the Japanese government, however, is a “tradition” that reflects the content of meals of some parts of the past ruling class and cannot be said to reflect the dietary tradition of the Japanese as a whole. It is, so to speak, an idealized Japanese diet and an invented tradition (cf., Hobsbawm and Ranger 1983).

What and how people eat play the role of enhancing their sense of belonging to a group they belong to (ethnic group, nation, group using the same language, namely, inner group) and facilitating their identification with that group (Onuki-Tierney 1993). The denationalization of eating in contemporary Japan, however, goes against such a role of eating. It is becoming difficult for contemporary Japanese to identify themselves as Japanese by way of eating. A “dietary tradition” is probably one of things that enable Japanese to enhance their sense of belonging to Japan and identify themselves in a more stable way. By following eating habits that are said to be traditional, aren’t Japanese trying to alleviate their identity anxiety as Japanese, aren’t they?

Currently, food globalization and denationalization are in progress not only in Japan but also in other countries. It is not easy to know what the true tradition is, but it is important to distinguish between the true tradition and the idealized and/or invented tradition.

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Cross-Cultural Testing of Dietary Restraint 64

Adrian Meule

Contents

Abstract

Restrained eating refers to the intention to restrict food intake deliberately in order to prevent weight gain or to promote weight loss. Research on restrained eating started in the 1970s and, thus, it now encompasses more than 40 years of investigation. This chapter provides a brief overview of the historical development of the concept, describes the most commonly used measures for the assessment of restrained eating, and reviews cross-cultural differences in dietary restraint.

Keywords

Restrained eating · Dietary restraint · Dieting · Weight concern · Cross-cultural

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> The hypothesis that differences in the pattern of eating behavior correspond to two theoretically distinct classes of individuals, obese and normal (as measured by degree of overweight), no longer seems tenable, at least in its most elementary form. Within the population of normal weight individuals, fairly sizable differences exist with respect to concern with weight and eating behavior—in our terminology, restraint [. . .]. Herman and Mack (1975, p. 657)

Introduction

In environments in which highly caloric and palatable food is cheap, constantly available, and easily accessible, eating more calories than the body can expend is easy. Thus, it seems that most people (except maybe endurance athletes) need to be conscious about their food decisions and the amount they eat instead of mindlessly indulging in eating. Yet, while it seems necessary to regulate one's eating to prevent becoming overweight, such intentional restriction is also notorious for causing further weight gain or increasing the risk for eating disorders (Schaumberg et al. 2016).

Research on this topic was heavily influenced — or in fact started off — by the works of C. Peter Herman and Janet Polivy (1975, 1983; Herman et al. 1978). In a seminal study (Herman and Mack 1975), participants were instructed to drink either none, one, or two milkshakes followed by a bogus ice cream taste test. It was found that participants scoring low on a measure of dietary restraint ate less ice cream when they before had to drink the milkshakes than in the no milkshake condition. Strikingly, participants scoring high on a measure of dietary restraint — so-called restrained eaters — showed the opposite pattern: they even ate more ice cream in the milkshake conditions than in the no milkshake condition (in which they actually ate less than the unrestrained eaters). Thus, this study indicated that when people restrain their eating behavior, this restriction can easily be disinhibited under certain circumstances (e.g., by consumption of a high-calorie preload).

In the decades that followed, several other manipulations were identified that similarly induce disinhibited eating in restrained eaters, for example, negative mood inductions (Evers et al. 2018). Yet, several limitations of the original conception of restrained eating have been noted in the past decades as well. For example, the Restraint Scale as employed by Herman and Polivy includes questions on weight fluctuations. While it was noted that participants (particularly unrestrained eaters) find these questions hard to answer (Wardle 1986), the items also confound a higher body weight as well as past dieting failures and restraint. As a consequence, Stunkard and Messick (1985) and van Strien et al. (1986) developed alternative measures in order to capture more "pure" cognitive control of eating behavior.

Regardless of which questionnaire is used, however, it seems that scores of dietary restraint scales do not relate to actual reduced food consumption (Stice et al. 2004, 2007, 2010). Thus, restrained eating cannot be equated with dieting, that is, actual caloric restriction. As most restrained eaters are not currently on a diet but are concerned about their weight and try to limit their food intake, restrained eating can rather be defined as the *intention* to restrict food intake deliberately in order to prevent weight gain or to promote weight loss.

Dietary restraint has been implicated as a risk factor for the development of eating disorders. Furthermore, because of the finding that restrained eating behavior can easily be disinhibited under certain circumstances and because higher restraint scores typically relate to higher body mass index, dietary restraint has a bad reputation for being a rather dysfunctional, unsuccessful strategy to control food intake. Yet, it seems that this deserves a more nuanced view as dietary restraint has also been linked to positive outcomes, particularly in conjunction with weight management programs (Schaumberg et al. 2016).

Measures of Restrained Eating

Several questionnaires have been developed for the assessment of restrained eating. In the following, the four most commonly used scales will be briefly described, each of which has been translated into at least 10 other languages (Table 1).

Restraint Scale

In the early studies by Herman and Polivy, different versions of the Restraint Scale were used (Herman and Mack 1975; Herman and Polivy 1975). The final version of the Revised Restraint Scale has 10 items (Herman et al. 1978; Polivy et al. 1978). The scale includes different response options. For example, some items are scored from 0 = *never* to 3 = *always* but other response categories include different ranges of pounds (e.g., for the question "What is the maximum amount of weight you have ever lost within 1 month?"). The scale can be further separated into two subscales: concern for dieting and weight fluctuations (Blanchard and Frost 1983).

Three-Factor Eating Questionnaire (TFEQ)

The TFEQ (sometimes also referred to as Eating Inventory) was developed by Stunkard and Messick (1985). It has 51 items with different response formats. The scale can be separated into three subscales: cognitive restraint of eating, disinhibition, and hunger. The restraint subscale consists of 21 items. Yet, it has been suggested that the restraint subscale is also not uniform but can be further divided with some items assessing a more rigid control of eating and some items assessing a more flexible control of eating (Westenhoefer 1991). A short version of the TFEQ with 18 items has also been developed (Karlsson et al. 2000). Yet, the three-factor structures of both the original and the short version have received mixed support in subsequent studies (Cappelleri et al. 2009; Mazzeo et al. 2003).

Table 1 Psychometric instruments for the assessment of restrained eating

Measure	Translations
Restraint Scale (Herman et al. 1978; Polivy et al. 1978)	Arabic (Madanat et al. 2007) Chinese (Kong et al. 2013; Mak and Lai 2012) Czech (Bernatova and Svetlak 2017) Dutch (Jansen et al. 1988) Estonian (Tiggemann and Rüütel 2001) French (Mobbs et al. 2008) German (Dinkel et al. 2005) Greek (Kkeli et al. 2018) Japanese (Madanat et al. 2011) Portuguese (Carvalho et al. 2016; Scagliusi et al. 2005) Spanish (Silva and Urzúa-Morales 2010)
Three-Factor Eating Questionnaire (Stunkard and Messick 1985)	Chinese (Chong et al. 2016) Dutch (Ouwens et al. 2003) Finnish (Anglé et al. 2009) French (Lesdéma et al. 2012) German (Pudel and Westenhöfer 1989) Greek (Kavazidou et al. 2012) Italian (Boschi et al. 2001) Japanese (Adachi et al. 1992) Malay (Ismail et al. 2015) Persian (Mostafavi et al. 2017) Portuguese (Moreira et al. 1998) Spanish (Jáuregui-Lobera et al. 2014) Swedish (Karlsson et al. 2000) Thai (Chearskul et al. 2010) Turkish (Bas et al. 2008)
Dutch Eating Behavior Questionnaire (van Strien et al. 1986)	Chinese (Wang et al. 2018; Wu et al. 2017) [a]Dutch (van Strien et al. 1986) French (Lluch et al. 1996) German (Grunert 1989) Greek (Zeeni et al. 2013) Italian (Dakanalis et al. 2013) Korean (Kim et al. 1996) Malay (Subramaniam et al. 2017) Maltese (Dutton and Dovey 2016) Persian (Nejati et al. 2018) Portuguese (Viana and Lourenço 2003) Spanish (Cebolla et al. 2014) Turkish (Bozan et al. 2011)
Eating Disorder Examination—Questionnaire (Fairburn and Beglin 1994)	Chinese (Leung et al. 2009) Dutch (Aardoom et al. 2012) Fijian (Becker et al. 2010) French (Carrard et al. 2015) German (Hilbert and Tuschen-Caffier 2016) Greek (Giovazolias et al. 2013) Italian (Calugi et al. 2017) Japanese (Nakai et al. 2014) Norwegian (Rø et al. 2010) Persian (Mahmoodi et al. 2016)

(continued)

Table 1 (continued)

Measure	Translations
	Portuguese (Machado et al. 2014) Spanish (Elder and Grilo 2007) Swedish (Welch et al. 2011) Turkish (Yucel et al. 2011)

[a]Note that the Dutch Eating Behavior Questionnaire — as it names says — was first conceived in Dutch, of course. However, as the English version (items of which are displayed in the original article by van Strien and colleagues) is usually used as the basis for translation in other languages; the list of translations is displayed like this here to be consistent across the different instruments

Dutch Eating Behavior Questionnaire (DEBQ)

The DEBQ was developed by van Strien et al. (1986). It has 33 items that are scored from 1 = *never* to 5 = *very often*. The scale can be separated into three subscales: restrained eating, emotional eating, and external eating. The restraint subscale consists of 10 items. The three-factor structure has generally received good support in other studies (Barrada et al. 2016).

Eating Disorder Examination—Questionnaire (EDE—Q)

The EDE–Q was developed by Fairburn and Beglin (1994). It has 28 items of which 6 items assess the frequency of key behaviors such as binge eating and self-induced vomiting in the past 28 days. The remaining 22 items have different response options (e.g., 0 = *no days* to 6 = *every day*) and can be separated into four subscales: restraint, eating concern, weight concern, and shape concern. Yet, this four-factor structure has received limited support in the literature (Rand-Giovannetti et al. in press).

Cross-Cultural Differences in Restrained Eating

Several studies have examined whether participants in different countries differ in their scores on restrained eating questionnaires. It has generally been observed that participants in Europe (e.g., in Germany, the UK, and the Netherlands) have lower scores on the Restraint Scale than participants in North America (Dinkel et al. 2005; Jansen et al. 1998; Wardle 1986; Fig. 1). Other studies (using either the Restraint Scale or the restraint subscale of the TFEQ, DEBQ, or EDE–Q) point towards lower restraint scores in African, Arabian, and Asian countries than in North American and European countries. For example, lower restraint scores have been found in Ghana versus USA students (Cogan et al. 1996; Fig. 1), Egypt versus UK women (Dolan and Ford 1991; Fig. 1), Iran versus UK/Greece students (Tapper et al. 2008), and China versus USA female students (Madanat et al. 2011). In Australia, lower

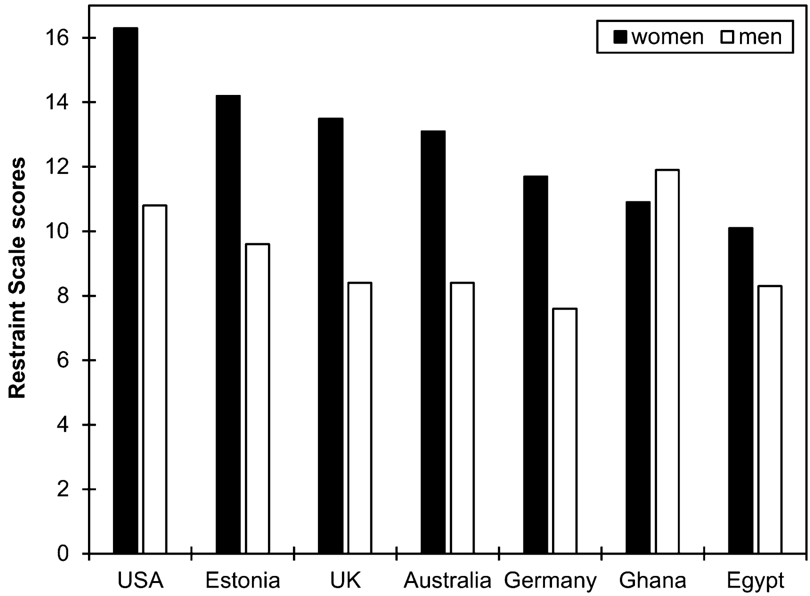

Fig. 1 Mean scores on the Restraint Scale in different countries as a function of sex. The data are taken from Cogan et al. (1996), Dinkel et al. (2005), Dolan and Ford (1991), Tiggemann and Rüütel (2001), and Wardle (1986)

restraint scores have been reported as compared to students in Estonia (Tiggemann and Rüütel 2001; Fig. 1) and Singapore Chinese women (Soh et al. 2007).

Although some of these studies only investigated women, studies that included participants of both sexes suggest that differences in restrained eating between countries seem to be primarily driven by restraint scores of women. Specifically, women usually display higher restrained eating than men do in North American, Australian, and European samples. This sex difference resonates with a large body of research showing than women are more concerned about their weight and shape and have a higher prevalence of disordered eating behaviors than men have. In countries with lower restrained eating scores, however, there seems to be no such difference between sexes (Cogan et al. 1996; Dolan and Ford 1991; Fig. 1).

Besides these cross-cultural differences, however, several studies found similar levels of restrained eating between different countries. For example, no differences in dietary restraint were found between UK versus Israel women during or after pregnancy (Shloim et al. 2015, in press), Lebanon versus Cyprus female students (Zeeni et al. 2013), Japan versus Jordan versus USA female students (Madanat et al. 2011), and Greece versus UK students (Tapper et al. 2008).

Thus, it seems that no broad conclusions regarding different world regions can be drawn as differences in restrained eating can be observed within the same continent (e.g., China vs. Japan; Madanat et al. 2011) or scores are sometimes similar across countries in different continents (e.g., Jordan vs. USA; Madanat et al. 2011). Furthermore, differences in dietary restraint can also be observed between different ethnic groups within one country. For example, lower restrained eating has been reported in Afro-American versus Caucasian female students in the USA (Abrams et al. 1993; Rucker III and Cash 1992). Thus, it seems necessary for future research to not only compare scores of participants in different countries but also to consider other factors (e.g., ethnicity, migration background) within each country.

Given these cross-cultural differences — although inconsistent — an interesting line of research pertains to the question of acculturation. Does moving to another country lead to increases or decreases in restraint scores because the new environment changes one's attitudes towards eating and body weight? Although there are not many studies on this, is seems that levels of restrained eating can be quite stable. For example, Abdollahi and Mann (2001) tested Iranian women living in Iran and Iranian women living in the USA and found no differences in restrained eating between groups. Furthermore, a recent study by Westenhoefer et al. (2018) found that seafarers from Kiribati had higher TFEQ disinhibition scores (and these were more strongly related to body mass index) than seafarers from Europe. Although disinhibited eating is not equivalent to (but is positively correlated with) restrained eating, this study suggests that cultural background can still account for differences in eating behavior in the same food environment.

Even if two cultures exhibit similar levels of restrained eating, its predictors and consequences might still be culture-specific. In a recent study by Shagar et al. (2019), for example, body dissatisfaction was linked to restrained eating only in Australian but not in Malaysian women. Furthermore, family influence related to internalization of the thin ideal only in Malaysian but not in Australian women. Although these differences were found, however, the authors also highlighted that overall there were more similarities than differences across cultures. For example, higher internalization of the thin ideal was linked to higher restrained eating in both Australian and Malaysian women.

In conclusion, studies that examined cross-cultural differences in restrained eating tend to show highest levels of dietary restraint in the USA, followed by European countries and Australia, and lowest levels in African and Asian countries such as Ghana, Egypt, Iran, and China. However, this conclusion is based only on a handful of studies and, therefore, findings need to be interpreted cautiously. Interestingly, it seems that studies that reported similar levels of restrained eating across different countries are more recent while research that reported differences between certain countries includes studies from the 1980s and 1990s. Thus, it might be speculated that there is an overall trend towards an alignment of restraint scores across countries, which may be due to changes in diet (e.g., Westernization of traditional Eastern diets) and other factors (e.g., media exposure, thin ideal internalization).

Challenges in Cross-Cultural Testing of Dietary Restraint

It is usually assumed that differences in restrained eating between countries or ethnic groups are due to cultural differences such as eating traditions, social interactions, or media exposure. However, there are also methodological and anthropometrical issues that need to be considered. For example — as discussed below — higher restrained eating scores can result from having a higher body weight. Thus, it may be that cross-cultural differences in restraint may be partially attributable to general differences in mean body mass index between countries. That is, higher restraint scores in a country may simply be the result of people being heavier there instead of reflecting dietary restriction. This may be particularly relevant for the Restraint Scale as answers to the weight fluctuations questions are highly correlated with body mass index.

Furthermore, the response categories of the weight fluctuations questions may not be equally applicable to all ethnic groups because of different body build. Asian populations, for example, have lower body mass index and different associations between body mass index and body fat than non-Asian populations (WHO Expert Consultation 2004). For instance, some Asian groups have higher percent body fat at a low body mass index than Caucasians due to differences in trunk-to-leg length and slenderness (Deurenberg et al. 2002).

Such differences in body build and body composition may also influence the relationship between body mass index and restrained eating. Specifically, higher restrained eating — particularly when assessed with the Restraint Scale — is usually positively correlated with body mass index. That is, most restrained eaters have a higher body weight than unrestrained eaters. This relationship is likely bidirectional: restrained eating may predict weight gain (van Strien et al. 2014), but having a high body weight may also lead to higher restraint scores as the desire for losing weight (and, thus, the intention to restrict food intake) increases with increasing body weight (Snoek et al. 2008). Surprisingly, however, restrained eating scores were unrelated to body mass index in some studies from China, even when participants were explicitly classified as successful and unsuccessful restrained eaters (Meule 2016).

Finally, it may be that differences in nutrition can account for differences in the relationship between body weight and restrained eating. For example, the traditional Chinese diet is healthier (i.e., less energy dense) than the typical North American diet (Lv and Cason 2004). Thus, it might be that rather unsuccessful restrained eaters living in countries with a healthier diet may still have a healthier weight than those living in countries with an unhealthier diet because — although they might consider themselves unsuccessful — they still do not consume large amounts of calories. Yet, as typical diets in many countries are more and more “Westernized,” it may be that this will also lead to a decrease of cross-cultural differences in the relationship between body weight and restrained eating.

Conclusion

Restrained eating or dietary restraint refers to cognitive effort exerted by an individual to eat less than they would like. Higher restrained eating scores have been related to instances of disinhibited eating and higher body weight. However, as

Schaumberg et al. (2016) have noted, “dietary restraint cannot be categorized as entirely healthy or unhealthy, but rather could be health promoting or detrimental depending on the circumstances under which it is employed” (p. 96). Although some studies point towards highest levels of restrained eating in North America followed by European countries and Australia and then African, Arabic, and Asian regions, the extant literature on cross-cultural differences in dietary restraint does not provide a consistent overall picture. This may be partially due to methodological and anthropometric issues that need to be considered in cross-cultural testing of dietary restraint.

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Attitudes to Food in Italy: Evidence from the Italian Taste Project

65

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Contents

Abstract

Several factors are involved in determining food preference and diet quality. The Italian taste project aimed at exploring the associations among variables belonging to different domains presumed to be important in determining food preference and intake. The present chapter focuses on "Food Behavior and Attitudes" domain and reports results from a sample of 2249 respondents, representative of the Italian adult population. Attitudes towards food were investigated using the Health and Taste Attitude Scale (HTAS) and the Food-Related Lifestyle (FRL) questionnaire. Differences across country regions (North, Center, and South) and influences of gender and age on food attitudes were investigated. General health interest did not change across the Italian regions, while interest for light food was higher while interest for natural products and taste-related dimensions were lower in Southern than Central and Northern regions. Women were more interested than

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men in general health aspects, natural products, and taste-related aspects. General interest for health and for natural products regularly increased with age, while the importance of taste-related dimensions tended to decrease. Results from FRL indicated a general higher attention paid to food selection and preparation by Southern and Northern than by Central regions. All the FRL subscale scores were higher in females than in males except for convenience, higher in males than females. Younger subjects paid less attention to product information and were more interested in price but spent more time cooking and were more interest in novelty. These sociodemographic and attitudinal variables significantly influenced preference for and intake of healthy and traditional food, taking vegetables and spicy foods as representative categories.

Keywords

Preference · Health and Taste Attitude Scales · Food Related Lifestyle Questionnaire · Age · Gender · Region · Vegetable · Spicy foods

Introduction

Food preference and intake depend on the interplay of several factors (sociodemographics, cultural aspects, attitudes, psychological traits, and taste responsiveness) that shape diet quality, energy intake, and susceptibility to food-related behavior diseases. To address the research field, a multidisciplinary perspective and the collection of data from subject representative of the population of interest are needed (Köster 2003, 2009). The Italian Taste project is a large-scale multidimensional and multidisciplinary study (more than 3000 respondents in 3 years) aimed at exploring the associations among a variety of measures – biological, genetic, physiological, psychological, personality-related, and sociocultural – describing the dimensions of food liking, preference, behavior and choice, and their relevance in determining individual differences within a given food culture framework.

The present chapter focuses on the “Food Behavior and Attitudes” domain and reports results from a sample of 2249 respondents (first 2 years of the study), representative of the Italian adult population. Attitudes towards food were investigated using the Health and Taste Attitude Scale (HTAS) and the Food-Related Lifestyle (FRL) questionnaire. Differences across country regions (North, Center and South) and influences of gender and age on food attitudes were investigated. These sociodemographic and attitudinal variables significantly influenced preference for and intake of healthy and traditional food, with vegetables and spicy foods taken as representative categories.

The Italian Taste project was launched by the Italian Sensory Science Society in 2015 and lasted 3 years (Monteleone et al. 2017). It involved on a voluntary base 19 research units of public and private organizations spread across the country: more than 3000 Italian adult subjects took part in the study. The main target of the project was to contribute to the uncovering of associations among variables along multiple dimensions that are presumed to be important in determining individual differences in food preference and choice. To explore the associations among the several determinants of food choices and preferences, four main domains were considered and, for each, several variables were measured (Fig. 1).

"Food Behavior and Attitudes" domain is considered in the present chapter since factors that guide food selection can be explored trough the examination of food attitudes. Attitudes defined as an "evaluation (favourable or unfavourable) of performing a behaviour" (Ajzen 1991) may vary depending on age, gender, and socioeconomic conditions and can influence and, to some extent, predict dietary behavior (Hearty et al. 2007). The relation between food attitudes and food-related behavior can be explained considering the informational bases of food attitudes (defined as the type of information that contribute to food like or dislike) and several evidences indicate that identification of factors important for a specific food attitude represent an effective strategy to design interventions aimed at improving food-related behaviors (Aikman et al. 2006).

Questionnaires were presented to collect information on the role of health and taste motives (Health and Taste Attitude Scale -HTAS; Roininen et al. 1999) and of the overall importance given to food in daily life (Food-Related Lifestyle – FRL; Grunert et al. 1993) in determining food choice and consumption. The questionnaires were translated into Italian by two different bilingual Italian native-speakers and then back translated into the source language. Back translations were reviewed by a bilingual expert in semantics and adjustments were made when necessary to select the most appropriate translation (see Monteleone et al. 2017 for detailed procedure). Responses were collected on familiarity with (five-point familiarity scale; Tuorila et al. 2001) and liking for (nine-point category scale; Peryam and Pilgrim 1957) almost 200 food items belonging to seven categories (Fruit and Vegetables; Cereal-based foods; Dairy; Fish, Meat, and Eggs; Beverages; Spices

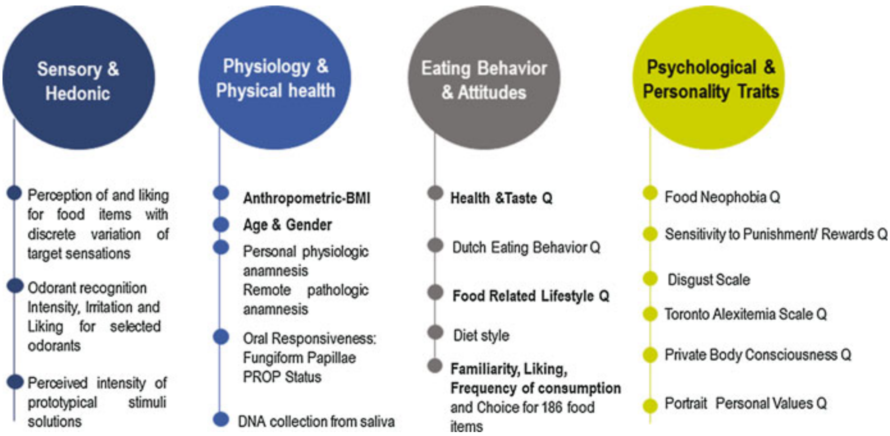

Fig. 1 Domains and relevant variables considered in Italian Taste project data collection. In bold data set considered in the chapter

and Seasonings; and Sweets and Desserts) representative of the daily Italian diet. The frequency of consumption of targeted food and beverages (alcohol, spicy food, coffee with/wo sugar), representative for consumption patterns affected by specific factors such as gender and cultural aspect was collected.

The chapter describes the differences across the country and the influences of demographic variables (gender and age) on food attitudes. The effects of these variables on preference for and intake of healthy and traditional food were explored taking vegetables and spicy foods as representative categories.

Participants

The sample of the data collected in the first 2 years of the project consisted of 2449 adult respondents (aged from 18 to 60 years). Sociodemographic characteristics of the total sample, grouped by region (North, Central, and South with Islands), gender, and age are described in Tables 1 and 2. Each region included a large city with one million inhabitants or more (Milan in the North, Rome in the Center, and Naples in the South), cities with more than three hundred thousand inhabitants (North: Turin; Center: Bologna and Florence; South: Catania), cities with more than one hundred thousand inhabitants (North: Trento, Udine; Center: Prato and Reggio Emilia; South: Sassari), and small cities with around fifty thousand inhabitants (North: Mantova, Bra-Cuneo; Center: Macerata; South: Potenza). Rural areas with small towns were not covered by the study due to their distance from the research units participating in the project. Females represented 58.4% of the sample on a national basis; this proportion was slightly higher than that reported for the adult Italian population (49.98%, http://demo.istat.it/pop2018). The distribution of males and females did not differ across regions (chi-square test, $p = 0.285$). Population was reasonably balanced for age class: 38.38% of participants have an age ranging from 18 to 30 years (age class 1, C1), 28.22% from 31 to 45 years (age class 2, C2), and 33.40 from 46 to 60 years (age class 3, C3). The distribution of age classes slightly differed across regions (chi-square test, $p = 0.007$); the proportion of C2 (31–45 year old) was higher in the Southern and lower in the Central populations. Age class distribution did not differ by gender (chi-square test, $p = 0.516$).

Almost all participants have at least the upper secondary education qualification: 47.22% have secondary school level and 43.04% have university or higher educational level, while only 7.77% have lower middle school level. The educational level of the considered population is higher than those reported at national level (60% of Italian citizens have upper secondary education qualification or higher, ISTAT 2018) and this could be related to the recruitment modality that in the youngest age class mainly reached university students. “Employee” was the most represented employment condition (43.94%) followed by “student” who represent 31.2% of participants on national base. Employees and students were the most representative employment conditions also considering subgroups by region, age, and gender with the relative percentage close to those observed at national level. The remaining 25% of the population spreads among the other six employment conditions. The distribution of

Table 1 Demographics and anthropometrics of participants, in the total population, by Italian regions and by sex

		Total		North		Central		South and Islands		Females		Males	
		n	%	*n*	%	*n*	%	*N*	%	*n*	%	*n*	%
n		2449	#	978	39.93	806	32.91	665	27.15	1430	58.39	1019	41.61
Female		1430	58.39	553	56.54	485	60.17	392	58.95	#	#	#	#
Age	C1 18–30	940	38.38	375	38.34	325	40.32	240	36.09	536	37.48	404	39.65
	C2 31–45	691	28.22	267	27.30	201	24.94	223	33.53	413	28.88	278	27.28
	C3 46–60	818	33.40	336	34.36	280	34.74	202	30.38	481	33.64	337	33.07
Educational level	Lower-middle school	190	7.77	57	5.83	70	8.70	63	9.49	104	7.28	86	8.46
	High school	1155	47.22	508	52	346	42.98	301	45.33	648	45.35	507	49.85
	University or higher	1101	43.04	412	42.17	391	48.32	300	45.18	677	47.38	424	41.69
Employment	Farmer	30	1.23	18	1.85	9	1.12	3	0.45	12	0.84	18	1.77
	Housekeeper	123	5.04	15	1.54	35	4.86	69	10.39	123	8.63	0	0
	Dealer/Artisan	53	3.81	43	4.41	29	3.61	21	3.16	44	3.09	49	4.82
	Unemployed	128	5.24	29	2.97	37	4.61	62	9.34	70	4.91	58	5.71
	Employee	1073	43.94	477	48.92	352	43.84	244	36.75	613	42.99	460	45.28
	Self-employed	181	7.41	68	6.97	70	8.72	43	6.48	33	6.17	93	9.15
	Retired	52	2.13	23	2.36	24	2.99	5	0.75	26	1.82	26	2.56
	Student	762	31.20	302	30.97	243	30.26	217	32.68	450	31.56	312	30.71
Family unit members	$n = 1$	268	10.96	140	14.33	35	10.56	43	6.49	155	10.85	113	11.09
	$n = 2$	413	16.89	189	19.34	153	19.00	71	10.71	244	17.09	169	16.62
	$n = 3$	581	23.76	243	24.87	183	22.73	155	23.38	345	24.16	236	23.21
	$n = 4$	843	34.48	303	24.01	263	33.16	273	41.18	486	34.03	357	35.10
	$n \geq 5$	340	13.91	102	10.44	117	14.53	121	18.25	198	13.87	142	13.96
Children (<16 years old)	$n = 0$	1821	74.45	749	76.66	614	76.27	458	68.98	1052	73.62	769	75.61
	$n = 1$	378	15.45	150	15.35	112	13.91	116	17.47	230	16.09	148	14.55

(continued)

Table 1 (continued)

		Total		North		Central		South and Islands		Females		Males	
		n	%	*n*	%	*n*	%	*N*	%	*n*	%	*n*	%
	$n = 2$	217	8.87	72	7.37	65	8.07	80	12.05	126	8.82	91	8.95
	$n \geq 3$	30	1.23	6	0.61	14	1.74	10	1.51	21	1.47	9	0.88
Food expense (euros/month)	<200	454	18.56	194	19.86	146	18.14	114	17.17	275	19.24	179	17.60
	200–400	1110	45.38	451	46.16	364	45.22	295	44.43	647	45.28	463	45.53
	401–600	683	27.92	254	26.00	221	27.45	208	31.33	391	27.36	292	28.71
	>600	199	8.14	78	7.98	74	9.19	47	7.08	116	8.12	83	8.16
Dietary style	Vegetarian/vegan	64	2.61	28	2.86	25	3.10	11	1.65	47	3.29	17	1.67
	Under weight	99	4.05	48	4.92	34	4.22	17	2.56	89	6.23	10	0.98
	Normal	1571	64.25	639	65.47	547	67.95	385	57.98	1011	70.75	560	55.12
	Over weight	618	25.28	237	24.28	178	22.11	203	30.57	246	17.21	372	36.61
	Obese	157	6.42	52	5.33	46	5.71	59	8.87	83	5.81	74	7.28

Table 2 Chi-square test on contingency tables: Differences in distribution of sociodemographic and anthropometric characteristics among Italian regions, sex, and age. Bold red characters indicate significant differences (Fisher exact test al level α = 0.05%)

		North	Centre	South	F	M	C1	C2	C3
Education Level	Lower middle school	**<**	>	>	<	>	**<**	**<**	**>**
	High school	**>**	**<**	<	**<**	**>**	**>**	**<**	>
	University or Higher	**<**	**>**	>	**>**	**<**	**<**	**>**	**<**
Employement	Farmer	**>**	<	**<**	**<**	>	**<**	<	**>**
	Housekeeper	**<**	<	**>**	**>**	**<**	**<**	>	**>**
	Dealer/Artisan	>	<	<	**<**	**>**	**<**	>	**>**
	Unemployed	**<**	<	**>**	<	>	>	**>**	**<**
	Employee	**>**	<	**<**	<	>	**<**	**>**	**>**
	Self employed	<	>	<	**<**	**>**	**<**	**>**	>
	Retired	>	>	**<**	<	>	**<**	**<**	**>**
	Student	<	<	>	>	<	**>**	**<**	**<**
BMI	Under Weight	>	>	**<**	**>**	**<**	**>**	>	**<**
	Normal Weight	>	**>**	**<**	**>**	**<**	**<**	<	**>**
	Over Weight	<	**<**	**>**	**<**	**>**	**<**	<	**>**
	Obese	<	<	**>**	>	>	**<**	>	**>**
Family members	1	**>**	<	**<**	<	>	**<**	**>**	**>**
	2	**>**	>	**<**	>	<	**<**	**>**	**>**
	3	>	<	<	>	<	<	<	>
	4	**<**	<	**>**	<	>	**>**	**<**	<
	5	**<**	>	**>**	>	<	**>**	**<**	**<**
	>6	<	<	>	<	>	**>**	<	**<**
Children <16y	0	**>**	>	**<**	<	>	**>**	**<**	<
	1	<	<	>	>	<	**<**	>	**>**
	2	**<**	<	**>**	<	>	**<**	**>**	<
	3	**<**	>	>	>	**<**	**<**	**>**	**<**
	4	>	**<**	**<**	**<**	>	**<**	**<**	>
	5	**<**	>	**<**	**<**	>	>	**<**	**<**
Food expenses	<200	>	<	<	>	<	<	**>**	**<**
	200 - 400	>	<	<	<	>	<	**>**	**<**
	401-600	<	<	**>**	<	>	>	**<**	**>**
	>600	<	>	<	<	>	<	**<**	**>**
Diet	No restrictions	<	<	>	**<**	**>**	>	<	<
	Vegetarian/Vegan	>	>	**<**	**>**	**<**	<	>	>

employment conditions significantly changes according to regions (chi-square test, $p = 0.0001$), age class (chi-square test, $p = 0.0001$), and gender (chi-square test, $p = 0.0001$). "Employee" is more frequent in the Northern regions and in the older age classes (C2 and C3) than in the Southern region and in the youngest age class (C1). The percentage of students was not affected by region or gender and was naturally higher in the youngest (C1) than in the other age classes (C2 and C3). Notably, only females declared to be "housekeeper" as employment condition, and the percentage is higher in Southern (10.39%) than in the Northern regions (1.54%), and more frequent in the oldest than in the youngest age class.

Almost 50% of participants belong to family units consisting of 3 or 4 members. A family unit of 4/5 members prevails in the Southern regions, while single and couples are more present in the Northern regions (chi-square test, $p = 0.0001$). Small family units (1 or 2 members) are more frequent in C2 and C3 age classes; the youngest respondents belong to family unit of 3/4 members probably because the young people, mainly students, participating in the study tend to live with parents (78% aged from 20–29 in 2017; https://appsso.eurostat.ec.europa.eu/). The vast majority of the respondents live in families without children aged less than 16 years (74.45 on national base). This percentage is almost stable by region, gender, and age. Significant differences are observed by region; the proportion of family without young children is lower in the South in respect to North of Italy, and as for age, with the proportion of respondents living in family with young children higher in the youngest than in the other classes.

The monthly food expense is around 200–400 euros for almost half of respondents, irrespective of region, gender, and age class, in agreement with the average monthly expense of 420–450 euros for food products reported for the Italian population between 2015 and 2017 (http://dati.istat.it/index.aspx?queryid=19692#). People with a monthly food expense from 400 to 600 euros were more frequent in the Southern regions. People with food monthly expense from less than 200 to 400 euros was more frequent in C1 class, while people with a monthly food expensed higher than 400 euros was more frequent in the C2 and C3 age classes.

The number of vegan/vegetarian represents a small percentage of the sample (2.6% on national base) and this variable has not been further considered. The body mass index (BMI) was computed according to the Quetelet formula and categorized into five levels according to WHO classification. Given the very low prevalence of subjects with BMI >30, the original three obese classes were collapsed into one single category (Obese). Almost 64.25% of the population was normal weight and 25% overweight on a national basis. The data are in agreement to what is reported for the adult Italian population, with the percentage of normal weight individuals ranging from 70% to 50% in the age range from 18 to 60 years old (https://www.istat.it/it/salute-e-sanita?dati). The distribution of BMI classes differed by region ($p < 0.0001$); Southern regions showed a greater proportion of overweight and obese subjects and a lower proportion of normal-weight and under-weight subjects. The proportion of normal-weight was higher in females than in males, and the proportion of over-weight was higher in males than in females. Normal weight and underweight subjects were more present in the youngest age class (C1), while overweight and obese were more present in the oldest class (C3). In general, BMI data confirm data from national surveys both on the positive association of weight-gain with male gender and age and on the difference by region (https://www.istat.it/it/salute-e-sanita?dati; Calza et al. 2008).

The general structure of sociodemographic and anthropometric data makes it possible to consider the participant sample as representative of the healthy Italian adult population.

Health and Taste Attitudes in the Italian Population

The perceived healthiness and expected pleasure from sensory properties represent two key motivations in food choice and preference. Health and Taste Attitude Scale (HTAS), developed by Roininen et al. (1999) consists in six scales: three of them are health-related and three subscales refer to taste. The health scale consists of three subscales: general health interest (GHI – eight statements), light product interest (LPI – six statements), and natural product interest (NPI – six statements). The taste scale consists of three subscales: craving for sweet foods (CSw – six statements), using food as a reward (FR – six statements), and using food as a pleasure (P- six statements). Respondents score their answers using a seven-point Likert scale from

1-strongly agree to 7-strongly disagree. HTAS was demonstrated as a powerful predictive tool of choice for healthier foods (Roininen et al. 1999, 2001; Saba et al. 2019), fat and vegetable intake (Zandstra et al. 2001). Positive attitudes towards health-related aspects were found associated with a healthy dietary pattern characterized by the consumption of fruit and vegetables, while negative attitudes towards natural products and high attitudes toward taste-related dimensions were associated with less healthy dietary patterns in young Polish women population (Kowalkowska et al. 2018). The HTAS questionnaire was already used successfully for Italian consumers profiling in relation to the acceptability of fruit with varied sensory profile (Endrizzi et al. 2015), and on subsamples within the Italian Taste study in relation to healthy food choice (Saba et al. 2019) and preference for vegetables with sensory properties critical for their acceptability (Monteleone et al. 2017). In agreement with these preexisting studies, HTAS subscales proved reliable when applied to the Italian population except for the pleasure subscale that showed low internal reliability and was not further considered.

Italian population rated health and taste subscales higher than the Likert scale central point (Health: GHI = 4.7; NPI = 4.5; Taste: CSw = 4.7; FR = 4.4) with the exception of LPI (mean score = 3.4) thus indicating that both health and taste aspects are important motivations in food choice across the whole country. General health interest does not change across the Italian regions, while significant differences were found for interest for light food, higher in Southern than Central and Northern regions; interest for natural products and craving for sweet foods, lower in the Southern than in the Northern and Central region; interest for food as a reward higher in the Northern than Southern and Central Italy (Fig. 2a). Women are more interested than men in general health aspects, natural products, craving for sweet foods, and food as a reward, while no significant differences resulted between genders for light product interest (Fig. 2b). General interest for health and for natural products regularly increases with age, while interest for light products, craving for sweet food, and food as a reward is lower in the oldest age class (Fig. 2c). Gender and aging driven differences in the importance given to health and taste-related aspects in food choice confirm what has been observed in other European countries (Roininen et al. 1999), and on previous studies on Italian population samples (Endrizzi et al. 2015).

Data from the present study show that scores of health subscales increase and score from taste subscales decrease with aging, thus indicating a sort of opposition between the importance given to taste and to health-related aspects in food choice according to age.

Mean scores of both health and taste subscales indicate that both health and taste aspects are important motivations in food choice for the Italian population participating in the study. This is in agreement to what observed by Roininen and colleagues in UK and Dutch populations (Roininen et al. 2001). Finnish adults tend to score higher health than taste subscales (Roininen et al. 1999, 2001) The same studies registered comparable mean scores in the three domains of the Health subscale in Finland, United Kingdom, and The Netherlands, although with some differences between countries. We noticed a low interest of the Italian sample for

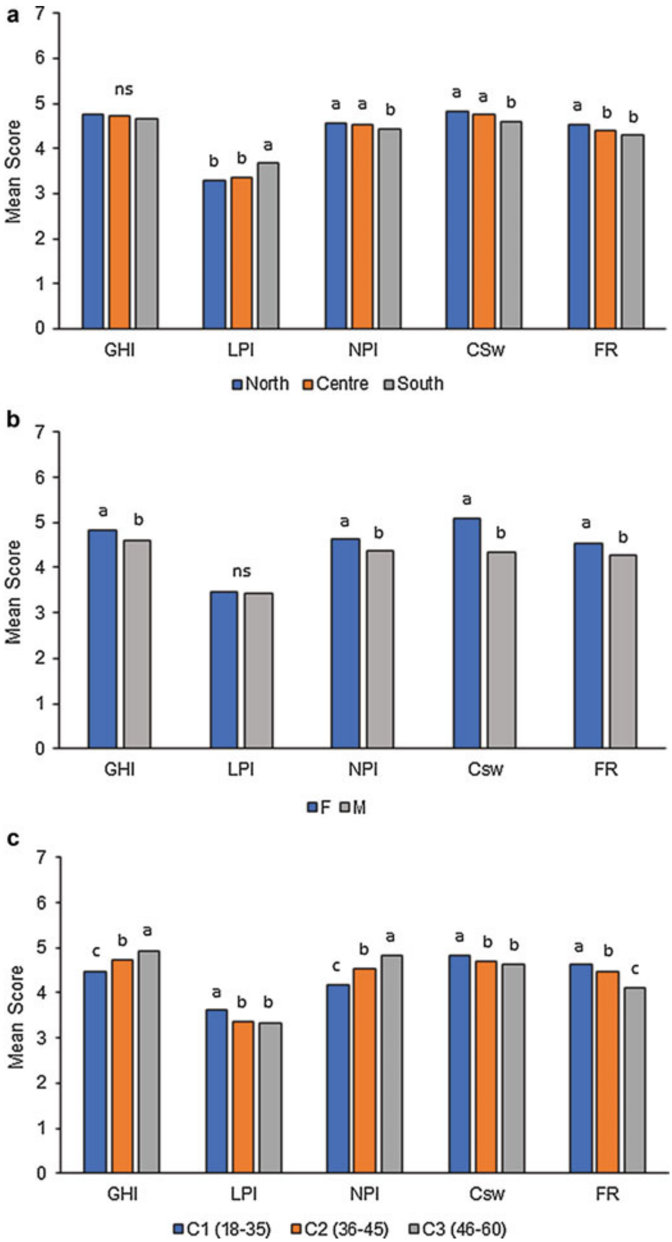

Fig. 2 Effect of Italian region (**a**), sex (**b**), and age class (**c**) on mean score of reliable HTAS domains (1W-ANOVA – fixed factor: region, gender, or age class; dependent variables: mean scores of reliable HTAS subscales). Different letters indicate significant different values, significance level fixed at $p \leq 0.05$

light products (LPI = 3.4) which may reflect a general tendency in the country to consider the Mediterranean diet healthy and tasty at the same time (Monteleone and Dinnella 2009), with a consequent low interest in light foods. On the other hand, if we consider the domain craving for sweet foods and using food as a reward, the mean in our sample (Csw = 4.7; FR = 4.4) are much higher than in Finland, and to a lower extent, in United Kingdom and The Netherlands.

Furthermore, subscales measuring interest for light and for natural products appear to be inversely associated in the comparison across regions and across age classes. This could possibly be due to the impression of Italian respondents from Central and Norther regions and from older age classes that light food has been highly processed, and the original composition modified to increase its healthy properties in opposition to natural food in which the technological impact is lower and the original composition preserved without adding extraneous components.

General Importance Given to Food in Daily Life and Food-Related Lifestyle

Food-Related Lifestyle (FRL) questionnaire has been proposed as a mediator between values and behavior (Brunsø and Grunert 1995; Brunsø et al. 2004; Grunert et al. 1998; Scholderer et al. 2001). FRL is defined as a system of cognitive categories, scripts, and associative networks relating a set of food-related behaviors to a set of values (Brunsø et al. 2004). The FRL questionnaire consists of 69 attitudinal statements each measured on a 7-point Likert scale from 1 – completely disagree to 7 – fully agree. Questionnaire items are grouped into five different domains of food-related lifestyles each consisting of several dimensions: ways of shopping (six dimensions), cooking methods (six dimensions), quality aspects (six dimensions), consumption situations (two dimensions), and purchasing motives (three dimensions).

Almost half of FRL subscales (12 out of the original 23) showed internal reliability (α -Chronbach ≥0.7), covering four FRL domains (1) way of shopping: importance of product information, specialty shops, price criteria, shopping list; (2) quality: health, organic products, freshness; (3) cooking methods: interest in cooking, looking for new ways in cooking, convenience, woman's task; (4) purchase motives: self-fulfillment in food and were considered to profile the population.

Among these, the most relevant dimensions for the Italians were freshness (6.2), health (5.6), and looking for new ways in cooking, self-fulfilment, and times for cooking (5.2). Comparing these results with previous studies, Italians were found to be more interested in cooking and more attracted by new ways in cooking than Spanish and German (Brunsø et al. 2004). Convenience was not very important, in line with the Spanish sample, but lower than in the German sample (Brunsø et al. 2004).

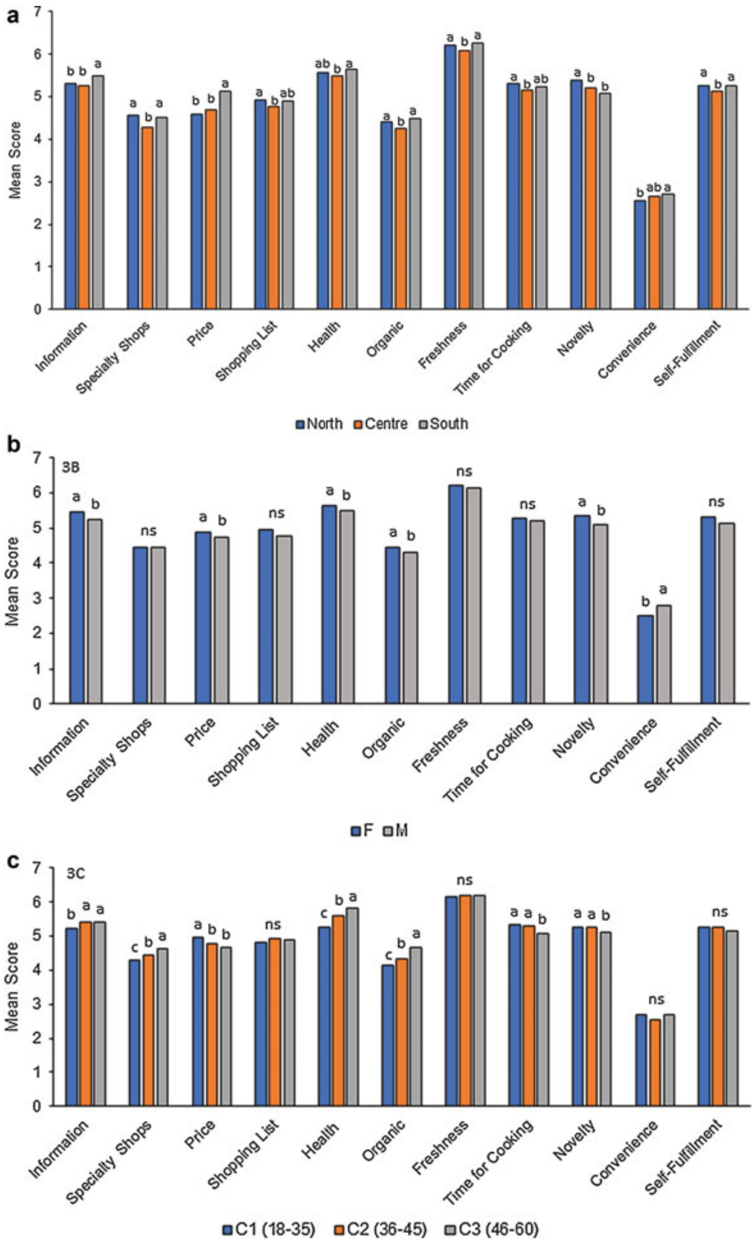

Fig. 3 Effect of Italian region (**a**), sex (**b**), and age class (**c**) on mean score of reliable FRL questionnaire subscales (1W-ANOVA – fixed factor: region, gender, or age class; dependent variables: mean scores of reliable FRL subscales). Different letters indicate significant different values, significance level fixed at $p \leq 0.05$

All the subscale scores are significantly affected by the factor "Region" (Fig. 3a). Information about products and price characterize more the way of shopping of subjects from South than those from North and Center. Specialty shops and shopping list are less important motives for Central than Northern and Southern populations and all quality aspects are less important in Central than in the rest of the regions. Time dedicated to preparing meals and seeking for novelty in food preparation are aspects more important in the North than in Center and South, while convenience is more relevant in the South than for the rest. The self-fulfilment in food is more important in North and South than in Center. These data indicate a general high attention paid to food selection and preparation in Southern and Northern regions, but these similar behaviors might depend from different motives. In the Northern Italy, the lower presence of housekeepers, the predominance of single and couple family units, and the low presence of children in the family possibly favor the association of the food purchase and meal preparation to a hedonic, rewarding, and comfort dimension. In Southern regions, food purchase and meal preparation seem more oriented to family care; the higher monthly expenses for food, the higher number of family members including children induces a careful selection of food in order to buy the best option in terms of quality for the best price. All the subscale scores significantly affected by the factor "gender" were higher in females than in males except for the convenience, higher in males than females (Fig. 3b). The picture thus indicates a significant gender inequality in the Italian population in which most aspects related to food purchase and meal preparation are more important for females who still represent the family member mainly responsible for purchasing and preparing food (61%, https://www.coldiretti.it/archivio/censis; Maugeri et al. 2019).

Figure 3c reports the effect of age class on FRL subscale score. Age significantly influences the way of shopping, with younger subjects that pay less attention to product information and are more interested in price. Shopping in specialty shops parallels the importance of quality aspects and regularly increases with aging while time for cooking and interest for novelty is higher in younger age classes. The results reflect the prevalence of students in the youngest age class with limited economic resources; however, despite the low interest for food products quality aspects, the young population spends more time in cooking and seeks for novelty in cuisine.

A study on a subsample ($n = 1224$) within the Italian Taste project (Saba et al. 2019) showed that people more convenience-oriented and less interested in product information and food quality had higher probability to have a lower interest in food-related health. Subjects with higher attitudes towards using foods as a reward had a higher probability to have a lower interest in food-related health. Furthermore, consumers differing in attitude towards health differ also in their preferences for the categories "Vegetables and Fruits," "Fish," "Red meat and preserved processed meat products," "Fat (saturated)," and "Alcoholic beverages." Those Italians highly interested in health had the highest mean scores of liking for "Vegetables and Fruits," and for "Fish" compared to the subjects with lower interest in health, and lowest for

“Red meat & preserved processed meat products,” “Fat (saturated),” and “Alcoholic beverages.” The subjects that were characterized by a lower interest towards health, on average, expressed a lower liking for “Vegetable and Fruits” and higher for “Red meat & preserved processed meat products” and “Fat (saturated)” (Saba et al. 2019).

Vegetable Preference and Familiarity in Italian Consumers

The higher consumption of plant-derived food such as vegetables and legumes represents one of the key features of the Mediterranean Diet adopted by the countries of Mediterranean area. Despite the contribution of such a diet to a favorable health status and to a better life quality have been widely reported (Godos et al. 2019; Sofi et al. 2010), a transition to Western diet emerged in Mediterranean population and a shift toward a lower consumption of vegetables and legumes in favor of animal origin food, refined sugar, and grains and animal fat has been observed (León-Muñoz et al. 2012). In Italy a significant increasing of diet “Westernization” has been observed in more recent years, when the global economic crisis has probably contributed to accelerate the change in dietary habits (Bonaccio et al. 2014). In fact, there is evidence in the literature that high-quality diets, including the Mediterranean Diet, are associated with higher monetary daily diet costs, compared to Western diets which are typically less expensive (Lopez et al. 2009). In general, it has been suggested that diet quality follows a socioeconomic gradient and people with higher socioeconomic status consume more vegetables (Darmon and Drewnowski 2008). Socioeconomic diversity in healthy food intake has been documented in European countries; consistently across countries, including Denmark, France, Czech Republic, and Italy, the highest vegetable intake has been found in women, high educated people, and elderly (Cavaliere et al. 2019; Mertens et al. 2019). Other socio-demographic factors reported to affect vegetables and legumes consumption in Italy include age, gender, educational level, employment conditions, and marital/family status (Cavaliere et al. 2019; Maugeri et al. 2019).

More specific to each individual, attitudes can be predictors of healthy eating behavior. High vegetable consumption has been associated with a greater appreciation of health and the value of a healthy diet (Appleton et al. 2017; Brown et al. 2011; Kowalkowska et al. 2018).

Vegetable items listed in the Italian Taste Food Preference and Familiarity questionnaires were classified in three categories: (1) “vegetables” consisting in food generally consumed cooked as side dish or as ingredient of main dish (broccoli, artichoke, chicory, tomato, radish, spinach, zucchini, cucumber, beetroot, fennel, asparagus, chard, and minestrone); (2) “legumes” (beans, peas, green beans, and legume soup); 3. “salads” consisting in vegetable generally consumed raw and used as ingredient of salad recipes popular in Italy (lettuce and valeriana mix; radicchio and rocket mix, cauliflower salad; carrot salad, crudités). The Food Familiarity and Food Liking questionnaires were developed to measure, respectively, familiarity with, and liking for, a selection of 184 foods appropriate in different eating situations. Eating situations were identified considering either the traditional Italian meal pattern (breakfast, lunch, and dinner), as well as new habits, such as snack/light meals and aperitif, that tend to substitute lunch or dinner, thus breaking the traditional meal timing. The item selection reflected variations in familiarity (more/less familiar foods), flavor (strong/mild), and energy content (high-energy/low-energy dense) as well. Items are grouped in product categories based on their chemical composition.

Data on national basis indicate that all vegetable categories are well liked with mean liking score around 7 (liking moderately) and a familiarity score around four indicating the occasional consumption frequency. Slight but significant differences were found on liking for and familiarity with vegetables, legumes and salads according to region, gender and age class (Figs. 4, 5, and 6). Few differences in liking for vegetables were found across regions; legumes were less liked in the North and salads less liked in the South (Fig. 4a). However, mean

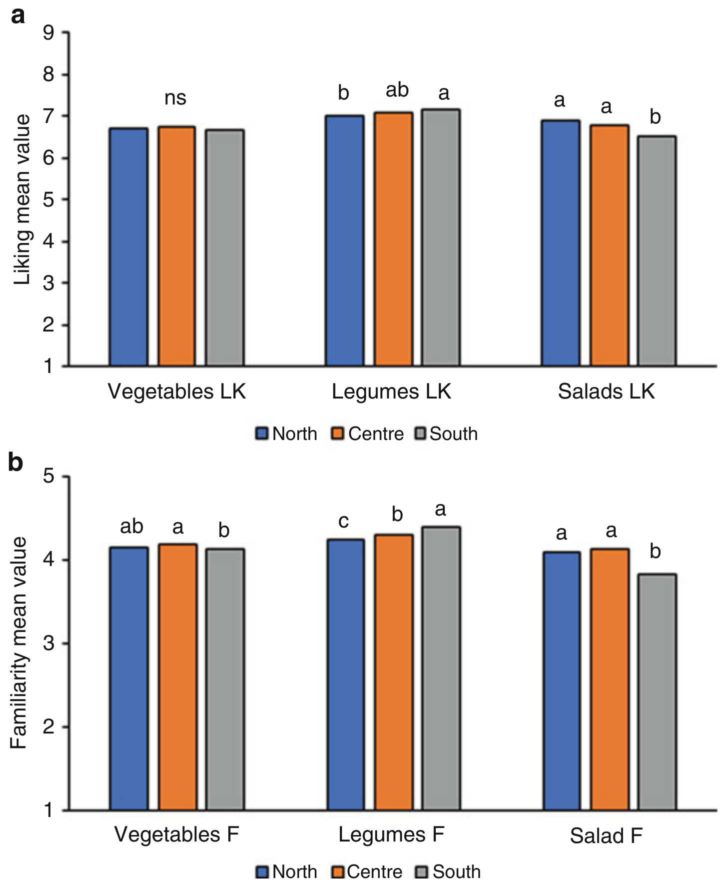

Fig. 4 Effect of Italian Region on liking for (**a**) and familiarity with (**b**) vegetable categories (1W-ANOVA – fixed factor: region, dependent variables: mean liking and familiarity scores). Different letters indicate significant different values, significance level fixed at $p \leq 0.05$

liking score for vegetable categories ranged from 6.5 to 7.1 thus showing that these food products are well accepted by adult Italian population across the country. Familiarity means scores indicate a consumption frequency in the range between occasional (4) and regular (5) (Fig. 4b). The lowest consumption of vegetable and salads was found in the South region, with legume consumption that regularly decreases from the northern to the southern part of the country. Italy presents remarkable economic differences between northern and southern regions. Results on vegetable liking and familiarity across regions reflect the well-documented positive association between socioeconomic status and healthy food consumption. In Italy, positive associations have been documented between vegetable consumption and income, while legumes were more frequently consumed by less affluent people (Cavaliere et al. 2019). The population sample participating in the study showed university and higher educational level more frequent in North than in South and the presence of unemployed people was higher in South than in North; both these differences support previous data on positive association of high educational level and employment rate with vegetable consumption (Cavaliere et al. 2019; Maugeri et al. 2019). The higher presence of overweight and obese people in the South than in the North further reinforces the differences in healthy food behavior across the country and their consequence on body weight. Positive health-related attitudes associate to healthy dietary patterns. The perceived naturalness of vegetables is reported as one of the most important motives of their choice and consumption (Kowalkowska et al. 2018). The lower interest for natural products found in South than in the rest of the country (Fig. 2) might contribute to explain the observed differences in vegetable consumption. The higher importance of price as purchasing motives in the South than in the rest of Italy further reinforces the role of the affluence gap across the country in healthy food consumption.

Gender significantly affected preferences for (Fig. 5a) and familiarity with (Fig. 5b) all vegetable categories, with both liking and familiarity for vegetables, legumes, and salads higher in females than in males. The observed result is well in agreement with gender-related differences for other socioeconomic and attitudinal factors determining vegetable consumption and preference. University and higher education were more frequent in females than in male population participating in the study, thus confirming the importance of educational level as pro-healthy food behavior factor. The importance of health-related aspects in food choice was always higher in females than in males, in agreement with the positive association of general interest for health and for natural products with vegetable consumption (Kowalkowska et al. 2018). In general, the positive attitudes of females to vegetable consumption seem also to be related to their lower perception of barriers to healthy food behaviors. In fact, evidences from other studies indicate that European women did not consider taste, time constraint, and price as barriers to healthy food consumption and vegetable intake (Pinho et al. 2018). The healthier food behavior of females in respect to males also reflects in body weight; the presence of overweight and obese is lower in female than in the male subjects participating in the study.

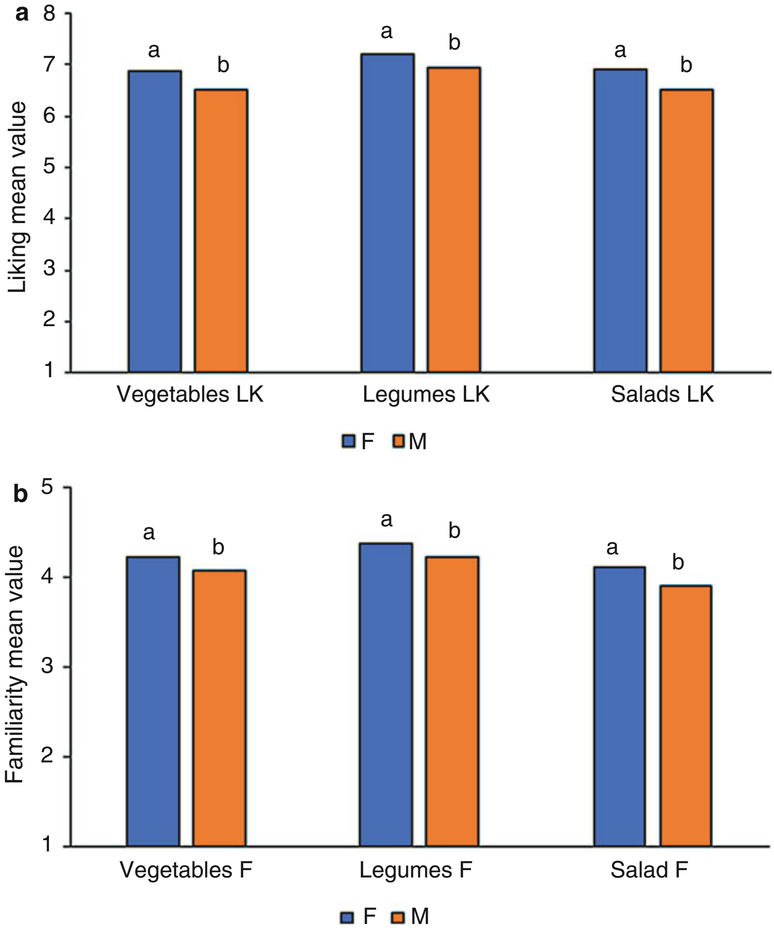

Fig. 5 Effect of gender on liking for (**a**) and familiarity with (**b**) vegetable categories (1W-ANOVA – fixed factor: gender, dependent variables: mean liking and familiarity scores). Different letters indicate significant different values, significance level fixed at $p \leq 0.05$

Liking for (Fig. 6a) and familiarity with (Fig. 6b) vegetable categories regularly increase with aging; the youngest age class showed the lowest liking and familiarity mean scores for vegetables and salads. The monthly expenses for food and the price as food purchasing motivation are higher in older than younger participant age classes, thus once again reinforcing the link between affluence and healthy food consumption. The regular increasing with age of the importance assigned to general health aspects and to natural product in food choice and purchase appears a relevant driver of the vegetable consumption. These results confirm what has been observed in the European population reporting the increase of vegetable consumption with age followed by a drop, presumably due to age-related deteriorations in function and abilities (Appleton et al. 2017). Moreover,

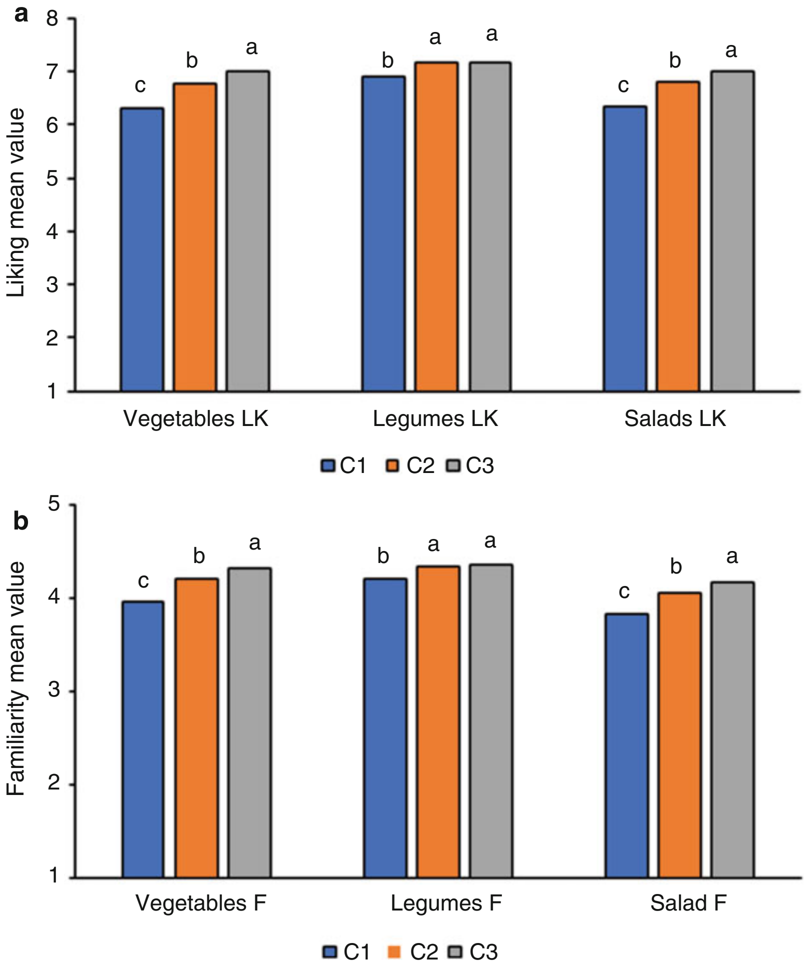

Fig. 6 Effect of age class on liking for (**a**) and familiarity with (**b**) vegetable categories (1W-ANOVA – fixed factor: age class, dependent variables: mean liking and familiarity scores). Different letters indicate significant different values, significance level fixed at $p \leq 0.05$

the data are in line with the diet "westernization" more evident in young population groups (Kowalkowska et al. 2018).

Food neophobia, originally defined as the reluctance to try or eat unfamiliar foods. Higher levels of food neophobia have been associated with reduced intake of fruits and vegetables in a Finnish sample ($n = 2191$; Knaapila et al. 2015) and reduced liking and intake for fruits and vegetables, and for food in general, in a New Zealander sample ($n = 1167$; Jaeger et al. 2017). In a study within the Italian Taste project on a subset ($n = 1225$), food neophobia was found to affect liking of all vegetables with a strong taste, while the effect on mild vegetables was observed only for one (i.e., green beans) out of eight items, thus suggesting that sensory properties play a role (Laureati et al. 2018). Furthermore, neophobia was found to be negatively associated also with the choice of vegetables with higher bitterness and astringency (De Toffoli et al. 2019).

Studies aimed to investigate the factors associated with vegetable preference and intake in Italian elderly (>65 yearold) confirm educational level as a reliable predictor of high and varied vegetable consumption and price/convenience as the most important purchase motives (Appleton et al. 2017). The same study showed that the traditional lifestyle of older Italians, the common practice to grow their own vegetables or to buy them in local shops associate with the availability of a wide variety of vegetables that represent the cheaper and convenient options according to the season. The comparison among elderly from ten European countries (Denmark, France, Germany, Greece, Italy, The Netherlands, Norway, Spain, Sweden, and the UK) identified a southern and a northern dietary pattern mainly differing for vegetable consumption, higher in countries from Southern Europe (Spain, Greece, and Italy) (Bamia et al. 2005) probably due to differences in culinary traditions. In fact, Italian traditional recipes include several vegetable/legume-based dishes as main course while vegetables often represent an ingredient complementing more complex recipes in northern European countries (Monteleone and Dinnella 2009).

Chili Pepper Consumption in Italian Consumers

Chili pepper is commonly consumed in Italy and it is particularly used in some regional cuisines. Usually associated with tomato in the recipes of the Italian traditional cooking, red chili pepper (capsaicin) is one of the constituents of the Mediterranean diet.

The preferred level of pungency in food – sensations of burning, bite, tingling, and so on – varies considerably in relationship with geographical areas, but also with other characteristics. How individuals come to like and enjoy foods characterized by pungency, in particular the intense and often aversive sensations produced by chilies, has been the subject of several studies in the last 50 years (McDonald et al. 2016).

Exposure has been shown to have a role in causing a hedonic shift; this may be due to an association of capsaicin with positive events, including enhancement of the taste of bland foods, post-ingestion effects, or social rewards (Rozin and Schiller 1980).

The consumption of capsicum spices was reported to be 2.5 g/person/day in India, 5 g/person/day in Thailand, and 20 g/person (one chili pepper) per day in Mexico (López-Carrillo et al. 1994). The maximum daily intake of capsaicin in the USA and Europe from mild chilies and paprika was roughly estimated to be 1.5 mg/person/day with a large variability between individuals (Govindarajan and Sathyanarayana 1991; Scientific Committee on Food on Capsaicin 2002).

Findings from the Italian Taste study ($n = 2446$) shows that there is large variability within the Italian population (Table 3). Only 14% of individuals declared to never consume chili pepper, while 24.4% consume it less than one time per month, for a total of 39.4% that we classified as *non-users*. The 28.5% of the

Table 3 Frequency of Nonuser, Medium-user, and User of spicy foods according to socio-demographic characteristics and BMI of participants

	%	Non-user	Medium user	User
Region	Center	29.5	31.9	37.9
	North	39.9	41.7	38.4
	South	30.6	26.4	23.6
Gender	F	68.1	54.4	50.1
	M	31.9	45.6	49.9
Age class	C1	38.0	39.7	37.7
	C2	28.5	28.8	27.3
	C3	33.5	31.5	35.0
	BMI	63.9	66.1	63.0
		7.4	4.4	7.0
		23.7	26.3	26.3
		5.0	3.2	3.7
Educational level	University or higher	45.8	46.1	43.0
	Lower-middle school	7.4	8.3	7.8
	High school	46.8	45.6	49.2
Food monthly expenses	<200	20.1	18.8	16.5
	200–400	44.0	45.6	46.9
	401–600	27.8	26.9	29.0
	>600	8.1	8.7	7.7
Employment status	Farmer	1.4	1.1	1.1
	Housekeeper	5.9	4.6	4.3
	Dealer/Artisan	2.7	3.7	5.2
	Unemployed	5.8	4.7	5.0
	Employee	43.8	44.4	43.7
	Self-employed	6.8	8.2	7.5
	Retired	1.9	1.9	2.7
	Student	31.7	31.4	30.4

participants who consume chili pepper from 1 to 3 times per month (*medium user*), and the remaining 32% consume it at least one or two times per week (*users:* 19% one/two times per week; 7.2% three/four times per week; 2.8% five-six times per week; 2.2% every day; 0.7% more the once per day).

The status of user of chili pepper varies with geographical area ($p < 0.001$) and gender ($p < 0.0001$), but not with age ($p = 0.716$). No association between chili pepper consumption and level of education or monthly expenditure for food was found. Furthermore, the consumption of chili pepper was not associated to attitude toward health or taste (HTAS questionnaire).

A strong association between chili pepper consumption and gender was found. Females constituted the 68% of *non-users*, while males were significantly more *medium users* or *users (Chi square test; significance by cell).*

This large difference between gender was found in previous studies on large samples, as reported in a US sample ($n = 1104$ individuals; Lillywhite et al. 2013). The reasons behind these differences require further exploration. Recent studies have shown that when analyzed separately, each gender shows similar trends, with likers of pungent foods that score lower the intensity of the pungency of capsaicin and personality traits that play a relevant role: neophobia, sensitivity to disgust and to punishment are associated with a lower choice of pungent foods in both females and males; instead, sensitivity to reward is associated with a choice of pungent foods only in males according to the Italian Taste study (Spinelli et al. 2018). These trends on the role of personality traits seem to be valid cross-culturally; Byrnes and Hayes (2015) showed on a US sample an association of personality traits and spicy food liking and highlighted a gender difference in these relationships, with spicy food liking and intake associated with sensitivity to reward in males and with sensation seeking in females. Personality is a complex concept which is intertwined with the cultural dimension. A better understanding of its role and analyses conducted separated by gender may help in gaining a better insight into the similarities and differences between genders.

Interestingly, when response to pungency was measured in a food matrix (tomato juice) spiked with different concentrations of capsaicin we observed that not only some traits have a differing importance in their links to chili and pungent food preferences but also that some traits are associated with burn intensity (Spinelli et al. 2018). We observed three patterns: (1) Personality traits that influenced both liking and perception of burning sensation. In both females and males, more neophobic individuals and those more sensitive to disgust had lower liking scores for tomato juice spiked with capsaicin and rated the intensity of pungency and overall flavor higher. Thus, it may be hypothesized that the personality traits were associated with a different perception of the key sensation and the "hedonic" meaning assigned to the sensory stimuli were probably modulated by the intensity of these sensations (burning, overall flavor). This finding is consistent with previous studies that reported infrequent chili users rated the capsaicin burn as more intense than did the frequent users (Prescott and Stevenson 1995). (2) A personality trait is linked to liking for, but not perception of, burning sensations. For both females and males, individuals more sensitive to reward gave higher liking scores for tomato juice spiked with capsaicin but did not differ in intensities of pungency and overall flavor compared to individuals less sensitive to reward. (3) Personality traits influence perception of burning sensations but not liking. In these cases, the personality traits of alexithymia and sensitivity to punishment play a role in perception but do not influence liking in females.

A higher percentage of users was found in the Italian Center region, while a higher percentage of nonusers was found in Southern Italy. This result may seem unexpected as the Southern traditional regional cuisines use more chili pepper than the other regions. This may be explained by a change in the dietary habits with a transition from the traditional regional cuisines to other type of cuisines. No difference by gender was found between the geographical areas.

Conclusions

This chapter summarizes some results from the Italian Taste study. Data on national basis indicate that health and taste aspects and quality in terms of freshness are important motives in food choice and purchase. Food preparations represents an important aspect of daily life of adult Italians, they look for novelty in preparing food, spend time in cooking, and find self-fulfilment in food. Vegetables represent a well-liked food category even if only occasionally consumed. The pattern of spicy food consumption, as representative of traditional Italian recipes, is quite evenly distributed across country and this let to hypothesize a transition from the regional to other type of cuisine.

Results show small even significant differences across country regions (North, Center, and South) and according to gender and age on food attitudes and target food liking and consumption. The small extent of the observed differences might not have practical implication in itself but represents a valuable information to identify food behavior and underlying motives in population subgroups thus helping in designing tailored intervention strategies.

General health interest did not change across the Italian regions, while interest for light food was higher while interest for natural products and taste related dimensions were lower in Southern than Central and Northern regions. Women showed more interest than men in general health aspects, natural products, and taste-related aspects. General interest for health and for natural products regularly increased with age, while the importance of taste-related dimensions tended to decrease. Results from FRL indicated a general higher attention paid to food selection and preparation by Southern and Northern than by Central regions. All the FRL subscale scores were higher in females than in males except for the convenience, higher in males than females. Younger subjects paid less attention to product information and were more interested in price but spent more time for cooking and were more interest in novelty. Slight but significant differences were found on liking for and familiarity with vegetables, legumes, and salads according to region, gender, and age class. Gender significantly affected preferences for and familiarity with all vegetable categories, with both liking and familiarity for vegetables, legumes, and salads higher in females than in males. Gender was also associated with a preference for spicy foods, with a higher percentage of females not user of chili pepper.

This suggests that gender is a very important variable to take into account. Personality was found to impact spicy food liking differently by gender, thus suggesting that the two variables have to be investigated in association.

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Eating and Drinking in Southern Africa

66

Gerrie du Rand and Hennie Fisher

Contents

Abstract

The Republic of South Africa has for many years been one of the economic powers on the African continent and has always played a major role in relations with its neighboring countries. It is therefore natural that cross-border exchanges would take place on all levels of cuisine development. This chapter offers an introductory insight into the environmental and agricultural business of South Africa within the larger Southern African and African continent context. An introductory summary of the cuisine of the four demographic groups of South Africa is discussed, with reference to similarities found in countries sharing South Africa's borders. The chapter ends with the unfortunate obesity and overweight situation of the region, possibly as a result of increased dietary changes that come with advanced lifestyle and challenges modern Southern African people have to compete with.

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Keywords

Southern African cuisine · South African cuisine · South African agriculture · Noncommunicable diseases (NCDs) · South African demographic groups

The Cuisine of Southern Africa

Introduction

This chapter broadly discusses the cuisine of South Africa, first through briefly introducing the region in the larger context of the African continent, and then within the regional characteristics of Southern Africa. Environmental data and in-depth detail of cuisine specifics of South Africa's neighboring countries are not yet fully researched and often limited. In this chapter, therefore, the emphasis is specifically on the geography, general agricultural practices, and cuisine of South Africa, with some comments on the bigger Southern African region in order to inform the reader of how these aspects of the larger region impact food provision, availability, and the cuisine as a whole. Cross-border influences between South Africa's cuisine (Du Rand et al. 2016, p. 2; Essop and Fraser 2012; Sackett and Haynes 2012) and that of her neighboring countries, and the movement of people into the region over time and how this shaped the cuisine to what may currently be considered Southern Africa cuisine, are discussed. In Southern Africa, such cuisine adoptions are similar to those across the whole of Africa, as proposed by Oktay and Sadıkoğlu (2018, p. 145) who stated that "every country has adopted a different food culture from a neighbouring society and every society has taken the food culture from those who migrated from far away countries." The chapter does not aim to give comprehensive detail of all the food and drink practices of the Southern African region but rather to provide a tempting introduction to further explore what the region has to offer. In this regard, the summary in Table 1 is in no way meant to be an all-inclusive catalogue of all the unique foods of Southern Africa. It is rather a presentation of some examples of foods and beverages enjoyed by the four major cultural groups. Since various cultural influences may apply to the same dish (Essop and Fraser 2012, p. 19), different language users may have adopted slightly different names for the same dish. Finally, on a lesser note, to contextualize the current health patterns of the nation, a brief mention is made of South African families' struggles with modern commercial food.

Originally, anthropologists such as Jack Goody of Cambridge University (Goody 1982) narrowly described African food as not being a properly defined "cuisine." According to Goody, everyone had the same diet regardless of their status in life and therefore food did not mark rank in power or class. However, this notion that African food did not display stratified food consumption habits and that it was mundane and unremarkable is very much contested today (McCann 2010, p. 4). Perhaps African cuisine as a whole may appear simplistic because African societies were often "on the run" as a result of hunger, disease, or tribal wars, with the result that they were unable to stay in situ for generations, an essential condition for developing a

Table 1 A summary of unique South African Food and Drink items and dishes

FOOD TYPE	TRADITIONAL DISH	Coloured South African	Indian South African	African ethnic groups of South Africa	White European South African
CONDIMENTS/ SAUCES	atjar/achar/atchar		•	•	
	chakalaka			•	
	chutney/blatjang (e.g. apricot)	•			•
	peri-peri sauces	•		•	
	sheba/tamatie smoor (umhluzin we tamatisi ne anyanisi)	•		•	•
SOUPS	bean & corn soup (isopho)			•	
	butternut soup				•
	cow heel soup			•	
FISH DISHES	bokkoms/bookem	•			
	minced perlemoen (abalone) curry	•			
	pickeled/curried fish	•			•
	smoortjie/smoorjtie - tomato based snoek stew	•			
	snoek with apricot jam	•			•
MEAT DISHES	bobotie (also with venison)	•			•
	boerewors			•	•
	bredie	•			•
	breyani/briyani	•	•		
	curry & rice		•	•	•
	curried tripe/penslawer, mgodu/mogodu	•		•	•
	denningvleis	•			•
	frikkadels (also a curry)	•			•
	kabobs/labarang/learan	•			
	longetjie bredie	•			
	mavrou/mafrew (beef & tomato curry/bredie)	•			
	mopani worms/phane/matomani with ground peanuts (masonja/dhovi) with tomatoes & onions (mashonzha)			•	
	oxtail stew			•	•
	porcupine back skin	•			•
	skilpadjies				•
	sosaties	•			•
	sout ribbetjie				•
	umleqwa (simmered farm chicken)			•	
	Venda dried meat (tshisevho)/biltong			•	•
	venison/game			•	•
BREADS & BREAD DISHES	askoek				•
	bunny chow		•		
	dombolo/dombeling/water bread (leqebekoane) - maize/wheat flour, also fermented, wholewheat flour (idombolo)			•	
	kota, gatsby, spatlo/sphatlo/spathlo	•	•	•	
	mosbrood (mosbolletjies)	•			•
	potbrood (also in three-legged pot)			•	•
	roosterkoek			•	•
	roti	•	•		
	rusks				•
	steamed bread (ujege)			•	
	vetkoek/magwenya	•		•	•
STARCHES/ STAPLE FOODS	mealie rice & beans (nyekoe)			•	
	melkkos				•
	pap/papa/mutuku (layered vhutetwe/vhuswa), fermeted (vhuswa), sorgum and maize fermeted (imbila), porridge that is fermeted (ting), krummelpap/putupap/phutu			•	•
	samp & beans, with ground peanut flour (tihov tinyawa na timanga)			•	
VEGETABLES & STARCHES	amadumbe			•	
	beetroot leaf stew (umbido)			•	
	maize and green leafy vegetables (umfino)			•	
	morogo/mukusule			•	
	pumpkin flesh and corn (umqa)			•	
	pumkin fritters (with caramel sauce)	•			•
	pumkin leaves & flowers with nuts and tomatoes (majenje), pumpkin leaves and peanuts (imfino yezintanga), pumkin leaves with roasted termites			•	
BEVERAGES	boeber/boeboer/bubur	•			
	ginger beer/gemere			•	•
	ithlodlwa			•	
	mageu			•	
	sorghum and maize beer (ithlodlwa)			•	
	sorghum beer			•	
	umqombothi			•	
	rooibos tea				•
SNACK ITEMS	bollas/snowballs	•	•		
	chili bites/bhajias/dhaltjies/dahltjies	•	•		
	Hertzoggies/Jan Smuts cookies	•			•
	saboeratjie	•			
	samosas/samoosas	•	•		
DESSERTS	koe(k)sisters	•			•
	melktert	•			•
	pannekoek				•
	souskluitjies				•

sophisticated cuisine (Van der Post 1970, p. 6). The defining characteristic of the continent is diversity, with more than 800 languages and dialects spoken. As a continent, it is often in turbulence, with ever shifting borders and governments coming into power (Samuelsson 2006, p. xvii). Van der Post's views echo what other Western scholars have maintained for many years, namely, that African cuisine is the result of European colonial and cultural dominance, and that African cooking shows distinctive qualities of technique and adoption (McCann 2010, p. 3). Although African recipes are therefore viewed as mostly a combination of simplistic ingredients (Marlène 2015, p. 9) and adopted techniques, cookery book author Dorinda Hafner (1993, p. 8) maintains that it is "some of the most exciting cuisines in the world." Africa's cooking is mostly "poor man's food" – simple stews, grilled meats and fish, vegetables and filling starches with side dishes, and a range of breads – "yet these simple foods are anything but dull," and lots of flavor is coaxed out of ingredients, while no scrap is wasted (Samuelsson 2006, p. xvii). In Africa, food as a topic should be approached from two viewpoints: firstly, many African people face a daily struggle for sustenance, as evidenced by the devastating famines of Ethiopia, Niger, and Sudan, and, secondly, to consider cooking and cuisine "at the heart of all cultural expressions of ourselves as human," where food becomes a marker of cultural identity (McCann 2010, p. 2). Various authors have referred to Africa's food as a double-edged sword: on the one side the immense variety, diversity, and quality in some parts of the continent, and on the other side the dire lack of even the basic staples in other parts of it (Hafner 1993, p. 8).

Africa's cuisine therefore exhibits prominent regional characteristics, linked to broad historical themes. In the developed world where the regional differences of African cuisine are unfamiliar, African restaurants often serve a hybrid menu that mixes a number of African national cuisines, cherry picked from around the continent, rather than presenting a coherent cultural and historical setting behind the true cuisine of a specific country or region in Africa (McCann 2010, p. 8). This can be likened to the TexMex phenomenon associated with Mexican food. "There is simply too much to African cooking for any one man to know it all" writes the editor of *Foods of the World*, Richard L Williams, when introducing Sir Laurens van der Post, who authored the volume on African Cooking in the series (Van der Post 1970, p. 6). Understanding the food of a continent this enormous and diverse is no easy task (Samuelsson 2006, p. xvii).

Like most ethnic food genres around the world, the African cuisine of today cannot be confined only within the borders of the continent. The trans-Atlantic food migration and the historic African diaspora, resulting from among others the slave trade, exerted vast influence on the cuisines of the Caribbean, Latin America, the United States, and others (Samuelsson 2006, p. xiii). In southern America "a rich culinary tradition was born out of necessity and innovation" (Yentsch 2008, p. 32).

While a meal in the modern developed world (and parts of Africa) may often consist of a hamburger, fries, and a Coke, in other parts of Africa, it might still more likely be a dish of pounded yam, fish, and a garden egg (*Solanum melongena* var. *esculentum* (Ray 2010, p. 41)) or one of many combinations of a starch and sauce (McCann 2010, p. 5).

The Environment

A regional cuisine is developed from a unique combination of factors based on geography, history, and culture (Sackett and Haynes 2012, p. 4), thus also identifying similar techniques, ingredients, and approaches to food preparation as used throughout the Southern African region. Four main geographical cuisine regions have been suggested for the African continent: north, west, east, and southern region (Samuelsson 2006, p. xvii). This chapter primarily focuses on the cuisine of South Africa, referring to cross-border similarities found within the larger Southern African area, which includes South Africa's neighbors Lesotho, eSwatini (formally Swaziland), Mozambique, Zimbabwe, Botswana, and Namibia. Many culinary traditions spilled over borders, causing many parallels to be found between Namibian and South African Afrikaner recipes, some of which were strongly influenced by German and other settlers (de Chavonnes Vrugt et al. 2009, p. 7).

The following maps, tables, and graphs elucidate the geography, land characteristics, climate, topography, agriculture, and demography of the region, contextualizing the environment and land use for food production.

The Southern African countries under discussion in this chapter are (in alphabetical order) Botswana, eSwatini, Lesotho, Namibia, Mozambique, South Africa, and Zimbabwe (Fig. 1). The people of these countries interact with each other on a regular basis and therefore their influences on daily life are taken as matter of fact. All seven countries are part of the Southern African Development Community (SADC), which works toward the common goal of regional integration and poverty eradication. Two of the main themes of cooperation are sustainable agriculture, which provides food security, and the protection of natural resources.

Geography

The map in Fig. 1 presents the Southern African region that stretches from roughly 10°S (northern border of Mozambique) to 35°S (Cape Agulhas in South Africa) and from 12°E (Namibia in the west) to 41°E (Mozambique in the east).

South Africa is the most southern country on the African continent and shares its borders from east to west with Mozambique, eSwatini (former Swaziland), Zimbabwe, Lesotho, Botswana, and Namibia with a total surface area of +/− 3.9 million square kilometers, larger than the size of India. Botswana, Zimbabwe, and Lesotho are landlocked while Mozambique, South Africa, and Namibia have a combined coastline of 6840 km. On the east coast, the warm Mozambique/Agulhas current (in the Indian Ocean) runs southward from the tropics, meets the cold Benguela current at Cape Agulhas, and then flows northward along the west coast of Southern Africa. Due to rich nutrients, the cold water of the Atlantic Ocean offers good fishing as a food source.

Topography

The topography of the demarcated Southern African region (Fig. 1) comprises a coastal zone between 60 and 240 km wide around the outer designated area with a much higher inland plateau. Namibia and South Africa's plateau have an average

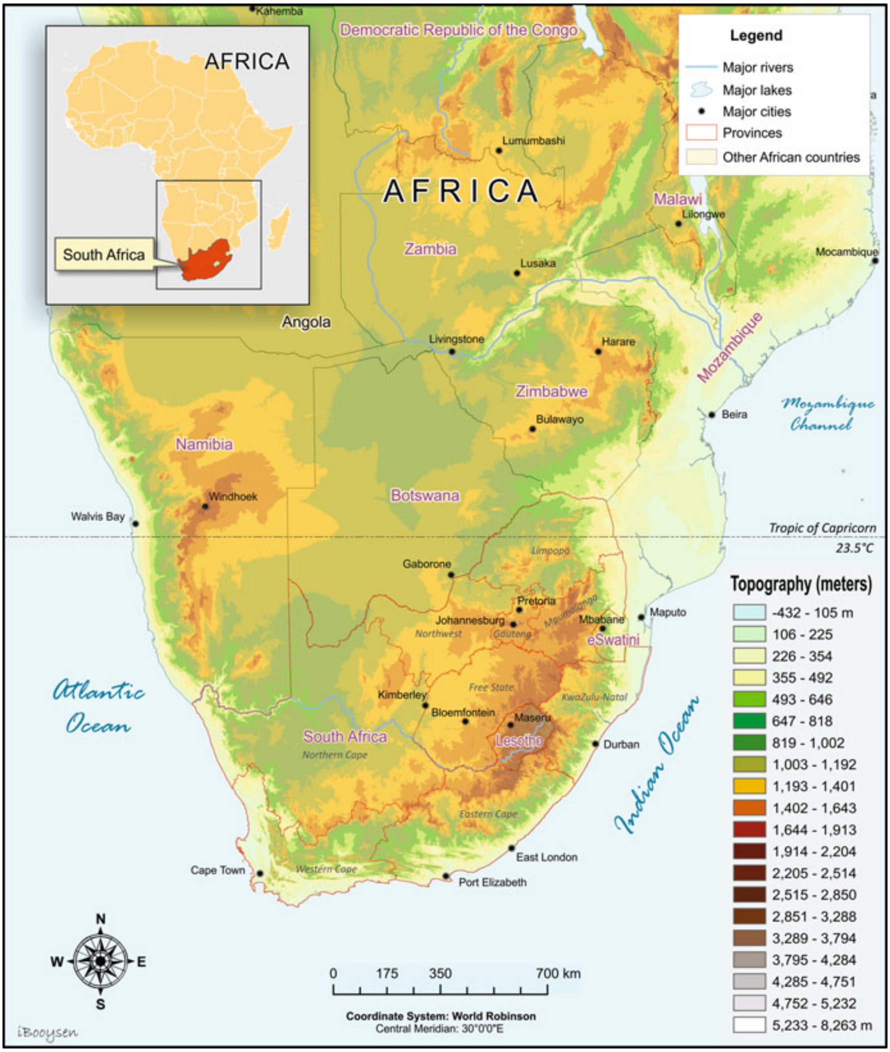


Fig. 1 Map of Southern African countries and topography discussed in this research

height of around 1200 m above sea level. South Africa also boasts the second highest point in the Maluti/Drakensberg/uKhahlamba escarpment to the east while mountainous Lesotho has the highest peak (3,482 m) of the region. eSwatini spans across the broken inland plateau with an average height of 1,100 m in the west. All of Zimbabwe lies on a plateau with a height of not less than 300 m above sea level. Just less than half of Mozambique covers coastal lowlands rising toward the western border with an average height of 776 m at the Ubombo Mountains. Botswana's highest point, 1,490 m is an outcrop called Tsodilo Hills (a UNESCO World Heritage Site of approximately 10 km^2 where 4500 rock art paintings going back

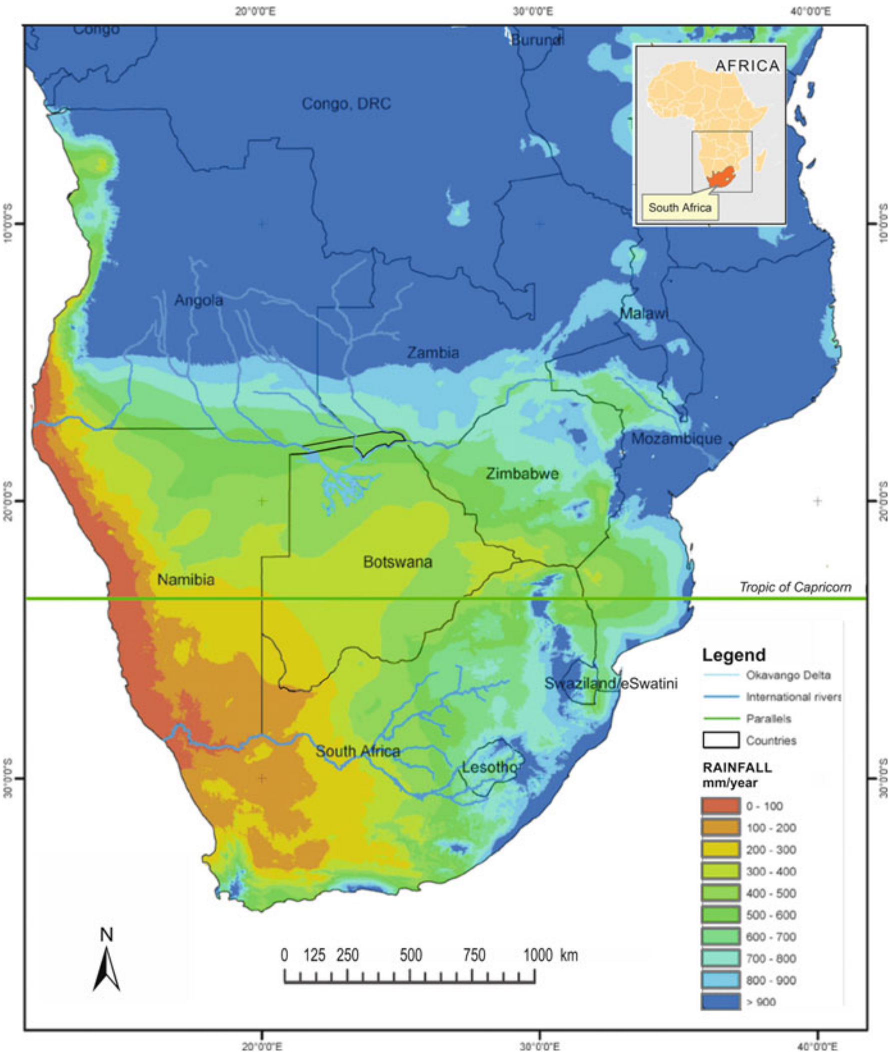


Fig. 2 Map of Southern Africa reflecting the mean annual precipitation/rainfall. (Adapted from Dintwe et al. 2014)

at least 100,000 years are preserved) in NNW Botswana, while its lowest point is 660 m in the east.

Natural Environment and Climate

The natural environment and climate of the demarcated area as reflected in the precipitation map in Fig. 2 follows. Rainfall is generally higher (>900 mm p/a) in the northern area of Mozambique thinning down to smaller area along its coastline in the south. Inland westward to Mozambique's border with South Africa's precipitation reduces to approximately 200–300 mm p/a. Mozambique, due to its location along the Indian Ocean, is exposed to extreme climatic conditions like cyclones, heavy storms, and floods, while the central and southern regions are prone to drought, which can drastically affect food security. Zimbabwe has a subtropical climate due to its high average elevation with the highest precipitation in the Eastern Highlands (900–1,000 mm) and to the north. Western Zimbabwe has an average rainfall of around 500 mm and a lesser amount (200–300 mm) toward the southern border with South Africa. Botswana is a semi-arid to arid region. The average summer rainfall is 500 mm per year in the northeast and less than 250 mm in the rest of the country. Eighty percent of Botswana is covered by the Kalahari Desert. Namibia generally has a hot and dry climate. The amount of precipitation increases from the coastal zone (Namib Desert, 0–100 mm) in the west to a maximum of 600 mm in the northeast, the Caprivi Strip.

Demography

The number of people residing in the demarcated Southern African region totals 111,641,399 (111 million persons) according to the World Bank estimate of 2019 and makes up 8.7% of Africa's total population. The density of persons per square kilometer ranges between 3.1 in Namibia and 81 in eSwatini. South Africa, Mozambique, and Zimbabwe have a density of 47, 39, and 44 people per square kilometer, respectively. Mozambique has the highest population growth rate (2.95%) and Lesotho the lowest (0.80%) as presented in the graph reflected in Fig. 3.

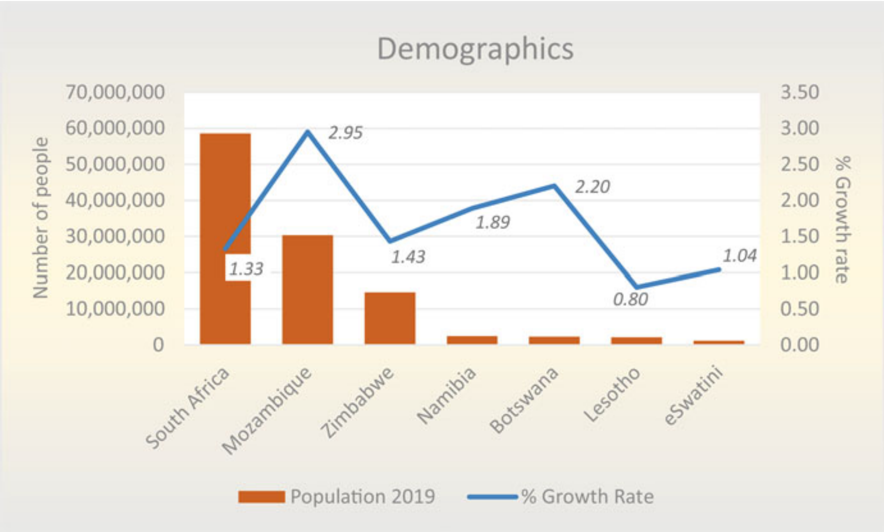


Fig. 3 Graph reflecting the population and growth of selected countries in Southern Africa (data extracted from: World Bank 2019. https://databank.worldbank.org)

Agriculture

The agricultural sector plays an important role in Southern Africa in providing food for consumption and production and as an export product. The following section contextualizes the contribution of the agricultural sector of South Africa to the sustainable provision of food products and creating food security in Southern Africa.

At the end of June 2017, 748,113 people were employed in the agriculture and related services industry in South Africa. South Africa's Census 2011 included (for the first time in South Africa's recorded history) households involved in subsistence agriculture or smallholder farming, and not only those involved in commercial agriculture (Statistics South Africa/Stats SA 2018, p. 6).

The income earned in the agriculture and related services industry in South Africa was R302,8 billion in 2017. As can be seen in Fig. 4, in 2017 "animals and animal products" generated the largest sales (R128,2 billion), followed by "horticultural crops and products" (R74,4 billion) and "field crops" (R57,0 billion). The highest percentage increase was recorded for income earned from the sale of "horticultural crops and products" 15.0% 7.9% and 5.9%.

Flowing from this information, 20% (2,9 million) of the approximate 14,5 million households in South Africa are categorized as agricultural households. From the Census 2011, Agricultural Households Report No. 03-11-01, 2011, involvement in various types of agriculture and percentage of households active in these agricultural sectors were calculated (Fig. 5). Take note that one agricultural household can have more than one agricultural activity (Statistics South Africa/Stats SA 2013, p. 5).

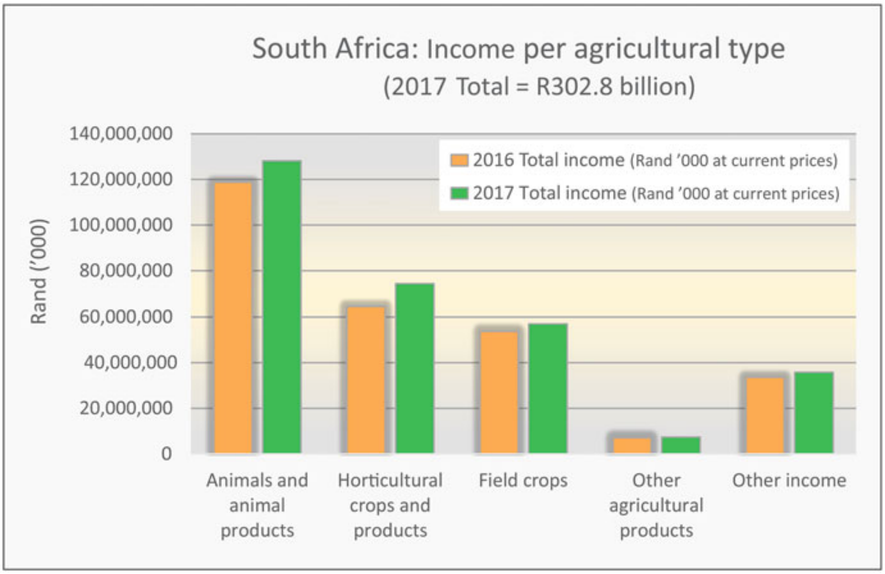
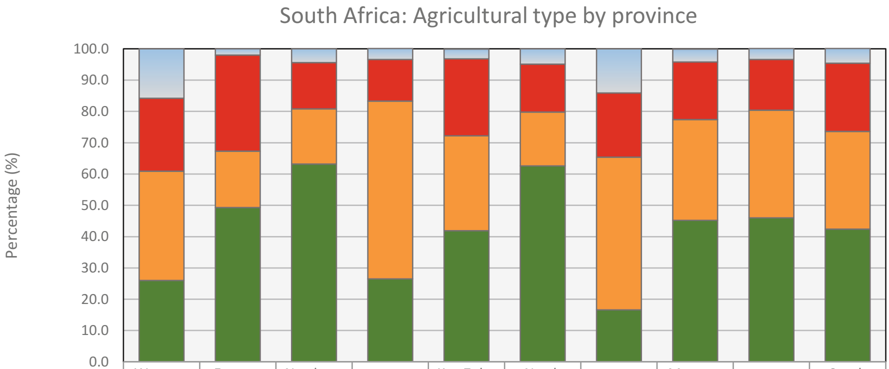


Fig. 4 South Africa: income by type of product in agriculture and related service industries, 2016 and 2017 (Statistics South Africa/Stats SA 2018, p. 6)



	Western Cape	Eastern Cape	Northern Cape	Free State	KwaZulu-Natal	North West	Gauteng	Mpuma-langa	Limpopo	South Africa
Other	15.8	2.0	4.4	3.5	3.1	4.9	14.1	4.1	3.5	4.7
Mixed farming	23.3	30.7	14.8	13.3	24.6	15.3	20.5	18.4	16.2	21.8
Crop only	34.9	18.0	17.6	56.8	30.3	17.2	48.8	32.2	34.4	31.2
Animals only	26.0	49.3	63.2	26.5	41.9	62.6	16.6	45.2	46.0	42.4

Fig. 5 South Africa: distribution of agricultural households by type of activity and province (Statistics South Africa/Stats SA 2013, p. 5)

Information derived from Fig. 6, for South Africa as a whole, is evident that most of the agricultural households are involved in poultry production (1,299,288), with 1,123,524 households ranking second in vegetable production and in third place, with just more than one million (1,096,854) households active in livestock production.

Farming Activities in South Africa

South Africa is diverse in its vegetation, climate, soil, and biodiversity; therefore, farming activities range from intensive crop production in both winter rainfall (Western Cape) and summer rainfall regions (the rest of South Africa) to cattle farming in the Northern Free State and Eastern Cape on the Grassland Biome. Sheep farming is mostly in the arid and semi-arid regions of the Northern Cape, where the Nama Karoo Biome and the succulent Karoo Biome are both sparsely vegetated and covered with low shrubland.

The map in Fig. 7 shows the land cover and land utilization, including agricultural production in South Africa. A brief overview of the agricultural production follows.

Grain

Grain is the largest of South Africa's agricultural industries, comprising 25–30% of the total gross agricultural production while *Maize* is the largest sector in the grain industry. More than 9,000 commercial maize producers are responsible for the main production of maize, together with thousands of small-scale maize farmers. The main maize producers are found in the North West, Free State, Mpumalanga Highveld, and KwaZulu-Natal's Midlands. Maize production is about eight million ton per year, and the surplus is exported to neighboring countries.

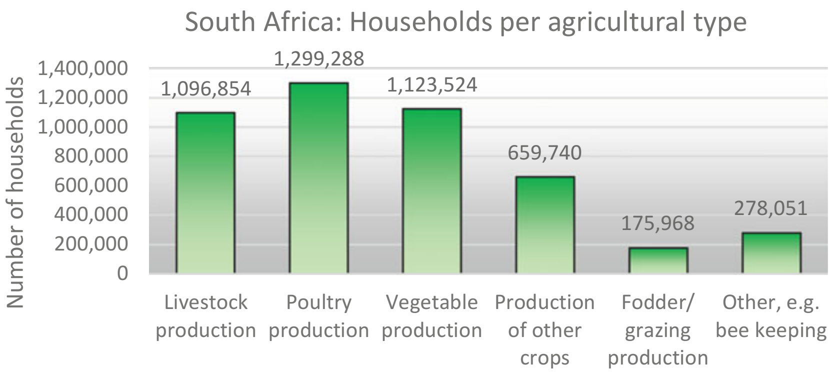


Fig. 6 South African households per agricultural type

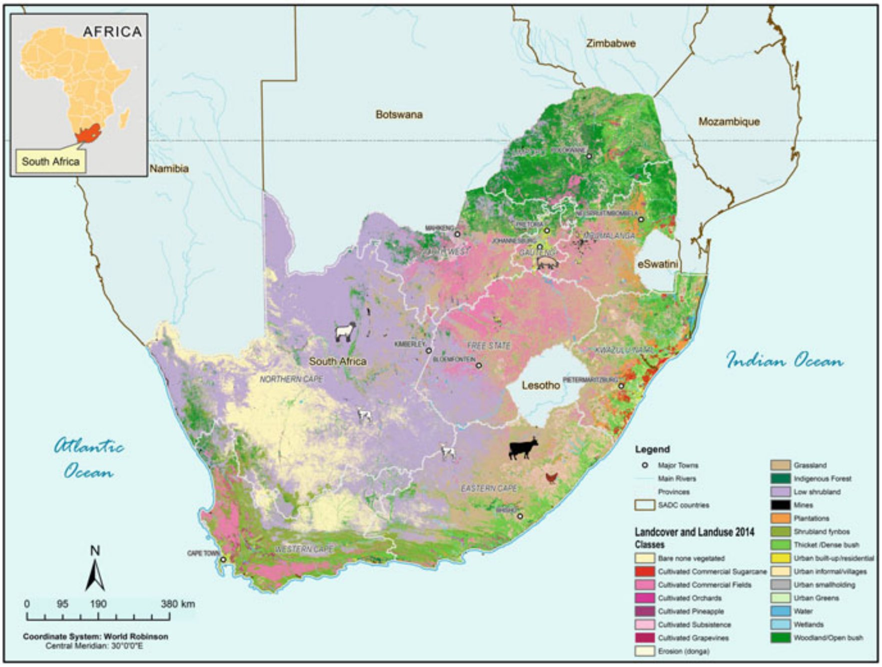


Fig. 7 South Africa: land cover and land use, 2013/14. (Source of original spatial data downloaded from https://www.environment.gov.za)

Wheat is produced in the winter rainfall areas of the Western Cape and in the Eastern Free State. *Barley* fields are found on the Southern Coastal plains of the Western Cape.

Sorghum crops are cultivated in the drier areas of Mpumalanga, Free State, Limpopo, North West, and Gauteng.

Sunflower fields are found in the Free State, North West, Mpumalanga Highveld, and Limpopo while groundnuts are grown in the drier areas of the Free State, North West, and the Northern Cape (Agri News Net/Farmingportal/Agriportal South Africa 2019).

Other

South Africa also produces *soya beans*, *groundnuts*, *and canola.* Income from these crops at the end of June 2017 was 32.3%, 304.6%, and 29.35%, respectively (Republic of South Africa, 2019. *South Africa Yearbook 2017/18, p. 7*). Field crops as discussed above are reflected by the bright pink areas on the land cover/use map labeled as "Cultivated Commercial Fields" (Fig. 7).

Worthwhile mentioning is South Africa's success with the macadamia industry. According to the Macadamia Magazine (The Macadamia, 2018), in 2017/2018, South Africa was the world's largest producer and exporter of *macadamia nuts.* Macadamia orchards are mostly found in Mpumalanga (49%) while Limpopo and KwaZulu-Natal follow with 21% and 20%, respectively. Local consumption is low while 98% of the yield is exported annually to mostly China and Europe.

Sugarcane

The land cover/land use map shows that the cultivated sugarcane fields (pink-orange color) are mainly found along the coast in KwaZulu-Natal, spreading approximately 100 km inland around Pietermaritzburg in the Midlands. Other sugarcane producers are found northward in eSwatini, in the southern Mpumalanga lowveld and in northern coastal regions of the Eastern Cape. In 2018 there were more than 20,000 registered sugarcane growers, of which more than 90% were small-scale farmers (South Africa Online (Pty) Ltd. 2018). According to the South Africa Cane Growers' Association and the South African Sugar Millers' Association, the sugar industry contributes R12-billion to South Africa's economy and provides 350,000 jobs, especially in the rural areas (Wilson 2017). South Africa ranks 13th as sugar producer in the world with an annual production of around two million tons of sugar (Agri News Net/Farmingportal/Agriportal South Africa 2019). Fifty percent of this sugar production is exported to nearby Southern Africa and the rest to other African countries, the Middle East, North America, and Asia.

Fruit

The main producers of *deciduous fruit*, i.e., plums, apricots, peaches and nectarines, apples, and pears are located in the Western Cape's Langkloof region around Ceres, Paarl, Wellington, Franschhoek, Villiersdorp, Robertson, and Ladismith. The climate north of Grahamstown in the Eastern Cape province lends itself toward the cultivation of plums, nectarines, and peaches. Prince Albert produces fresh and dried figs. Apple and pear orchards are found around Elgin and Grabouw while irrigated apple farms started producing fruit in the Eastern Free State from 1996 according to *The Farmers Weekly* magazine (Uys 2015).

Citrus farms are found around Citrusdal along the Olifants River (Western Cape), Port Elizabeth (Eastern Cape), Marble Hall in Limpopo, the Mbombela/Nelspruit-Komatipoort region in Mpumalanga, around Pongola in Northern KwaZulu-Natal, and along the Orange River. Smaller citrus producers are also located around Rustenburg in the North West Prince. A total area of 68,263 ha was under citrus production in South Africa during 2016 (South Africa: Department of Agriculture, Forestry and Fisheries: Citrus 2017, p. 6). Since 1995, South Africa's export of citrus fruit has been growing steadily to become the largest citrus exporter in the Southern hemisphere. This can be accredited to the good quality of the citrus products grown. In 2015, 117 million 15 kg cartons of citrus fruits were exported worldwide.

Pineapples (see dark purple areas on land cover/use map). Of the more or less 262 fresh pineapple suppliers in Africa, South Africa is the largest. The pineapple industry is seasonal, mainly operating between March and November. Pineapples are subtropical fruit and are mainly produced in the coastal areas of the Eastern Cape around East London, Port Elizabeth, Alexandria, Port Alfred, and along the Great Fish River. Northern KwaZulu-Natal and Limpopo also contribute to South Africa's pineapple production. The total pineapple production during 2016/17 was a declining 88,763 tons in comparison to the previous 104,379 tons in 2015/16 due to international competitive markets (South Africa: Department of Agriculture, Forestry and Fisheries: Pineapples 2018, p. 6). Ninety percent of the pineapples are canned in the Eastern Cape (Alibaba.com).

South Africa also produces *avocados*, *mangoes*, *bananas*, *litchis*, *guavas*, *pawpaws*, *and granadillas*. These are grown in the more subtropical regions of Mpumalanga, Limpopo, KwaZulu-Natal, and the Eastern Cape.

Grapes and Wine

Wine is one of South Africa's largest agricultural exports (Sihlobo 2019). The Western Cape province is the main wine region of South Africa (see land cover/use map – maroon colored areas) mostly concentrated around Cape Town, Stellenbosch, Paarl, Franschhoek, Robertson, Tulbagh, Darling and Cape South Coast, Northern Cape, and the Little Karoo. Wine producers employ over 60,000 people, and in 2018 South Africa ranked sixth in the world export of wine valued at Euro 663 million.

According to 2018 data of the International Organisation of Vine and Wine (OIV), South Africa ranks 9th among the wine-producing countries in the world, producing 9,5 million hectoliters (mhl). South Africa has 2,873 farms where grapes are grown for winemaking. It boasts 542 wineries in total, 213 are classified as Wine Estates, 121 are wholesalers, 47 cooperative wineries, and 468 independent wineries. The total area under vine and wine grapes are 93,021 ha (275 m vines) vs 94,545 ha in 2017. Annual wine production in 2018 was 824 million liters. In 2018, export sales totaled 420,2 million liters while annual domestic sales came to 431,4 million liters, i.e., just more than 50% is sold locally (Top Wine 2019).

Vegetables

Potatoes

South Africa is self-sufficient in the production of potatoes (Harvest 2017), which is achieved on less than 1% of the land utilized for agricultural purposes. Limpopo, Eastern and Western Free State, and the Sandveld (West Coast) contribute to 68% of the total annual production, while other high-lying areas in Mpumalanga, Western and Northern Cape, and KwaZulu-Natal produce the rest. Between 45,000 and 50,000 people are employed, permanently and seasonally, in the potato industry.

South Africans consume 90% of the potato production, and approximately 8% is exported to neighboring countries. Consumer spending for 2016 on potatoes and potato by-products was around R25 billion and demand gradually increases on a year to year basis (Harvest 2017).

In South Africa, potatoes (40%) and other vegetables (38%) like onions, green mealies, and sweetcorn generate farmers' main gross income. Onions are grown in Mpumalanga, the Western Cape, and the Southern Free State. Cabbage is concentrated in Mpumalanga and KwaZulu-Natal around Greytown and Camperdown.

Other mentionable products:

Tea (*honeybush and rooibos*) has had increased production over the past few years. Honeybush tea grows mainly along the coast and in the mountains of the Western Cape but also in the Eastern Cape. Rooibos tea is an indigenous herb produced in the Cederberg (Clanwilliam area) of the Western Cape (http://www.farmingportal.co.za). Approximately 8,000 farm laborers produce 14,000 tons of rooibos a year (sarooibos.co.za), of which half is exported and the rest is consumed locally (The South African Rooibos Council 2018).

Livestock Farming

Livestock comprises mainly sheep, cattle, poultry, and pig farming as part of the agricultural sector in South Africa, with 13,8 million cattle and 28,8 million sheep in 2017. The poultry industry, both on commercial and subsistence farms, is larger than the cattle farming and very intensive (Agri News Net/Farmingportal/Agriportal South Africa 2019).

Poultry

According to the South Africa Poultry Association, which was established in 1904 and is one of SA's oldest agricultural organizations, the poultry industry remains the largest single contributor (19.8%) to the agricultural sector in South Africa. Of the total agricultural gross value, 19.9%, and 40.0% of animal product gross value in 2017 stemmed from poultry production. The industry provides direct employment for over 54,000 people (South African Poultry Association 2017). Approximately 76% of poultry is used for meat production and the remaining 24% in the egg industry. The poultry industry continues to be the highest feeder of animal protein sources combined. South Africa dominates regional production of chicken meat, accounting for 73.1% of total production in the SADC bloc in 2017 (Food and Agriculture Organization of the United Nations (FAO) (2019). Although egg exports (R316 million) decreased by 13% in 2017 compared to 2016, the main destinations for South African egg exports in 2017 were Mozambique (78.2%), eSwatini (9.5%), Lesotho (5.8%), Zimbabwe (2.9%), Namibia (2.0%), and Botswana (0.3%).

The gross value of primary agricultural production from poultry meat (inclusive of all types of poultry) for 2017 was R40,04 billion (South Africa: Department of Agriculture, Forestry and Fisheries/DAFF). Poultry meat production is the largest product sector in agriculture in South Africa, ahead of all other animal sectors (beef production (R36,6 billion), milk (R17,5 billion), and eggs (R10,8 billion)) and ahead of all field crop and horticultural sectors. The maize sector, for example, had a gross value of R29,8 billion and deciduous and citrus fruit were valued at R19,0 and R19,2 billion, respectively. Poultry meat's share of the gross value of all agricultural production was 15.9%, and of all animal products 32.1% (South African Poultry Association 2017). Poultry and pig farming are found near metropolitan areas of Gauteng, Durban, Pietermaritzburg, Cape Town, and Port Elizabeth.

Beef Farming

South Africa produces only 85% of its meat requirements because demand is higher than production. Fifteen percent of meat is imported from Namibia, Botswana, eSwatini, Australia, New Zealand, and the EU. Cattle farms are mostly found in the Eastern Cape, some areas of the Free State and KwaZulu-Natal, Limpopo, and the Northern Cape (Agri News Net/Farmingportal/Agriportal South Africa 2019).

Sheep and Goat Farming

Sheep farming is concentrated in arid and semi-arid regions of the Northern and Eastern Cape, Northern area of Western Cape (includes the Karoo region), and the Free State. Indigenous boer goats are adaptable to various climate conditions and make 30% of commercial goat numbers. Angora Goats in South Africa produce mohair from approximately 700 commercial and 300 smaller farms.

The *game farming and aquaculture* industries also play an important role in the farming sector. The main game farming areas are in Limpopo, North West, Mpumalanga, Free State, Eastern Cape, the Karoo, Kalahari (in the Northern Cape), and the thorn scrub region of KZN. The major aquaculture species in South Africa are mussels (Saldanha in the West Coast of the Western Cape), trout, tilapia, catfish, oysters, and waterblommetjies (Western Cape).

In summary, GDP from Agriculture in South Africa decreased to 69,058.48 ZAR Million in the third quarter of 2019 from 70,443.35 ZAR Million in the first quarter of 2019 (Trading Economics 2019). South Africa's exports for 2018 came to $9,9bn, which is 0.5% lower than that of 2017. South Africa's top export products were edible fruits, beverages (largely wine), spirits, vegetable, and wool (Sihlobo 2019). The estimated volume of agricultural production in 2016/2017 was 7.7% more than in 2015/2016 (Republic of South Africa 2019 – Agriculture, p. 7). Africa remains South Africa's largest market for agricultural exports, i.e., 38% (Sihlobo 2019).

The maps, tables, and graphs used in section "The Environment" addressing the environment provides contextual information explaining why South Africa is regarded as an important country in the production of food and a major role player in providing food security in Southern Africa and Africa as a whole. However, the Southern African region is not without its problems. Climate changes such as higher temperatures and prolonged droughts affect agricultural food production in many regions. As development increases and people choose more convenience foods, they are faced with similar health related problems as other societies of the world.

People of Southern Africa and the Development of the Cuisine of the Region

Often cited as the birthplace of humans, Africa has been inhabited for millions of years (Ackerman 2013, p. 137; Lelliott 2016, p. 2). *Homo sapiens* have been around the landscape of South Africa, Botswana, Zimbabwe, Mozambique, Lesotho, eSwatini, and Namibia (collectively referred to as Southern Africa) for more than 50,000 years, and tribes have distinct cultures (Samuelsson 2006, p. xxi). These original inhabitants of Southern Africa are believed to be the ancestors of the San or Sanqua people (San correctly referring to the language), from places such as the Tsodilo Hills in Botswana, Zimbabwe, Namibia, and South Africa (Osseo-Asare 2005, p. 51). A further group of early inhabitants of Southern Africa is the KhoiKhoi (KoiKoi or Kwena), who were cattle herders and who lived a more sedentary life than the San. They were important traders with the seventeenth century European explorers for provisions to their ships (Osseo-Asare 2005, p. 52).

Apart from the Khoi and San people, the Bantu migration roughly 4000 years ago into Southern Africa saw the introduction of skills such as iron work, agriculture, and distinctive pottery. Many of today's black Southern African ethnic groups are descendants of these earlier groups (Osseo-Asare 2005, p. 53). The diet of the country's first people obviously consisted of veldkos (field or bush food) (Leipoldt 1982, p. 29). The food that could be foraged included leaves, such as mustard leaves, sorrel and wild asparagus that were staples of the Khoisan people's diets (Osseo-Asare 2005, p. 57). The first Dutch colonists of the Cape, in 1652, encountered a related group of local inhabitants, whom the they named Strandlopers (beach walkers), and who "kept no cattle and did not hunt but lived off the sea consuming things such as mussels, abalone, crayfish, seagulls, penguins, and seals" (Osseo-Asare 2005, p. 57). In Renata Coetzee (2018), *A Feast from Nature: Food Culture of the First Humans on Planet Earth* (2018), the author meticulously recounts the food culture of early humans, as well as how the indigenous KhoiKhoi transformed natural edible products and developed their own cuisine.

Additionally to the local San people (Coetzee and Miros 2009) and the Bantu and Khoi people who migrated into Southern Africa, other non-African immigrants (such as the Arab traders linked to Great Zimbabwe, as well as Malay and Indian indentured slaves), including the colonial powers (the Dutch, English, Portuguese, French, and Germans), played crucial roles in the formation of the culinary heritage of the region from the sixteenth century onward (Osseo-Asare 2005, p. 57). The formation of the maritime empire at the Cape of Good Hope promoted the processes of migration, which resulted in class hierarchies, cultural overlays, and social borrowing, which were fundamental to the emergence of the cuisines of Southern Africa over time (McCann 2010, p. 4).

Initially, Cape Malay people cooked very much in the style of the Dutch colonists, but by the middle of the eighteenth century, food habits had been modified to suit the surroundings, owing as much to the east as it did to the west (Gerber 1978, p. 10). Slaves who were good cooks were sought after as domestic servants, "a circumstance which affected in a high degree the alimentary customs of both master and slave," with the result that many of today's South African food show Orient and Occident blends (Gerber 1978, pp. 11, 12). A distinct cuisine, known as Old Cape Cookery or Cape Malay cuisine evolved through a blend of European cuisine with those of people that came to the Cape as slaves from Angola, Guinea, Mozambique, Madagascar, Java, Bali, Indonesia, Malaysian peninsula, China, and India (Osseo-Asare 2005, p. 57). Traders from Mozambique and Angola, sister colonies of Portugal, brought with them corn, beans, chili peppers, particularly to the southern parts of Africa (Samuelsson 2006, p. xxii).

Cuisine of South Africa in the Twenty-First Century

In a time where global racial polarization is again at the forefront of human consciousness (Abramowitz and McCoy 2019, p. 137), and furthermore, in context of South Africa's historic system of institutionalized racial segregation, it is important to introduce the cuisine of South Africa along cultural divisions with sensitivity. It is important to not marginalize one South African group over the other, but rather that this introduction to South African cuisine should celebrate the uniqueness and cultural diversity of the nation as a whole. After more than 25 years of democracy in South Africa, the struggle against persistent inequality among the Rainbow Nations' different population groups remains real. Food is one of the few unifying cultural aspects, as evidenced by the fervor with which National Braai Day (actually Heritage Day) is celebrated annually on 24 September. However, even though today a much more inclusive food culture is celebrated, 10 years ago "if anything [were] mentioned about South African cuisine, it [was] usually only about Afrikaans or Cape Malay food" (Sitole 2009, p. 4).

The cuisine of South Africa has been shaped over time and influenced by many factors previously mentioned. In order to describe current food practices in Southern Africa, one would probably need to refer to recipes and recipe books, as they are considered to be the primary historical source about cooking, and furthermore are believed to be markers of accumulated experiences of previous generations of cooks (McCann 2010, p. 11).

In the remainder of this section, the cuisine of South Africa is explored in four main groups, much like most ethnic classifications are made in the country, namely, Colored South Africans, South African Indians, African ethnic groups of South Africa, and finally European races of South Africa. It is however important to understand that the cuisine of those classified as colored South African would differ between those who consider themselves colored and those who consider themselves Cape Malay. Similarly, the cuisines of black ethnic South African groups would differ among the different ethnic groups, such as Zulu, Xhosa, Bapedi (North Sotho), Ndebele, Basotho (South Sotho), Venda, Tsonga, Swazi, and Batswana. Similarly, English-speaking white South Africans eat differently from Afrikaans or other European descendant white South Africans and Hindu South African Indians have different food habits from Muslim South African Indian people. Table 1 presents a summary of unique South African food and drink items and dishes and indicates to which of the four cultural groups these dishes are specific, but also which items are shared as a nation. Some of the items in the table may further also be part of South Africa's neighbor's cuisine, possibly with small variations and with language-specific names for such dishes.

As per the previous discussion regarding the Southern African agricultural practices, the region of Southern Africa is rich in nutritious robust foods such as dry beans, samp, maize rice and maize meal, corn rice, sorghum, groundnuts, offal, caterpillars, dried meat, vitamin-packed morogo, unusual vegetables such as amadumbe and others (Sitole 2009, p. 5). Interactions and consequent influences between South Africa and neighboring countries (Du Rand et al. 2016, p. 9) have shaped the current cuisine and will likely continue in the future, such as peri-peri sauce which originated from countries with Portuguese influences like Mozambique and Angola (Niezen and Fitzpatrick 2012, p. 101).

Colored South African People

Colored South African or Cape Malay people are mostly descendants from people originating from Indonesia, Sri Lanka, and Malaysia who were enslaved in the seventeenth and eighteenth centuries by the Dutch East India Company and brought to the Cape (Samuelsson 2006, p. 309). Even though many colored people still suffer economic hardship, particularly in areas on the Cape Flats such as the suburb of Mannenberg, it is made bearable by the "togetherness through food" says cookbook authors Sydow and Sydow Noordien (2019, p. 6). Since those early days, a hybrid cuisine was created, melding curries, chilies, and spices such as ginger, cinnamon, and turmeric and the concept of serving meat with cooked fruit (Samuelsson 2006, p. 164). Over time, dishes evolved with delightful names, such as a *warme worsie smoortjie* that is made from "*oulap worsies*" or *Penny Polonies*, an inexpensive Vienna sausage and tomato stew (Sydow and Sydow Noordien 2019, p. 36).

Colored or Cape Malay people delight in eating and feast often, which is also part of their religious tradition, with food mostly being about flavor, rather aromatic than hot (Gerber 1978, p. 9). *Dhaltjies*, for instance (a deep-fried chickpea flour, masala, and chili fritter, also referred to as a chili bite), is often served during the month of fasting on the *Boeka* table (Sydow and Sydow Noordien 2019, p. 22) and *mavrou* "not quite curry nor a bredie – but somehow meets in the middle" (also *mafrew* (Abrahams 1995, p. 69)) – a beef and tomato dish traditionally served at weddings (Sydow and Sydow Noordien 2019, p. 116). *Kabobs*, oblong *frikadelles* are hard-boiled eggs wrapped in mince and fried and are often served at Eid-ul-fitr, also called Labarang or Lebaran (Gerber 1978, p. 16; Lagardien 2008, p. 106). Finally, for prayer gatherings a plain sugar biscuit called a *Saboeratjie*, studded with a row of three dried currants down the middle of the round biscuit is served (Lagardien 2008, p. 131; Sydow and Sydow Noordien 2019, p. 174).

Cape Malay people even have a special cook/chef, the *motjie kok*, who is highly regarded in the community to cook for weddings and funerals for up to a 1000 people (Abrahams 1995, p. 9). Says contributor Kubra Mohamed "every Saturday for the past 18 years, I've been cooking *koesisters* [*koesisters*] for the people of the Bo-Kaap" (Riffel et al. 2016, p. 270).

African Ethnic Groups of South Africa

Many of the previously differentiated black South Africans in this group enjoy simple food, often cooked on open coals for maximum flavor (Samuelsson 2006, p. 278). "The concept of *Shisa Nyama* comes from our African identity, culture and heritage. Customer[s] come in, pick the meat of their choice, and our braai masters cook it to perfection" says Rita Zwane (Riffel et al. 2016, p. 132). Urban and rural black South Africans also display differences in their diets, such as rural people who may also partake in the consumption of insects, although perhaps not to the extent people from the neighboring countries do. Just a little north of Zimbabwe, in Malawi, a group of housewives included recipes for a range of insects in their Malawi Cookbook, such as bee larvae (*ana a njuchi*), large green bush crickets (*bwamnoni*), grasshoppers (*dziwala*), red locusts (*dzombe*), flying ants (*inswa/mbulika*), black flying ants (*mafullufute*), green caterpillars (*mofa/pphalabungu/kawichi/mbwabwa/katondo*), sand crickets (*nkhululu*), large green shield bug (*nkhunguni*), lake fly (*nkhungu*), shield bug (*nsensya*), and cicadas (*njenje*) (McCann 2010, p. 149). Other traditional dishes, as per Table 1, include steamed breads, simmered farm chicken, grain beers, and many more. Leafy green vegetables, or *morogo*, the generic term for such wild leaves, include examples such as bean plants, beetroot leaves, and sweet potato (Sitole 2009, p. 42). Also referred to as *mukusule*, these variety of greens may even be sun-dried and kept for the future when in excess, particularly during the winter months (Sitole 2009, p. 58).

European Races of South Africa

White South Africans are mostly differentiated by their home language, such as Afrikaans, English, or other European languages such as Greek, German, or Portuguese. The cuisine of these specific language users often direct their home food habits: English-speaking white South Africans probably eat foods based on traditional English food practices, while Afrikaners' food is historically based on Dutch cuisine that was very much influenced by English food, German, and French influences, as well as some of the local black and Portuguese cuisine influences. It is, however, specifically the Malay influence for spices that contribute to what is considered Afrikaner cuisine or Boerekos (Van Zyl 1985, p. 5). As can be observed from Table 1, many meat dishes exist in the repertoire of this group.

South African Indian People

Indian cookery in South Africa dates back to the first boatload of indentured laborers who arrived in South Africa in 1860 (Parbhoo 2008, p. 7). Even though these arrivals were for the same reason, they were by no means a homogenous group, bringing a vast array of food variances that came with their linguistic, geographical, and religious differences (Mayat 2007, p. 18). Even though Indian cookery in South Africa is typically Indian, it differs from India and Pakistan, and have *biryanis*, *bhajias* (chili-bites), samosa, curry and rice, and *achars*, which have become familiar fare for all racial groups in South Africa (Mayat 2007, p. 18). Curry, the generic term that the British used to group all spicy sauce and gravy-based Indian dishes under one label (Govender-Ypma 2017, p. 7), is another much loved South African cross-cultural dish, so much, so that author Ishay Govender-Ypma (2017, p. 6) identified no less than 64 distinct curries, spread over seven of South Africa's 9 provinces, to such a degree that the concept of a Durban curry is said to be "not a blend of North and South", "... not a clone. It originated here!" (Platter et al. 2015, p. 10). Many preparation and cooking methods for South African Indian dishes follow styles such as those in India, where, for instance, spices and flavorings in curry dishes, for example, are fried off prior to other South African-specific ingredients that are added.

A Rainbow Cuisine of South Africa

From Table 1, it is clear that many dishes are only specific to the particular cultural group as discussed before. However, it would be impossible to "dress up and package" the cuisine of South Africa into stand-alone separate groups (Engelbrecht and De Beer 2005, p. 8), to the extent that the concept of a Rainbow Cuisine, as an inclusive South African cuisine, has been proposed (Snyman and Sawa 2001). It should however be noted that some of the food items in Table 1 will also be found as part of the cuisine of South Africa's neighboring countries, possibly with small variations and certainly called by a different name.

A dish such as *biriyani* that may be considered a very Indian dish is equally found in the Cape Malay cuisine and that of the Afrikaner (Van Zyl 1985, p. 36). Crossover flavors include the use of dried *naartjie* (clementine) peel, which is ground into a powder and used to flavor cakes, puddings, meat dishes, and vegetables (Sydow and Sydow Noordien 2019, p. 13). Samuelsson (2006, p. 285) writes that there is one dish South African families gather for on Sunday afternoons, whether Afrikaner, Cape Malay, or of black descent, that is called *bobotie* (a curried minced meat dish, baked with a savory custard topping) – colored families may add almonds and raisins, while Afrikaners may prefer a simpler version, also sometimes made with venison, such as made by Annatjie Reynolds (Riffel et al. 2016, p. 74). Colored people often also serve their *bobotie* (and other dishes) with yellow rice, made slightly more flavorsome with sultanas and cardamom (Lagardien 2008, p. 81). *Potjiekos*, a meat and vegetable stew cooked in layers in a three-legged cast iron pot over an open fire, is another firm favorite of the whole nation, irrespective of culture, and many *potjiekos* competitions are held countrywide. Even though *boerewors*, in Table 1, is indicated as a food item from the European and black cultural groups, it is one of the quintessential South African foods (Samuelsson 2006, p. 281). Although made with a myriad of spice mixes and flavors, these days it should essentially be made a mixture of beef and pork meat, coarsely ground and stuffed in a continuous intestine casing, and often *braaied* on an open fire (Van Zyl 1985, p. 83). Pickled fish, also referred to as curried fish (Van Zyl 1985, p. 24), is equally revered by many population groups of South Africa, even though colored people often serve it on Easter Friday with hot cross buns (Sydow and Sydow Noordien 2019, p. 38). *Roosterkoek* (Essop and Fraser 2012, p. 22; Roodt 2016, p. 75), basically bread rolls cooked on a grid over a "braai" fire, by Thelma Ntombozi Magwadi (Riffel et al. 2016, p. 282), or *vetkoek* (Van Zyl 1985, p. 156), deep-fried yeast bread dough buns such as that made by Ntombenhle Mtambo (Riffel et al. 2016, p. 150) and possibly even *askoek* (Essop and Fraser 2012, p. 115), bun sized pieces of bread dough baked directly in the coals, are essentially all made with the same dough recipe but cooked in different ways. *Vetkoek* would be what black South Africans sometimes may call fatcakes or *magwenya* (*magwinya* as they are known in Botswana). The bunny chow, from the slang term for hunks of bread with a saucy bean curry, bania chow, eaten by the mercantile class (Mayat 2007, p. 297), is indeed a shining example of the saying "necessity is the mother of invention." Essentially half a "government" loaf bread, of which the inside is scooped out and filled with meat and/or vegetable curry such as made by the Patels (Riffel et al. 2016, p. 296) in the apartheid years when places to sit down and consume a meal were reserved for whites only (Platter et al. 2015, p. 11), the bunny chow provided both container and filling starch in one go. Other street food sandwiches, such as the Gatsby (Sydow and Sydow Noordien 2019, p. 118), s*patlo* (also spelled *sphatlo* and *spathlo*), and *kota*, are South African sandwiches popular in the townships of Gauteng. It is made from a hollowed out quarter loaf of bread, filled with a variety of ingredients, often chips, cheese, polony, and *atchar* and even *chakalaka* (Sitole 2009, p. 55), a delicious condiment salad made with carrots, onions, peppers, and curry powder.

Finally, one of the staples of the region, *pap*, is made of ground maize flour and water cooked together to varying thicknesses. *Stywepap* (Van Zyl 1985, p. 99) is stiff porridge, often eaten at a *braai* (barbeque) but also often eaten with milk and sugar for a filling breakfast. Even though maize, whole, dried, crushed, or ground, may be a staple of many African countries, Dorah Sitole (2009, p. 21) considers the isiXhosa of the Eastern Cape the "custodians" of the grain. Even presentation is important in such a humble dish, such as *vhutetwe/vhuswa*, where the cooked porridge is poured out in layers on a plate to resemble thick pancakes that are kept covered so they stay moist and the layers are peeled off when required (Sitole 2009, p. 60). When a straight maize porridge is made that is fermented, it is called *vhuswa* (Sitole 2009, p. 59), while *imbila* is a sour fermented porridge made with maize meal and sorghum. When the porridge itself is not fermented or soured, such as *ting* (Sitole 2009, p. 38) (also made from *mabele* meal (Sitole 2009, p. 63)), but made with sour milk, it is called *imphalishi elimuncu* by Zulu South Africans (Sitole 2009, p. 32), or *sebube* of the Setswana (Sitole 2009, p. 63). *Krummelpap*, or *putupap* (or simply *phutu* (Sitole 2009, p. 30)), is another variance of the nation's staple food that is made in a crumbly version that resembles bright white couscous (Roodt 2016, p. 16). On the Highveld of South Africa and Lesotho, it is called *mealie pap* (*mielie pap*) or *papa*, while in Venda near the Limpopo river it is referred to as *mutuku*, and further across the border into Zimbabwe it is called *sadza*, and called *xima* or *upswa* in Mozambique (McCann 2010, p. 137). When made by Xhosa speaking people from the Eastern Cape, it is often cooked together with a variety of wild green vegetables and called *umfino* (McCann 2010, p. 152). In this region, maize rice is also often cooked the same way (Sitole 2009, p. 26). When made simply with spinach leaves and maize meal, it is called *isijabane* by Swazi people (Sitole 2009, p. 46), or a sugar bean and maize meal porridge that is called *sishwala*, also made by Swazi people

(Sitole 2009, p. 48). As one of the core staples of a large part of the African continent, “it is remarkable that it almost never appears in published literature on cooking” (McCann 2010, p. 138) – there are only three references of maize (none of them referencing the porridge that most populations consume, but rather as *samp*, a dried whole maize kernel), in Jessica Harris’s *The African Cookbook*. In the much more academic comprehensive work by Fran Osseo-Asare, Food Culture in sub-Saharan Africa, only one recipe for a maize dish, namely, Congolese *bidia*, is offered. Similarly, Laurens van der Post’s African Cooking provides only two recipes, of which one is for a green mealie bread (made with fresh white maize kernels), which makes little sense, considering maize is Africa’s most produced food crop (McCann 2010, p. 139). It is also the food item people rely on in times of need, such as Mozambique women’s account when there is severe poverty, and they say that then the *xima* is even eaten without a sauce, instead a small piece of dried fish will be cut off and roasted over the fire, so that people can sit around and smell the fish, which makes the *xima* more appetizing and makes people feel more full (McCann 2010, p. 139). A similar tale, as told by Lizz Meiring, is called *pap en tik*, of Knysna forest workers that were so poor, that they hung a piece of meat from a string above the table, so that each person could touch (*tik*) their ball of porridge (*pap*) against the meat to get a bit of the flavor of the meat. These days *pap* however even comes in a modernized luxurious tart, made with layers of tomato sauce, mushrooms, bacon, and cheese (Roodt 2016, p. 147).

Ginger beer, a slightly effervescent sweet drink made from water, sugar, yeast, and various gingers, sometimes with raisins added (Van Zyl 1985, p. 183), is one of the cross-cultural drinks of the nation, while rusks (those dried-out slightly sweet bread-like biscuit with a cup of coffee or tea) and *biltong* are eaten by most people in the country as snack food (Essop and Fraser 2012, p. 63; Roodt 2016, p. 278). Other beverages may include *Klippies en Coke*, a brandy and Coca Cola drink made from a brand of brandy called Klipdrift. Fermented home brewed beers are made by various black cultural groups, such as those displayed in Table 1, *umqombothi* from the Xhosa and Zulu people that is produced from maize, maize malt, sorghum malt, yeast, and water.

In conclusion, whether the specific food dishes belong to any of the four specific demographic or ethnic groups of South Africa, or is considered a true Rainbow food, the cuisine of the region is vibrant and evolving. These days celebrity chefs and restaurants celebrate the inclusive cuisine of South Africa in a variety of ways, such as Zayaan Khan (Riffel et al. 2016, p. 182) and restaurateur Kobus van der Merwe, who celebrate the notion of a foraged cuisine that includes items such as seaweed, grey leaves (*Salvia africana-lutea*), *Aasbos* (*Coleonema alba*), tortoise berry (*Muraltia spinosa*), crowberries (*Searsia*), sour figs or *vygies* (*Carpobrotus edulis*), and kei apples (*Dovyalis caffra*). Other modernizations of traditional dishes include Swartland Eggs Benedict, *skilpadjies* (minced sheep’s liver in caul fat (Essop and Fraser 2012, p. 155)) with pan gravy and poached eggs, as made by Adi Badenhorst (Riffel et al. 2016, p. 112) or an *amadumbe*, *mbuya*, and purslane salad by Nompumelelo Mqwebu (Riffel et al. 2016, p. 244). Indigenous ingredients are often celebrated and even given certified status, such as Karoo lamb that is defined as Karoo lamb or Karoo mutton which denotes the origin of sheep meat products and can be associated to carcasses, freshly packed or frozen meat or derivative products complying with the certification standards (KD Foundation 2019). A cuisine develops over time with many contributions, which are, among other, also determined by specific indigenous ingredients, such as *waterblommetjies* (water flowers) or Cape pondweed; *Aponogeton distachyos*, grown in dams and vleis of the Cape (Sitole 2009, p. 16); *mawuyu* or *umkhomo*, a baobab fruit dessert made in Zimbabwe (Sitole 2009, p. 74); or *muthumbula* (*mandioca*), deep-fried cassava from Mozambique (Sitole 2009, p. 81). Kalahari truffle, from which several dishes can be made, such as truffle oil (de Chavonnes Vrugt et al. 2009, p. 22), is an edible dessert fungi, *Kalaharituber pfeilii* (once known as *Terfezia pfeilii*), that forms a symbiotic relationship with the roots of several plant species, most commonly, the Tsamma melon. Particular names are also often given to dishes, such as *Pofadder* (in fact the name of a snake) (Van Zyl 1985, p. 93) is chitterling stuffed with liver and mutton tail fat (Essop and Fraser 2012, p. 29); *slaphakskeentjies* (Van Zyl 1985, p. 121), a sweet and sour whole small onion in sauce dish; *smileys* – cows heads – because of the way the cow's lips curl over the teeth (Samuelsson 2006, p. 278); a chicken neck curry, called *fluitjes* (whistles), that may be considered poor man's food (Sydow and Sydow Noordien 2019, p. 72); *krapvleis* (scratch meat), the fine meat removed with a spoon between the chine bones (Essop and Fraser 2012, p. 106); or Karoo oysters, lamb's testicles baked until tender (Essop and Fraser 2012, p. 153).

Finally, an influx of migrant people from other countries means that much of the food in Johannesburg's inner city is now a vibrant mix of Ethiopian, Indian, Nigerian, and Congolese cuisines according to Jo Buitendach (Riffel et al. 2016, p. 314), similar to what is found in some of South Africa's other major centers.

Food Struggles of Twenty-First Century People of the South

Individuals and societies, who display upward economic mobility, such as in growing parts of Southern Africa, experience lifestyle changes, which may affect their food and nutritional behavior. Referred to as the nutrition transition, this epidemiologic transition is associated with an increased prevalence of obesity and noncommunicable diseases (NCDs). Although correlations are also drawn between poverty and NCDs (Nishtar et al. 2018, p. 2) under nutrition as a result of poverty is not the only health concern associated with eating and nutrition behavior. What is referred to as the double burden of nutrition-related diseases, in fact, incorporates both under- and over-nutrition, or food insecurity (reflected in Table 2) versus overweight and related complications (Popkin 2014, p. 91). The nutrition transition is "defined as the changes in dietary patterns and nutrient intakes when populations adopt modern lifestyles during economic and social development, urbanization and acculturation" (Vorster et al. 2011, p. 429). Also referred to as the "diet transformation," such changes often come about as a result of many factors such as females – traditionally the food preparers in family structures – joining the work force and

Table 2 Food insecurity by selected Southern African country

Country	Number of severely food insecure people, 3-year average (mil)	Percentage of total population: severely food insecure people (%)
Botswana	0,9	41.3
eSwatini	0,4	29.5
Lesotho	1,1	50.0
Mozambique	12,6	42.5
Namibia	1	39.0
South Africa[a]	16,6	29.2
Zimbabwe[b]	7,8	53.5

Source: FAO.org (FAOSTAT), 2018
Zimbabwe's data source: reliefweb.int/report/Zimbabwe, 2018
aCountry with the lowest percentage
bCountry with the highest percentage

male workers working further and further away from home, causing them to rely on convenience foods rather than home prepared foods.

Figure 8 portrays the prevalence of overweight adult men (a) and women (b) in 46 sub-Saharan African countries according to the African Health Observatory of the World Health Organization (WHO) (http://www.aho.who.int/profiles_information). Apart from Mozambique, the other Southern African countries mentioned in this research have a high overweight prevalence with South Africa 2nd (40.5% for males and 65.4% for females) and Botswana 4th (29.7% for males and 56.5% for females) on the list for both men and women. Africa in total has had a dramatic increase in its overweight and obese prevalence rate from 28.4% in 2000 to 41.7% in 2016.

Tschirley et al. (2015, p. 644) maintain that in the Eastern and Southern African region, processed food constitutes as much as 40% of the entire food budget across all households. As much as 70–80% of rural and urban middle-class people purchase processed foods. In an interview referring to the South African middle class, a respondent said: "they are prioritising, they've got the DSTV or their Skybox [television channels] or whatever, you know. They might have a decent car, but they are eating badly. . ." (McEwan et al. 2015, p. 15). Africa's urban food market share has also grown quickly and currently constitutes more than half of the overall human food consumption. Consumption itself is changing beyond grains, dairy, fish, meat, and similarly produced foods, and it is now into "heavily into processed foods" (Reardon et al. 2015, p. 1).

Such changes spur the purchasing of processed convenience food and commercially prepared food. This "diet commercialization" means that nurturing individuals and societies have changed from what was previously predominantly home-produced or homegrown food to purchased food (Reardon et al. 2015, p. 5). Acknowledging the importance of a cuisine within a particular culture, and working proactively to retain traditional indigenous food knowledge, may help curb the commercialization of the Southern African diet.

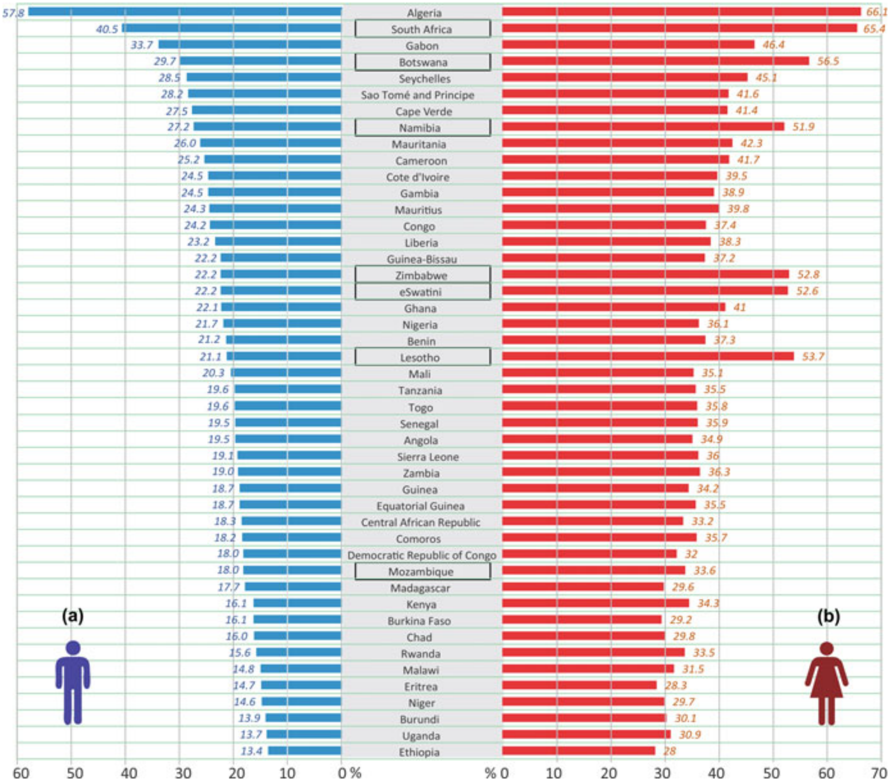


Fig. 8 Prevalence of overweight adults (a = males, b = females) per sub-Saharan African country (http://www.aho.who.int)

Conclusion

Not dissimilar to any cuisine of the world, South African cuisine, as part of the larger Southern Africa region, is home to a unique cuisine that may well in future be acknowledged internationally. The rationality of a South African cuisine, or the larger regional cuisine of Southern Africa, would join the global cuisine and be incorporated in the global food arena (Meiselman 2019).

In South Africa, with her long history of racial segregation, the people are slowly awakening to a celebration of the vast regional and cultural specifics of their own cuisine. The publication of cookery and food-related books and magazines are a steady interest in South Africa and slowly also of her neighboring countries. Food television, food shows, produce markets, and other platforms, which exposes the man on the street to food in general, are part of the influence of what citizens internalize as their cuisine. Interactions with cultures of neighboring countries contribute similarly.

The Southern African region is not without its problems, and as development increases and people choose easier convenience foods, they are faced with associated health-related problems in the same way other societies of the world do.

South Africa and her neighbors, however, have a richly diverse cuisine that is worthy of celebration; a regional cuisine that the world should take note of, explore and celebrate.

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Diet in Korea

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Abstract

These days, many foreign peoples are interested in Korean foods and diet, because of its history and healthiness. Many scholars ask us what is the nature of Korean diet in addition to history, culture, and health. When it comes to the values embedded in Korean food, which has traditions that date back thousands of years, three things come to mind. The first is respect and looking out for others, the second is balance and harmony, and the third is health. When defining the K-diet, various components are considered, such as raw materials or ingredients, traditional cooking methods, technology, and fundamental principles and knowledge. However, it would be preferable to establish the definition of Korean food by focusing on the preservation of traditional methods and core principles. The Korean meal table is characterized by servings of bap (cooked rice), kuk (kinds of soup), and dishes on one table. While various cooking methods are used in Korean cuisine, the most representative method is fermentation which enhances both the flavor/taste and preservation of the food. The K-diet is composed of bap and kuk and various dishes with one serving called bapsang. Kimchi is always served at every meal. The principal aspects of the K-diet include proportionally high consumption of vegetables, moderate to high consumption of legumes and fish, and low consumption of red meat. Banchan, a kind of side dishes, is mostly seasoned with various Jang (fermented soy products), medicinal herbs, and sesame or perilla oil. The points of taste in K-diet are quite different from those of western tastes. Unique expressions of Korean taste are kan, the right taste, and siwonhan-mat, which is typical in Korean delicious tastes. This chapter provides the features of the K-diet as well as an introduction to K-food and the traditions and health value of the K-diet and K-food. Moreover, this is vital to promote the cultural values of Korea (K-value) by bringing together traditional principles and scientific evidence. Lastly, a couple of representative bapsang (K-diet) and some representative K-foods (K-food) among a hundred kinds of Korean foods will be introduced.

Introduction

Nowadays, the transportation is convenient and easy to go anywhere in the world, so many travelers and people are increasingly interested in the ethnic or traditional food of each country. Also Korean diets are emerging due to its history and healthiness. They ask us what is the nature of Korean diet in addition to history, culture, and health (Kwon et al. 2017a). Based on “Korean Diet and Their Tastes” in the book of *Korean Functional Foods* (Kwon and Chung 2018), I wrote this chapter. Korea has developed a unique food culture connected to its long agricultural history. In Korea, other lifestyles as living house style and clothes wearing style are totally changed to western style; however, eating and diet style is conserved as traditional ways of eating. Nowadays Korean family still prefer the Korean diet as traditional ways of eating at their homes and even in restaurants, even in young generation. Only cooking kitchen is modernized. Recently, interest in Korean food, especially regarding its health benefits, has greatly increased. However, there are insufficient resources and research available on the characteristics and definitions of Korean cuisine. Although the Korean diet (K-diet) has been widely discussed in regard to raw ingredients, traditional cooking methods and technology, and fundamental principles and knowledge, it would be valuable to preserve the traditional methods and knowledge of Korean foods rather than focus on the raw materials themselves. Korean meals have historically been served with bap (cooked rice), kuk (dishes with broth), kimchi, and banchan (side dishes) to be consumed at the same time. As traditionally baking and frying were not common methods, Koreans tended to use fermenting, boiling, blanching, seasoning, and pickling. Among these methods, the most characteristic method is fermentation. The process of fermentation enriches food flavors and preserves foods.

Korea, located in Northeast Asia, has an agricultural history that has continued for more than 5,000 years despite its close proximity to China. The Han Chinese, who founded the Three Kingdoms and Qin, Tang, Song, and Ming dynasties, developed their own language and controlled China until the Qing dynasty emerged. Korea, from Kochosun and the period of the Three States (including Kokuryo, Baekje, and Silla) to Koryo and Chosun, maintained independence from China and developed a unique culture and language (Woo 2018). Linguistically, Korean belongs to the Altaic language group along with the Japonic, Mongolic, Tungusic, Hungarian, and Finnish languages. Moreover, the Mongolian spot, slate gray nevus by congenital dermal melanocytosis in the surface of skin in infants, that is prevalent among Koreans suggests biological differences between Koreans and Chinese. Likewise, Korean food culture has also developed distinctly from Chinese cuisine (Chung et al. 2019).

According to Kwon (2015), the development of food technology was prompted by the desire to preserve food resources and to eat delicious. For example, in China, frying and pickling were the prevalent methods in reducing water content (a_w) to protect against microbial spoilage of food and to increase the tastes. In contrast, the limited production of cooking oils in Korea led to the development of the fermentation process for food preservation, which utilizes effective microorganisms against microbial spoilage. While milk was the main ingredient in fermented products, such as cheese and yogurt, in countries with strong livestock industries as in western countries, the main ingredients in Korean fermented foods were grains and vegetables. This was due to their settled lifestyle and focus on agriculture. The Korean foods have developed from the necessity of preserving them during hot summers and long, harsh winters on the Korean Peninsula characterized by rocky ocean fronts on the east, south, and west and by rugged mountains on the north. This geographical isolation from neighboring countries and the distinct weather allowed the early Korean people to develop the most enduring cultural legacies of the Korean diet. In this environment, salted beans, fish, and vegetables were preserved by fermentation. Historically, Koreans have made various jang (fermented soy products) (Shin and Jeong 2015; Yang et al. 2011), including kanjang (soy sauce), doenjang (soybean paste) and kochujang (red pepper paste), and diverse types of kimchi (Jang et al. 2015) with vegetables. These unique fermentation techniques are examples of authentic Korean food (Kwon et al. 2014). All these fermented jang and kimchi are essentials for Korean Foods to be tasty and delicious or to eat, to pass through the throat and digest well.

Korea has developed unique foods as well as a food culture that is fundamentally distinct from Chinese or Japanese food cultures. Food is one of the key elements of culture and presents possibilities for promulgation of various cultural contents. However, this effect has been diminished by a lack of cohesive definitions and concepts in Korean food culture. Therefore, it is necessary to establish consistent definitions and concepts to be used in relation to the Korean diet.

Definition of Korean Diet (K-Diet)

The establishment of consistent definitions and concepts in Korean food (K-food) should be based on systematic and scientific research in order to promote its health benefits globally. For that, scholars of the food and nutritional sciences have collaborated and announced the “Seoul Declaration on K-diet: Korean Heritage and Healthiness.” In the postindustrial age, culture is one of the key elements of a country’s competitiveness in the global market. Therefore, this chapter will discuss definitions, characteristics, and representative K-foods that have been introduced in the Seoul declaration and embody fundamental aspects of a Korean meal (Kwon 2016).

K-diet (Korean diet) and K-food (Korean food) are two separate concepts. The concept of K-diet is used to represent traditional Korean food culture, cooking methods, and dietary habits and patterns; K-foods are the food constituents of the K-diet. K-food and K-diet are often described as Korean cuisine, Korean diet, or traditional Korean food. A few elements of defining food culture have been put forward, such as frequently consumed foods, raw ingredients or materials, technology or cooking methods, and the fundamental principles found in the country’s dietary patterns. These views put different emphases on food and diet.

The first aspect introduced, which views K-foods as frequently consumed foods, would allow popular foods among youth, such as jajangmyeon (noodles with jang), pizza, or fried chicken, to be considered K-food. The criteria of the time period for Korean food would be needed but introduce unneeded complexity. The second idea which has often been cited by the Korean Ministry of Agriculture suggests that K-food should be made with ingredients (agricultural products) produced only in Korea (Chung 2015). This is very limited in that K-foods should only use raw materials or ingredients grown in Korea. It is not reasonable because so many crops and vegetables have imported around the world now. According to this view, kimchi made from imported cabbage would not be considered K-food. The third view proposes the use of traditional cooking technology as the key element of K-food in an attempt to overcome this issue. Although it is important to preserve traditional Korean cooking methods, this point of view focuses only on the physical and material aspects of methods. As this view overlooks technological advances, doenjang fermented in jars other than hangari (Korean earthenware crock) would not qualify as K-food (Kwon and Chung 2018).

Therefore, when discussing K-food and K-diet, one should focus on whether certain foods or dishes are made with traditionally used ingredients regardless of the origin of produce, made following traditional cooking methods and principles, and, lastly, preserve the spirit behind traditional Korean food practices. The definition of traditional Korean food by Chung (2015; Chung et al. 2016b) reflects these ideas: “Food made with raw materials or ingredients that have been traditionally used in Korea, or with the similar ingredients, use authentic or other similar cooking methods, have historical and cultural characteristics, and have developed and been passed on through people’s lives.” This meaning contained in Korean food has been interpreted as consistency, patience, consideration, beauty, and appreciation for arts. In the Seoul declaration, the definition of K-diet represents the interpretation as follows:

> K-diet is composed of bab (cooked-rice) and kuk, and various banchan with one serving called bapsang. Kimchi is always served at every meal. The principal aspects of K-diet include proportionally high consumption of fresh or cooked vegetables(namul), moderate to high consumption of legumes and fish and low consumption of red meat. Banchan is mostly seasoned with various Jang (fermented soy products), medicinal herbs, and sesame or perilla oil.

The traditional ingredients of K-food consist of grains and vegetables; however, oceanic regions have used fish and seaweed. Medicinal herbs such as garlic, green onions, and red pepper have also been used to enhance flavor/taste and add to the health benefits of food. Korean fermentation technology has played an important role in preserving these food resources, including legumes, vegetables, and fish. Historically, grains, including rice and barley, were the main source of carbohydrates. Legumes and fish provided protein. Vegetable oils made from sesame or perilla served as a main supply of fat. As metabolic disorders caused by overnutrition have become a serious problem in developed countries, the Korean diet can be promoted as a healthy alternative. From a sociocultural perspective, the structure of the traditional Korean meal (Kim et al. 2016), which allows people to share various banchan together, has played an educational role in teaching common etiquette and courtesy to be practiced while eating communal meals (see Fig. 1 in Kim et al. 2016).

Characteristics of K-Diet

The characteristics of K-diet include:

1. *Various recipes based on rice and grains*
2. *More fermented foods*
3. *More vegetables from wild landscapes and the seas*
4. *More legumes and fish and less red meat*
5. *More medicinal herbs like garlic, green onion, red pepper, and ginger*
6. *More sesame and perilla oil*
7. *Little deep-fat fried cooking*
8. *More meals based on seasonal produce*
9. *Various local cuisines*
10. *More home-cooked meals*

These ten characteristics are explained in more detail next.

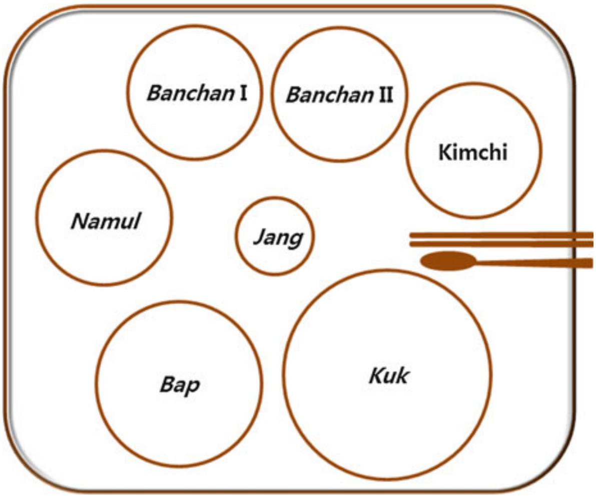

Fig. 1 Diagram of basic bapsang in everyday Korean diet. The structure of the traditional Korean bapsang (Kwon and Chung 2018, Kwon et al. 2017a). Bap is served alongside kuk, which assists in the swallowing and digestion of the food. In the bapsang, it is comprised of kimchi, namul, one additional vegetable dish (Bancha I), and high protein dish (banchan II) usually made from fish or meat as chim or gui. Jang, or salted dishes such as jangat-ji and jeotgal, are used to season food and stimulate one's appetite. A variety of bapsang can be constructed using diverse ingredients and cooking methods depending on the season, regions, and one's preference. Overlapping ingredients and methods allow for well-balanced flavors and nutrients

Various recipes based on rice and grains: While the main energy source found in western cuisine is wheat, the predominant Korean dietary energy source is grains such as rice and barley. Bap is served with kuk and banchan (Fig. 1). Variations of this format such as kukbap, a dish that combines kuk and bap served in one bowl, and bibimbap (Chung et al. 2015), a dish with mixed bap and banchan, are also popular (Kim et al. 2016; Kwon and Chung 2018). Sungnyung (Moose 1911) is the last step of a meal. It is a traditional Korean drink made from the roasted crust of rice that forms on the bottom of a pot after cooking rice.

More fermented foods: Throughout the agricultural history of Korea, fermentation technology has been widely used to enrich the flavors of food by utilizing effective microorganisms against microbial spoilage. Fermented soy products such as kanjang, doenjang, chongkukjang, (Shin and Jeong 2015; Yang et al. 2011) and kochujang are the fundamental ingredients of various sauces and kuk. Doenjang-kuk, made with vegetables and doenjang, is a traditional iconic kuk. Kimchi is another representative Korean fermented food known for its authenticity and its health benefit of reducing the activity of harmful bacteria. Jeotgal is salted fermented seafood used to enhance flavor and appetite rather than increase the nutritional value of food (Koo and Kim 2018). As seen before, traditional fermentation technology has been used to intensify flavors in food beyond its role in food preservation.

More vegetables from wild landscapes and the sea: The Korean diet is characterized by high vegetable intake, which is due to the agricultural environment of the country. Vegetables such as lettuce, peppers, carrots, or cucumbers were often consumed raw with sauces made of kochujang, doenjang, kanjang, or vinegar and topped with sesame seeds. Cabbage or spinach was often blanched and seasoned with traditional spices. Both raw and dried vegetables were ingredients for kuk, which was flavored with doenjang (Kang et al. 2016). Kimchi is the most widely enjoyed vegetable dish in Korea. Korean cuisine also includes various types of seaweed dishes made from laver, green algae, kelp, *Hizikia fusiformis*, and *Capsosiphon fulvescens*, all of which are abundant sources of dietary fiber and vitamins.

More legumes and fish and less red meats: Koreans have enjoyed diverse legumes such as soybeans, mung beans, red beans, cowpea, peanuts, walnuts, and ginkgo nuts. Surrounded on three sides by oceans, Koreans have also consumed fish using various techniques to prepare them, such as grilling, boiling in sauce, and marinating. Because lamb, horse meat, beef, and pork were rare in the agricultural environment, the main source of protein intake was poultry, such as chicken and pheasant, but pheasant is rarely used these days.

More medicinal herbs like garlic, green onion, red pepper, and ginger:Compared to the geographically close countries of China and Japan, one of the interesting characteristics of Korean food is the diverse use of yangnyom (a kind of seasoning), created with garlic, green onions, red pepper, and ginger (Surh 2003; Na and Surh 2018). While spices like black peppers have been widely used to hide the unpleasant odors of food in Southeast Asia, medicinal herbs have been used to enhance flavors and increase the food's health benefits (Hur 1610).

More sesame and perilla oils: Historically, the amount of animal-based and vegetable cooking oils produced in Korea was quite limited. While camellia, castor, sesame, and perilla oils were produced in Korea, mainly sesame and perilla oils were used in cooking. With its distinctive aroma, sesame oil was used in kuk, namul, and bibimbap. Perilla oil was used in pan-frying foods or making yukwa (a puffed rice snack).

Little deep-fat fried cooking: As mentioned before, deep-frying techniques could not have developed in Korea due to the limited production of animal-based and vegetable cooking oils. Instead, cooking methods such as pan-frying or stir-frying, which did not require large amounts of oil, were developed. Jeon, a type of pancake made from flour batter, is the most representative example of this cooking method.

More meals based on seasonal products: Korea has an advanced agricultural industry and four distinctive seasons, which provide an abundance and diversity of ingredients. For this reason, its cuisine has developed recipes that use fresh ingredients available in each season. For example, Koreans make fresh kimchi all year round utilizing different varieties of seasonal cabbage, except during the winter, as kimchi is stored underground in jars to control temperature for fermentation (Jang et al. 2015).

Various local cuisines: Surrounded by oceans on three sides, Korea lacks extensive plains- mountains cover over 70% of its territory. Recipes have been developed based on regional characteristics: grain-based dishes such as bibimbap in the plains (Surh 2003), seafood dishes in oceanic regions (Kim and Jang 2015), vegetable dishes such as namul (Lee 2018) in mountainous regions, and dishes with freshwater fish or clams in regions near rivers. The identification and refinement of these regional recipes and ingredients would be valuable.

More home-cooked meals: The history of agriculture in Korea has shaped a group culture based on family and community. Dedication, communication, and consideration among family members are deeply held values in its culture. As meals are cooked with natural ingredients rather than processed ingredients, usually by mothers, Koreans have believed that food represents a mother's love. This idea has been reflected in the K-diet with Jipbap (home-cooked meal) and umma-sonmat (the taste of mother's love).

The Structure of Bapsang and Representative K-Diet

The Structure of Bapsang of K-Diet

As mentioned in our previous works (Kwon 2016; Kwon and Chung 2018), it is crucial to analyze the components of a K-diet and identify K-foods representing these characteristics.

For easy understanding, we adapted our previous paper's report (Kwon 2016) to introduce Korean bapsang as follows (Fig. 1): Korea's traditional meal (bapsang) is generally made up of four constituents.

Bap (cooked rice) provides calories, the main source of energy.

Kuk (soup) allows people to chew and swallow rice, in turn supporting the digestive system. Previously, the word kuk was translated into soup; however, kuk is quite different from western soup (Kim et al. 2016; Kang et al. 2016) (see section "Determining Factors of Siwonhan-mat").

Banchan (side dishes) make up the third element and make the food taste better to support digestion while replenishing the body with nutrition. Usually namul, legume, and fish comprise banchan.

Jang (one of sauce, made from soy or fish) was served to stimulate peoples' appetites (Shin and Jeong 2015; Hwang et al. 2005). Yangnyom (one of sauce) includes herbs like garlic, green onions, red pepper, and onions. Unlike spices that are often used to cover or remove unpleasant smells of food, Korean yangnyom is used to enhance flavors and increase the health benefits of the foods it is combined with (Surh 2003; Na and Surh 2018).

The kinds of bap (cooked rice) that are used in main dishes include steamed rice, boiled barley, and multigrain rice. As for kuk, doenjang-kuk, miyok(sea mustard)-kuk, and beef kuk are commonly eaten. Kimch is always there. Kimch was listed as one of top five healthiest food in worlds (Health Magazine 2006). And as a part of banchan: others including roasted meat, vegetables, and salad dressed with garlic and chili powder; vegetables served as cooked or fresh namul; cooked namul seasoned with sesame seed/oil or perilla seed/oil, and fresh vegetables seasoned with vinegar - are also served as side dishes. The most basic seasoning used to make the food savory is kanjang (fermented soy sauce; jang in Korean means fermented soy sauce or paste), doenjang (fermented soybean paste), vinegar, kochujang, and jeotkal (fermented fish sauce from anchovies, shrimp, etc.) (Shin and Jeong 2015; Koo and Kim 2018). Jeotkal can be eaten as a side dish itself and more often is used as seasoning (Hwang et al. 2005; Koo and Kim 2018). In Korea, people like to drink sungnyung made from leftover scorched rice on the bottom part of a pot to finish off a meal like a tea or coffee (Moose 1911). By using these four fundamental foods, Korean people have been developing their own unique meals (bapsang) by choosing one or more elements in each category even in the group food services as school and factory.

Key elements of the Korean meal structure have been established, and the 100 most representative K-foods have been selected according to these elements (see Table 1). Most Korean meals are composed of banchan served with bap, but they are often misunderstood as main dishes by westerners. Although some modern Korean restaurants offer food served in courses, the traditional Korean meal is served all at once on the table. One-bowl dishes are not included in the bap category in Table 1 as one-bowl dishes and rice cake are consumed during busy farming seasons or on special occasions, such as weddings, sixtieth birthdays, and ancestral rites (Kwon and Chung 2018). Examples of one-bowl meals include kuksu (a noodle dish), kukbap made from kuk and bap, bibimbap (Chung et al. 2015) made from bap and banchan mixed with jang, and theok-kuk made from theok (rice cake) and consumed on New Year's Day. The kuk category includes kuk and kuk-based one-bowl dishes (Kwon and Chung 2018), such as chigae, jeonkol, and tang. The banchan category consists of kimchi, namul, and banchan made from protein sources such as meat and

Table 1 Categories of elements which are constructing in Korean Diet (Korean bapsang) (Fig. 1) and representative Korean foods (K-food). K-food lettered in red in the list will be described in text in short

Category	Sub-category		Representative Korean foods (K-food)
Bap (main dish)	**Bap**		Ssalbap (white rice, brown rice, black rice), boribap, kongbap, okokbap (five grain rice), nurungji
	Juk		Juk (rice juk), pumpkin juk, abalone juk, mung bean juk, red bean juk
	One-bowl food		Bibimbap, theokmandutkuk (theok-kuk, mandutkuk), kuk-bap, kuksu (naengmyeon, kalkuksu, kongkuksu, kuksujangkuk)
Kuk/tang	**Kuk/tang**		Doenjang-kuk, bukeokuk, kongnamulkuk, miyok-kuk, beef/radish-kuk, torankuk, sundaekuk, fish/maeuntang, komtang (seollungtang, kalbitang), haemul-tang, samkye-tang, yukgaejang, cheuo-tang, dakdori(chicken-dori)-tang
	Chigae/chonkol		Kimchi-chigae, doenjangchigae, cheongkukjangchigae, sundubuchigae, oigamjeong
Banchan	**Kimchi**		Baechukimchi (bossam kimchi), kkakdugi, oisobagi, chonggak kimchi, mul kimchi (dongchimi, nabak kimchi), yeolmu kimchi, gat kimchi
	Namul	**Saengchae**	Saengchae (radish, cucumber), juksunkyeojachae, buchumuchim, dalraemuchim, miyokmuchim, paraemuchim
		Sukchae	Kong(soybean)-namul, sikeumchinamul, dorajinamul, kosarinamul, beoseotnamul, aehobaknamul, gajinamul, chwinamul, naenginamul, gondrenamul, meowideulkkaejeuptang, japchae, tangpyeongchae (mukmuchim), gujeolpan
	Banchan	**Chim**	Kalbichim, suyuk, saengseonchim, sundae, kaetnipchim
		Gui	Kimgui, saengseongui, kalbi, bulgoki, samkyopsal, teok-kalbi, bukeogui, deodeokgui, borigulbi
		Jorim	Saengseonjorim, soegokijangjorim, kongjaban, yeongeunjorim, dubujorim
		Jeolim	Jangat-ji
		Bokeum	Myeolchibokeum, ojingobokeum, jeyukbokeum, theokboki, oibokeum (oibaetduri)
		Jeon	Saengseonjeon, chaesojeon (squash, eggplant, burdock, shiitake), hwayangjeok (pasanjeok), pajeon, haemulpajeon, nokdubindaeteok, buchujeon, dubumuchim, yukjeon
		Hoe	Saengseonhoe, hongeohoe, kanghoe (green onions, water parsley), dureupsukhoe
		Dried Banchan	Bukak, ssam (loose leaf lettuce, perilla leaf, crown daisy)

(*continued*)

Table 1 (continued)

Category	Sub-category	Representative Korean foods (K-food)
Jang/ yangnyom	**Jang**	Jang (doenjang, cheongkukjang, kochujang, kanjang)
	Yangnyom	Yangnyom (green onion, onion, chili, ginger), oil (sesame oil, perilla oil)
	Jeotgal	Jeotgal (shrimp, oyster, pollack roe), kajamisikhae
Desserts	**Theok, hankwa**	Shaped theok (songpyeon), pounded theok (injeolmi), steamed theok (baekseolki, ssukseolki, sirutheok, jeungpyeon, yaksik), karae theok, pan-fried theok (hwajeon), boiled theok (gyeongdan), yakkwa
	Drink/beverages	Sikhye, sujeongkwa, omija-cha, hwachae, sungnyung

fish. The jang category comprises jang, which is used for seasoning and stimulating one's appetite. This includes salted banchan, such as jangat-ji and jeotgal, and other types of yangnyom. Drinks such as sungnyung, theok, and hankwa are included in the dessert category. Although this classification is disparate from the traditional Korean meal structure (Yoon 1999), it is helpful for sharing with those who are familiar with the theories and concepts of modern food science. More discourse will be needed to refine this table to effectively bridge this approach between traditional understandings and modern food science.

The Representative Bapsang of K-Diet

While cuisine from the Korean royal court has been widely studied and is currently served in restaurants, this chapter focuses on food traditionally consumed by the common people. The traditional Korean meal table, or bapsang, is categorized by the purpose of the meal. It differs depending on whom the meal is for and the occasion for the meal. For example, a meal for guests would be different compared to a meal for elders of a family. Food consumed during celebrations such as birthdays and weddings would not be the same as food for funerals and ancestral rites. Each Korean holiday, including *Seollal* (New Year's day), *Daeboreum* (day of the full moon), *Chuseok* (Korean thanksgiving day at full moon in mid-Autumn), *Dano* (the fifth day of the fifth month of the year according to the lunar calendar), *Chilseok* (July 7 in the lunar calendar), and *Dongji* (winter solstice), is celebrated with unique and seasonal dishes such as spring bapsang, summer bapsang, autumn bapsang, and winter bapsang.

As seen previously (Kwon and Chung 2018), the Korean bapsang varies according to the purpose of the meal. This section introduces *Jeongwol Daeboreum-sang* (a kind of bapsang at first full moon of the lunar year) as an example of a holiday meal and *Kawul Bapsang* (bapsang for Autumn) as an example of a seasonal bapsang (a kind of bapsang served at autumn).

Jeongwol Daeboreum Bapsang: Koreans traditionally used the lunar calendar, so a full moon was considered to have a special importance, and it was believed that days with a full moon were filled with yin/yang (see Chung et al. 2015). The celebration of the first full moon, which falls on the 15th day of the lunar calendar, is the biggest holiday along with the eighth full moon, *Chuseok*. During the celebration people wish for good health and fortune in the upcoming year by playing traditional games and sharing meals (Fig. 2). In the morning of *Jeongwol Daeboreum*, people make okokbap with five grains (glutinous rice, red beans, beans, sorghum, and millet) and dried namul (bracken, mushroom, eggplant, squash, cucumber, dried radish greens, and aster), which is preserved from the past year to be consumed in the winter. These dried namul are first soaked in water, blanched, then seasoned, or stir-fried. Dried namul is a great source of nutrients, dietary fiber, minerals, and vitamin D, which is difficult to source during the winter season. Cracking *bureom* (nuts, such as walnuts and ginkgo nuts) is another popular tradition believed to prevent skin problems through the consumption of unsaturated fatty acid. People also enjoy the custom of *kwibalkisul*, which is sharing a type of rice wine together while wishing good fortune for the year ahead. *Kwibalki* means "ear-quickening."

Fig. 2 *Jeongwol daeboreum*-sang: This bapsang is served on jeongwol daeboreum-sang, the 15th day of the lunar calendar. It consists of okokbap, gomkuk, namul from the past year (eggplant, bracken, squash, dried radish greens, aster, pepper, cucumber, mushroom), kimgui, nabakkimchi, yaksik, and bureom. People share gwibalgisul with the meal and wish for good health and fortune in the upcoming year. Gwibalgi means "ear-quickening"

Kawul Bapsang: Bapsang served in the fall follows the basic structure of the K-diet described in Fig. 3. This structure of bapsang was established in the Chosun dynasty. It consisted of bap made with new-harvest rice and other grains, kuk, kimchi, and various banchan. Depending on the available ingredients, mothers would make banchan using an appropriate cooking method, such as the ones suggested in Table 1, and then they would season with jang, garlic, green onions, ginger, red pepper powder, and sesame or perilla oil. In this sense, banchan can be considered a bricolage food. Banchan typically consists of 80% namul dishes and 20% high-protein dishes that are made with meat, fish, eggs, or tofu. The varieties of banchan offer a healthy, balanced diet that is rich in nutrients and phytochemicals. All dishes are served on a table at once, so people can consume them based on their need and preference (Kwon and Chung 2018).

Values of Korean Diet

When it comes to the values embedded in Korean food, which has traditions that date back thousands of years, three things come to mind. The first is respect and looking out for others, the second is balance and harmony, and the third is health (Kwon 2019b).

Respect and Consideration

When preparing a meal in Korea, it is common to put elders first and cater to their preferences in terms of food selection. All family members sit around the table (bapsang) and eat together. Sometimes, a separate meal is served for elders out of respect. When seated around the bapsang, other family members wait for elders to

Fig. 3 Kaeul bapsang, an example of a simple seasonal bapsang. New-harvest rice, doenjangkuk, dakdori-tang, dububuchim, beoseot-namul, paraemuchim, and chongkak kimchi are served with kanjang

pick up their spoons first before beginning to eat. These dining customs, which are a common part of Korean food culture, were borne out of broader cultural norms of mutual respect and looking out for another. Korea has a long history as an agrarian society, but this history is not filled with abundance. In fact, as recently as the twentieth century, some Koreans were forced to sustain themselves on herb roots and tree bark during the Japanese colonial period. This is why it was not always easy to obtain a full meal, and providing hospitality to others in the form of a meal was a way of showing care and respect. Although the usual greeting in the west is “good morning,” it is traditional in Korea to greet elders in the morning by asking “have you eaten?” In the old days, it was even customary to look out for travelers who were staying at sarangbang (guest room) in a house by offering them a meal. These cultural traditions are still alive in some rural restaurants in Cholla Province, where travelers are served a full traditional meal. Preparing a K-diet is an elaborate task that takes a lot of respect and work (Kwon 2019a,b).

Westerners unfamiliar with Korean culture think strange that Koreans regularly eat meals consisting of nothing but banchans served with bap and kuk and are often surprised that banchans are shared together by chopsticks and spoon. Some were critical of the fact that Koreans dip the spoon again in communal dishes such as tang and chigae again. Of course, from a hygiene perspective, this criticism is not ill-founded. However, this is one of the features of Korean food culture. The influence of this cultural heritage can be seen in restaurants. When eating in western restaurants, westerners tend to order a single dish for each person, while Koreans will order several dishes to share while chatting. This dining culture led to development in the range of banchans that are served with bap, the custom of sharing banchans between multiple people, and the cultural practice of looking out for others. Eventually, this sharing culture created broader social norms of caring for and giving way to others. Even today, a group of four customers at a Korean restaurant will typically only be given a single menu, while each member of the group receives a menu in western restaurants.

Balance and Harmony

One main difference between Korean food and western food is that the question is not “what shall we eat?” but “what shall we eat bap with?” Selecting banchans to pair with bap was of vital importance when Koreans in ancient times decided what to serve for a meal. One of the most important questions to consider was balance and harmony (Kwon 2019a). People put effort into achieving balance between nutrition and health, vegetables and meat, and even the colors of side dishes. Sometimes color is more important for food to be mouth-watering. While foods were divided into categories based on four qi and five elements theory (4氣5味論) in China (Ko et al. 2014), ordinary Korean women would naturally seek balance and harmony when preparing meals even if they had no knowledge of this theory. Careful consideration on the balance and harmony when making K-foods also affected considering the health of people who eat food.

Because Korean food culture developed from the country's agrarian history, nature is an integral element. This is why Korean food differs by season, and Koreans developed cultural traditions of praying to nature during natural disasters such as poor harvests while thanking nature for bumper crops. Because Korea's agriculture and food culture are rooted in the belief that seasonal foods are the healthiest and most natural foods, Korean food is healthy in both biological and cultural terms. Seasonal foods and foods based on the 24 divisions of the lunar calendar demonstrate the way in which Korean food seeks harmony and balance with nature.

While pursuing harmony and balance, Korean food also guarantees right to choice. By serving bap and a variety of banchans as part of the same meal, traditional Korean table settings allow each person to choose what they eat based on their personal preferences. This is why Korea developed a different "chopsticks culture" from that of China or Japan. This chopsticks culture is a symbolic part of Korean food culture, in which each person can choose from among a variety of banchans presented on one bapsang. In western culture, once the question of "what shall we eat?" has been answered, there is little room for further choices at table. All orders as a variety of sauces, a variety of side-dishes, and cooking style are placed individually before serving. In contrast, because the question of "what shall we eat it with?" is more important in Korean food culture, each individual can choose what to eat based on their tastes and preferences even after the meal is served at table and shared. This tradition led to the customs of offering and sharing side dishes (banchans) with one's dining companions and respecting and looking out for other people. In fact, the diversity of Korean food should contribute greatly to harmony and balance of Korean food.

Healthy

As leading healthy lifestyles have become an important global trend (Kwon 2018), renowned healthy diets, such as the Mediterranean (Willett et al. 1995) and Nordic (Adamsson et al. 2012) diets, have been studied and promoted globally. Moreover, studies on the French diet have reported an interesting epidemiological observation called the French paradox (Ferrieres 2004), referencing that French people have low incidence of cardiovascular disease (CVD) despite high consumption of saturated fats in their diet. It is presumed that the French lifestyle and consumption of red wine (resveratrol) lower their incidence rates of CVD (Simini 2000). Of course, consuming red wine is not the only reason; the French do not snack, so their intake of salt and fat is reduced. Moreover, moderate drinking of wine with family or friends is related to lowering CVD risk.

Research has suggested that the health benefits of Korean food are due to the diversity of ingredients and cooking methods used in Korean cuisine (Health Magazine 2006). The average life expectancy in Korea is over 80 years despite the popularity of high salt dishes such as kuk, tang, and kimchi. Excessive salt consumption is a risk factor for CVD (cardiovascular disease). This phenomenon has been referred to as the Korean paradox (Park and Kwock 2015), and some researchers have claimed that the paradox can be explained by the regular consumption of vegetables and the types of salt used in Korean cuisine. Historically, Koreans have used unrefined, baked, or fermented salts, which may have different health effects compared to refined salt in relation to CVD. Research has shown that consumption of fermented foods like kimchi is not associated with high blood pressure (Song and Lee 2014). Moreover, high-potassium intake assists in discharging salt from the body and, as a result, reduces the risk of CVD (Park and Kwock 2015).

As problems of overnutrition have become prevalent, the Korean diet (Kwon and Chung 2018), characterized by the high consumption of namul (Lee 2018) seasoned vegetable dishes) and fermented foods, can bring about positive impacts worldwide. While the health benefits of the Korean diet have been supported by research, resources are needed to further understand the elements of balanced meals in the Korean diet. Although there are some definitions and characteristics of individual dishes available, there is not a holistic approach to categorizing the data in order to explain the health benefits of Korean food.

The Tastes of Korean Foods

While there are several ways to describe the characteristics of food, such as smell, taste, color, and nutrient content and composition, the most frequently used is taste (mat; 맛). Taste is the sensory impression of food in the mouth reacting with taste buds along with smell and trigeminal nerve stimulation. Taste can be defined in both a narrow physiological way and in a broad general sense (Ryu 2015). According to the physiological definition, taste is the chemical sensation produced when a substance reacts with taste receptor cells in the taste buds, which is then transferred through chemical reaction to the central nervous system by way of gustatory nerves. Research has revealed that there are five basic tastes (味): sweet, sourness, salty, bitter, and umami (spicy), which was found in the twentieth century by Japanese scientists (Bear et al. 2006; Ryu 2015).

However, in some cases, this physiological approach is inadequate to fully explain the characteristics of tastes found in food. Alternatively, taste in a broader sense includes the sense of pain that stimulates somatosensory nerves such as the spiciness of peppers and astringency of persimmons. Experiential characteristics of tastes such as siwonhan-mat (Lee et al. 2013), kipeun-mat, and eolkeunhan-mat (taste, a little spicy and hot) (Ryu 2015) are also included in taste in this broader sense. In addition, the sense of temperature, such as cool and hot, plays an important role in enjoying food (Choi 2009).

As we have seen, taste is crucial in assessing the quality of food and initiating preference. Generally, flavor (including taste and smell) and quality of processed foods are determined solely by taste sensed through receptors on the tongue. However, there is a unique taste, beyond the chemical or physiological definition of taste, found in traditional foods of various countries. This unique taste, the third taste, is not experienced through gustatory cells. The diverse sensations of food touching soft tissues in the mouth, swallowing food in the throat, digestion in the stomach, and appreciating the color of foods are examples of the third taste (Li et al. 2002). Therefore, in order to understand the ethnic food of a country, one is required to understand cultural expressions and the components of food found in that country.

Kan

All nations and ethnicities have their own traditional foods and tastes. In most countries, those tastes remained intact at least up until the advent of the industrialization and, unlike in modern times, were not always sweet. In fact, many of these traditional tastes were viewed as inedible by outsiders, who thought such foods had a strange taste. In particular, traditional Korean fermented foods such as kimchi and doenjang were difficult for foreigners to eat. Books written by western missionaries a century ago describe the unique foods and tastes found in Korea (Moose 1911).

In Korea, people traditionally used the expressions “kan is matda” (the level of saltiness is right) and “kan is not matda” (the level of saltiness is not right) to describe foods as tasty or not. When Korean women wanted to gauge the taste of a tang, kuk, or namul, they would check to see howkanwas (Kwon 2017a; Song 2009). Kan was used as the yardstick for measuring taste. Countries in which sugar was hard to find tended to use salt as a seasoning for food. It is easy to forget that salt, not sugar, is the best-tasting ingredient in the world. In Korea people learned from the oldest that thought that salt is the best-tasting material in the world. In the West, people described a food as “sweet” if they liked the taste, but Koreans believed that food was tasty if it was suitably kan (salty) and ill-tasting if it was not. Food was considered to have a poor taste if it contained too little salt, while too much salt made it excessively salty and bitter. Kan is a typical representative characteristic of harmony and balance of K-diet. Unlike sugar, which has no upper limit, adjusting kan by adding extra salt beyond a certain level makes food taste bitter. This is why the Korean expressions for delicious and poor-tasting are derived from getting the level of kan just right.

Sugar tends to override other tastes, while salt mixes with and brings out other traditional tastes. In traditional Korean cooking, care was taken to avoid adding too much salt in order to create a balanced and harmonized taste. Recent researches show that Korean food is viewed as having “siwonhan-mat” (a refreshing taste) only when it contains the correct level of salt (Kang et al. 2016; Jang et al. 2016). Other researchers on oriental traditional medicine suggest that the right level of saltiness makes food taste great, and they believe that when people enjoy their meals with right tastiness and deliciousness, people will be more healthy in general. Delicious foods by adjusting kan is more healthier.

In addition to salt, kanjang (original meaning of kanjang is the jang which adjusts kan) is another common seasoning found in Korean cuisine. Salt helps to bring out the natural taste of foods, and soy sauce is the best complement for producing a pleasant taste. Kanjang is made with fermented soybeans and has a deep, rich taste on its own with protein hydrolyzate such as peptides and amino acids. When Koreans used to make kanjang in the olden days, they would describe it as having "kemi" if the taste was satisfactory (Kim 1996). Adjusting the taste of a dish or banchan with kanjang rather than salt is one way to create a unique traditional Korean taste and flavor.

However, as Korea became an industrialized nation, many people, including chefs, began researching how to replace traditional tastes with newer and tastier ones. This is why so many countries, including Korea, now add sugar to food. Sugar reigns supreme when it comes to masking the taste or smell of unfamiliar foods and making them taste sweeter. Sugar led to the abandonment of traditional tastes and facilitated the pursuit of a new "taste hegemony" based around sweetness. While salt and kanjang require balance and harmony, adding more sugar to food simply makes it sweeter. Nowadays, people around the world have developed a sweet tooth, but this trend has led to excessive consumption of sugar over the last few decades, resulting in severe health problems. Conditions like obesity, diabetes, and cardiovascular disease are now prevalent with excess of calories in many countries.

Baro-keumat (The Right Taste by Mother)

In this sense, studying traditional Korean food, or K-diet, entails a thorough understanding of the unique tastes of Korean food. Many Koreans feel nostalgia for the flavors found in traditional foods they used to enjoy. For example, many people have strong memories of the unique taste of doenjang-kuk (see section "Representative Korean Foods (K-Food)" in this chapter described below) prepared by their mother growing up, which is said to come from "umma-sonmat (the taste from mother's hands and love)" (see section "Characteristics of K-Diet" of this chapter described above). In fact, there are many expressions related to taste in Korean. However, it is unfortunate that many of these traditional flavors have disappeared in the modern era and been replaced with a simplified, universal sweet taste. So what kinds of expressions are there for the flavors of Korea?

A substantial number of expressions in the Korean language describe baro-keumat (the right taste by mother): the third taste or compounded taste (Kim 2008; Lee et al. 2013; Kwon et al. 2017a). Lee et al. (2013) have listed the third tastes of Korean food:

Mat-itneun: delicious
Mat-upneun: unsavory
Siwonhan: fresh, pleasureful, and feel good digestibility
Kipeun (kemi): the rich and real the taste which can be realized by the stomach and spiritual in addition to the tongue
Kkalkkeumhan: a taste feeling cleanliness
Keoljukhan: a taste feeling thick or juicy
Jeongkalhan: a taste feeling neat or nicely presented
Kosohan: a taste feeling delicate or aromatic

(*continued*)

Hyangkeuthan: a taste feeling fragrant or fresh
Thatheuthan: a taste feeling warm or heated and comfortable
Sangkeumhan: a taste feeling fresh or refresh
Chagaun: a taste feeling cool or cold
Neukkihan: a taste feeling repellently or oily (contrarily to siwonhan)

Generally, compounded taste refers to taste created through combinations of the five basic tastes (saltiness, sourness, sweetness, bitterness, and spiciness or umami). However, baro-keumat in Korean food indicates combined tastes acquired from the tongue and other organs in the body. For example, jeongkalhan-mat and kkalkkeumhan-mat are compounded tastes using taste buds and vision. Kosohan-mat, hyangkeuthan-mat, and sangkeumhan-mat are tastes using taste buds and smell. The combinations of pain, taste, and temperature are also found in expressions related to Korean food. Of all bar-keumat in Korean food, siwonhan-mat (Bear et al. 2006; Ryu 2015) and kipeun-mat are considered the most important ones and are often referred to as the third taste. Siwonhan-mat is a refreshing and pleasurable compounded taste experienced through taste buds and body organs and includes the sensation of food touching soft tissues in the mouth, swallowing food in the throat, and digestion in the stomach (Kwon and Chung 2018). Kipeun-mat is another important taste in baro-keumat, especially in fermented foods such as Makgeolli (Korea traditionally wine), doenjang, kanjang, kochujang, and jangat-ji; it is also called kemi in Cholla province in Korea similar to the taste in kokumi in Japan. The sparkling taste in well-fermented skate (hong-eo) in Cholla-namdo is well-known as kemi due its kipeun-mat (Kim 1996; Kim and Jang 2015).

Despite the importance of food culture currently, there is a lack of funding for research on the tastes of Korean food beyond the five basic tastes. A scientific and systematic evaluation of the tastes found in Korean food is needed in order to develop and improve the exposure of Korean traditional food in the global market.

Siwonhan-mat: The 3rd Taste of Korean Foods

Understanding Siwonhan-mat from Linguistic and Literary Approaches

Origin of Siwonhada (Infinitive Form of Siwonhan)

When Koreans talk about the delicious taste of food, the most common word is siwonhada. Thus many foreigners who tasted Korean diet asked us what is the meaning of siwonhada. According to the *National Korean Language Dictionary* (Hangeulhakhoe 1991), the usage of "siwonhada" includes "The weather is refreshing," "The broth of this kuk (soup) feel good digestibility," "I am relieved of my worries," and "He is merry and cheerful, affable and amiable, and clean and neat." This demonstrates siwonhada's wide use of describing combinations of mind and work, words and behavior, and words related to the body, food, and space (Song 2011). The diverse usage of siwonhada suggests that it conveys more than just a mere description of temperature. For example, when someone says the kukmul (broth of kuk) is siwonhada, it describes the experience of having hot broth calming the stomach. It does not describe the surface temperature of the broth but the sensation resulting from consuming the food. Kuk with kimchi and dried pollack with kan are also dishes described with siwonhada. As described previously, kan means balancing the salt concentration to enhance the flavor of food (Song 2009; Jang et al. 2016). The most common seasoning in Korean cuisine is kanjang. Salt and doenjang are also widely used. In this case, siwonhada is used to represent the refreshing sensation experienced during digestion as well. When explaining low temperatures with food, "chagapda" (cool) is used instead of siwonhada.

Starting in the fifteenth century, siwonhada began being used in diverse contexts to describe a refreshing and pleasurable sensation (Song 2009). Starting in the late nineteenth century, siwonhada started being used in association with food when quenching thirst with liquids such as water or broth (Song 2011) and when describing low-temperature food. Moreover, cathartic emotions from stories, novels, or movies are often described as siwonhada as well. These references suggest that the linguistic origin of siwonhada is "being relieved of worries" (Hangeulhakhoe 1991). Also, siwonhada means that it is pleasant and vital when cool and refreshing air is inhaled and a hot bath makes our body reboost energy (qi). Therefore, siwonhan-mat refers to the refreshing and soothing tastes of food regardless of its temperature.

People who are not familiar with the origin of siwonhada and non-Korean speakers often perceive the meaning of the word as "cool" and raise questions about the usage of siwonhada when eating hot kuk. When entering a bath, Koreans (generally adults) often describe the feeling as siwonhada. It is a hard concept to grasp for children who often perceive siwonhada as cool or cold. As a result, siwonhada is frequently perceived as cool or another antonym of hot. Some scholars have tried to explain this misunderstanding through the concept of polysemy (Lee 2011) viewing siwonhada only as a temperature-related word.

In addition, the incorrect translation of Korean words also contributes to the misunderstanding of the word's meaning. For example, "maepda (spicy)" and siwonhada are often translated into hot and cool-temperature-related words. The erroneous meaning of siwonhada would be spread this way due to mistranslation. Therefore, it would be desirable to retain the original concept of siwonhada rather than translating the word as "cool."

Understanding Siwonhan-mat from a Scientific Approach

According to the evolutionary point of view, the development of the sense of taste is closely related with human survival instincts (Lee et al. 2013; Ryu 2015). For example, the sense of taste would have been an important determining factor when consuming new food substances in a primitive age. According to the physiological definition of taste as a chemical reaction experienced through taste buds, taste can be split into five basic categories: sweetness, sourness, saltiness, bitterness, and umami (Bear et al. 2006; Ryu 2015). More recently research has revealed the existence of thermoreceptors, sensory receptors responsible for the sense of pain and temperature. Thermoreceptors react with various temperature levels. However, extremely high or low temperatures activate not only thermoreceptors but also pain receptors, which results in a simultaneous sensation of temperature and pain (Bear et al. 2006). TRPV1, also known as the capsaicin receptor, is the first isolated thermoreceptor and is activated by temperatures greater than 42 °C and the chemical compound found in hot chili peppers, capsaicin. Capsaicin of chili is the main element in fermenting kimchi, and the red color of chili is the main essence of appetizing taste of Korean food. TRPM8 is activated by temperatures lower than 25 °C (McKemy 2011). Examples of tastes sensed through thermoreceptors are spiciness, astringency, and temperature-related tastes such as hot and cool.

Historically, Koreans have tried to describe the characteristics of food through a health lens (Anonymous BC 200; Kim et al. 2012) with four attributes (Anonymous 500 BC; Kim et al. 2012). In Korea and China, medicinal and food ingredients are categorized by the four attributes (qi) or natures. The four medicinal natures are cold, hot, warm, and cool. For example, warming ingredients decrease oxygen consumption and slow metabolic activity in the body. In addition, they hinder fluid intake and suppress the central nervous system. Warming ingredients also have anti-inflammatory properties and have the effect of raising yang (qi) and warming the body by improving circulation and dispelling cold. On the other hand, cooling ingredients increase oxygen consumption and metabolism. They also promote fluid intake and stimulate the central nervous system. In addition, cooling ingredients have nourishing and detoxifying effects on the blood (Anonymous 500 BC; Kim et al. 2012). In other words, Korean food and its food culture are deeply related to survival to live and can be conceptualized by the idea of *yaksikdongwon* (medicine and food arises from the same source). About 2,500 years ago, Hippocrates recognized that food was as important as medicine in humans by saying, “Let food be thy medicine and medicine be thy food.” Similarly, in Asia, the importance of food life is acknowledged with the expression “*yaksikdongwon*” a long time ago (Chung et al. 2016a).

The meaning of siwonhan-mat can be properly understood in the context of health and survival, rather than the mere appreciation of smell, color, and taste. Siwonhan-mat characterizes Korean food and is a vital concept to understand in Korean food culture.

Determining Factors of Siwonhan-mat

As mentioned previously, siwonhan-mat is a refreshing taste that is associated with the sensation of food touching soft tissues in the mouth, swallowing food in the throat, and digestion in the stomach. An antonym of siwonhan-mat is not thateuthan-mat but neukihan-mat, which describes an unpleasant indigestive feeling.

It is presumed that siwonhan-mat is composed of several elements other than the five basic tastes, such as salinity, acidity, spiciness, and a feeling of refreshment. For example, siwonhan-mat is often experienced through kuk or tang (Kwon et al. 2015), types of Korean dishes with broth, and in this case, siwonhan-mat is associated with the proper kan (Song 2009) of the dish. More research on determining the exact elements of siwonhan-mat should be conducted to allow further understanding of this taste. Kuk is often mistranslated as “soup.” Korean kuk is not the same as western soup, which is served before the main dish rather than with the main dish like kuk. Kuk helps with digestion when rice is served; they go together like coke and hamburgers.

Representative Korean Foods (K-Food)

As shown in Table 1, there are hundred kinds of Korean foods (K-food), while there are dozens of representative bapsang (K-diet) (Kwon et al. 2017a). Among them, some representative K-foods listed by red letters in Table 1 are introduced as follows:

Kimchi

Kimchi is unique and famous fermentation food in Korea. Kimchi is fermented vegetable food in Korea, where fermentation of salted vegetables with red pepper (kochu) powder was used as a food preservation method about 2,000 years ago (Jang et al. 2015; Yang et al. 2015). There are hundreds of kinds of Kimchi in Korea depending on the raw materials, manufacturing methods, and other characteristics. Baechu kimchi mainly prepared with baechu cabbage is the major kimchi. These days, the health effects of kimchi in terms of metabolites and microbiome by fermentation are studied as scientific data (Park and Ju 2018).

Korean Chili (Korean Red Pepper)

Also, the taste of food is related to the color of food; especially if we look at the well-cooked food with red color, our saliva come up before tasting. Usually Korean makes and cooks the foods to be delicious with colorful sauces such as red pepper powder; red pepper is very common in K-food. Korean chili (Korean red pepper) grew in Korea since half million years, while chili was born in the earth 19.6 million years ago (Kwon et al. 2017b; Yang et al. 2017). It is not known scientifically in which continent chili was born in the world. Anyway chili was spread into other continents through birds for 10 million years and then evolved to more than 50 different species. Korean chili (*Capsicum annuum*) is unique due to its less spicy and sweet taste, which is quite different from those of Central America and South Asia. Korean people found that if they mixed bachu cabbage with red pepper powder for better taste, it was still edible after 2-3 days passed even with odorous smell, This is why they found very decious fermented kimchi (Kwon 2019b).

Namul

Namul means all kinds of edible vegetables from mountains and fields as well as banchan (Table 1) prepared with namul. Among namul, wild greens are called pusae, while cultivated greens are called namsae (National Institute of Korean Language 2017). Korean vegetable dish namul is prepared as fresh (saengchae), cooked by blanching or stir-frying with small amount of oil (sukchae) with various seasonings. Dried namul are first soaked in water, blanched, and then dried. Dried namul (bracken, mushroom, eggplant, squash, cucumber, dried radish greens, and aster) is preserved from the past year to be consumed in the winter (Lee 2018).

Jang

Jang, doenjang, kanjang, kochujang, and chongkukjang are typical fermented soybean products in Korea (Kwon et al. 2015; Shin and Jeong 2015). Traditional jang (doenjang and kanjang) is fermented first by making meju using boiled soy bean and with rice straw as a starter culture and the main ingredient of the jang, and then the meju is further fermented in brine (salt+water) (Yang et al. 2011). The fermented liquid part (kanjang) is separated from the fermented paste (doenjang) after fermentation (Park and Park 2018). Chongkukjang is short-term fermented foods with cooked soy bean for 2–3 days (Chunget al. 2019). Kochujang is made mainly of meju powder (fermented soybean powder), including red pepper powder and small amounts of rice cereal starches (Kwon et al. 2015; Shin and Jeong 2015). These jangs have a long history and are the most basic K-foods for Korea and are very healthy foods (Park and Park 2018).

Yangnyom

If food is cooked with low temperature heating, food is not so tasty. Namul is representative low heated cooking. To eat namul as delicious food, Koreans developed many yangnyom (sauce for vegetables) using spices such as red pepper, onion, ginger, green onion, and garlic. Korean people usually red pepper powder was used to be looks gorgeous color and delicious spicy (Kwon 2019b). In thousands years, Korea did not have tomato or other red color ingredients, only they have red pepper powder for red color. These yangnyom were prepared using kanjang, doenjang, kochujang, and sesame and perilla oil. Main components of the yangnyom, capsaicin, gingerol, allicin, and others were powerful antioxidants and anti-inflammatory.

Jeotgal

Jeotgal is traditional fermented fish food in Korea, produced from the whole meat and/or internal organs of fish and shellfish. Fish and shellfish are highly perishable due to the high moisture content and nutritive elements; thus jeotgal has been produced using salt and fermentation to avoid deterioration from spoilage, autolysis, and microbial activities and to enhance the preservation. Jeotgal is an important part of Korean cuisine because of its nutritional value, healthful effects on digestion and appetite, and beneficial microorganisms (Koo and Kim 2018).

Okokbap

Usually, in *Jeongwol Daeboreum* (first full moon in lunar year), they cooked okokbap (boiled rice with five grains: glutinous rice, red beans, sorghum, and millet) to celebrate the festival and to pray for every person to be happy and healthy.

Okokbap is rich in nutrients and is healthy due to their ingredients. In *Jeongwol Daeboreum*, people believed that they will be rich if they have three different houses okokbap (Han 2005).

Red Bean Juk (Danpat-juk)

Korean usually make juk (like as porridge) using rice, pumpkin, mung bean, and red bean in a year (Han 2005). Especially in dongji (winter solstice day), danpat(red bean)-juk was eaten in belief that red color of the beans (azuki beans) had positive energy that could drive away evil spirits. Azuki beans are rich in nutrients; in addition, cooked red bean was used to make popular patbingsu (shaved ice dessert).

Bibimbap

Bibimbap is rice with mixed meat and assorted vegetables, which has characteristics differing from usual Korean bapsang as a meal (Cha 2018; Chung et al. 2015). Compared to Korean bapsang, Westerners often served a meal as a single dish, bibimbap resembles Western dishes because bibimbap served as one bowl (han greut meal), which has made it very favored and loved. It is served as a bowl of warm white rice topped with namul (sauteed and seasoned vegetables) and kochujang. Bibimbap is one of the definitive Korean dishes in the eyes of both Koreans and international enthusiasts (Yang et al. 2015). Jeonju bibimbap is historical and the most popular bibimbap in Korea as well as in the world.

Doenjang-kuk

Kuk is the second important food in Korean diet as shown in Fig. 1. Kuk is essential in Korean bapsang. Doenjang-kuk is very common, because they can make any kinds of doenjang-kuk with various substances such as vegetables, seafood, and meat. Spinach, scallion, a curled mallow, and siraeki (dried radish greens) are typical substances for vegetable doenjang-kuk. Healthy doenjang meets nutritious vegetables rich in phytochemicals and vitamins and makes food delicious. Epidemic case data of centenarians of KuKokSoonDam (Kurye-Koksong-Soonchang-Damyang Province) area of Chollado showed that doenjang-kuk is critical for longevity (Kang et al. 2008; Lee 2019; Park 2003).

Miyok-kuk

There are dozens of kuk in Korean diet, but miyok-guk (sea mustard soup) is very special, because it is a symbol of birthdays for Koreans. By custom, it is the first meal mothers eat after giving birth, so it has become a food representing birth. Even those who dislike miyok-guk usually eat it on their birthdays. This kuk, which is known as the first kuk, is clear and seasoned only with soy sauce and sesame oil, as opposed to ordinary miyok-kuk which contains beef. Rich in calcium and iodine, miyok helps the womb contract and stimulates the production of new blood cells, whose benefit was first proven scientifically (Korean Food Storytelling 2019).

Sundae and Sundae-kuk

Sundae is a type of blood sausage in Korean foods using pork colon. Traditional sundae, pig intestine (colon) stuffed with seonji (blood), minced meats, rice, and vegetables such as green onion and leek, was an indulgent food consumed during special occasions, festivities, and large family gatherings (Kim and Jang 2014). After the Korean War, when meat was scarce during the period of postwar poverty, artificial edible film and dangmyeon replaced intestine and meat fillings in South Korea. Korean sundae has their own and long history back to the Kochosun; simultaneously and naturally, they imagine how to eat pork or beef intestine deliciously and safely and develop their own style (Yook 2017). Sundae-kuk is another favorite dish as one-bowl food, which is made by adding sundae and some other small intestine and boil.

Kimchi-chigae

Kimchi is always served in Korean bapsang. Koreans were so diligent and clever to create more delicious foods using kimchi: kimchi-kuk, kimchi-jeon, kimchi-jeonkoland, and kimchi-chigae. Kimchi-chigae is cooked by putting some chopped baechukimchi and some pork in a pot and boiling them with other yangnyom. There is no other food like a bowl hot kimchi-chigae to be siwonhan-mat and relieve stress and anxiety. It is also the most frequently served dish in Korean homes, perhaps because kimchi is always available in any household through the year, and anyone can make a savory chigae with well-fermented kimchi alone.

Japchae

A dish that is always served at Korean parties and special occasions is japchae. The name of japchae is a combination of jap meaning “miscellaneous and together” and chae meaning “vegetables,” and thus japchae literally means “a mixture of vegetables” (Yoon 2018). The main idea is to combine noodles (dangmyon, glass noodle made from sweet potato starch) with namul. The components of namul are spinach, carrot, onion, and mushroom. Marinated beef strip is also added for individual taste.

Kalbi and Kalbi-chim

Kalbi is a meat dish that is cooked on a grill over charcoal fire by putting seasoned ribs. It is one of the favorite but expensive cuisines in Korea. The meaning of kalbi is ribs of meat. Basically, kalbi is from beef ribs, but now sometimes kalbi is made using pork ribs because of the price of beef. Kalbi is the most expensive menu in Korean restaurant.

Kalbi-chim is cooked by adding a variety of seasonings on carefully prepared beef ribs in a pot, which is then slowly brought to a boil over low heat just to braise some yangnyom could be absorbed. Kalbi-chim is loved by all not just because it is nutritious food and high in protein but also because of its soft texture and rich flavor (Lee 2010b).

Bulgoki (Grilled Seasoned Beef)

Bulgoki is another typical and unique Korean food, in which the meat is grilled after seasoning with yangnyom. Sliced beef sirloin was used as a meat. Grilling is done just before eating after yangnyom is thoroughly absorbed into the meat (Lee 2010b). Once the seasoned beef strips are placed on a shallow grill or pan, the juices from the meat are mixed creating tasty gravy that hugs the meat (Yoon 2018).

Samkyopsal-gui

The most popular menu among Korean people who love to grill meat on the table is samkyopsal-gui since 1980. The meat is called samkyopsal (literally meaning "three-layered meat") because it has alternating layers of meat and fat. Basically, roasting the high-fatted meat at high temperature caused it to be delicious and even more with garlic green chilies (Lee 2010a). Usually, they loved samkyopsal by wrapping lettuce or sesame leaves using sesame oil sauce or doenjang (doenjang specially called ssamjang).

Jangat-ji

Jangat-ji (pickled vegetables) is the best dish created with jang. The original meaning of jangat-ji is the fermented ji (kimchi) in the jang like as doenjang and kochujang (Yang et al. 2015). Some vegetables or fruits are preserved and aged in jang. Numerous ingredients can be used in jangat-ji. From radish, bamboo shoots, dried yellow croaker, garlic or garlic stems, and cucumber in spring to wild sesame/perilla leaves, green chili, deodok (roots of *Codonopsis lanceolata*), bellflower root, plum, persimmon, and winter gourd, all kinds of produce are made into jangat-ji at various times of the year (Lee 2010b).

Theokboki

Theok is a Korean tradition valuable cake based on the cooked rice. In someone's birthday ceremony or in Sollal (lunar new year) and Chuseok (thanksgiving full moon), Koreans prepared various kinds of theok for celebration. After celebration, theok is easily retrograded because of starch of rice. If we want to eat theok later, it is hard to eat without re-gelatinization by heating like steaming and baking or stir-frying. Baked theok (origin of theokboki) was made by heating in the classical brazier and then eaten by dipping with honey or jochong (Korea traditional fructose made from sweet potato) and kanjang or kochujang. This theokboki is commercialized after import of wheat flour since 1960 by making cheaper wheat-based theok. Theokboki, especially kochujang theokboki, coated with mouth-watering kanjang, is Korea's favorite food and is one of the popular street foods in Korea (Lee 2010b).

Haemul-pajeon

Jeon is a dish made by lightly coating meat, fish, or vegetables with flour and batter and then shallow frying with sesame or perilla oil on a griddle (Yoon 2018). In the rural area, every sunny day they have to work on the farming fields; however, they cannot do any works outside if it rains suddenly. Inevitably they stay inside the house together, and they think about that what they can prepare the food easily as munchies between the main meals (Kwon 2019b). Pa (green onion) and leek are used as vegetables for making jeon, because these are always available in the fields. With this historical memory, although they live urban area moved from rural area, they crave a pajeon on a rainy day. The delicious pa and abundant haemul (sea food) blended perfectly to create a savory flavor for haemul-pajeon, which quickly became a popular dish throughout the nation (Lee 2010b).

Sikhye

Sikhye is a traditional dessert beverage made by fermenting rice in malt (yotkireum). Also known as sweet liquor (kamju), it is called sikhye if you drink it together with the grains and kamju when the liquor is separated out. Sikhye's essential ingredient is malt made from sprouted barley. Since malt is rich in amylase, a diastatic enzyme, sikhye has been traditionally offered as dessert drink after eating heavy meals on celebration or festival days. It was a favorite digestive tonic after overindulging during the days when other forms of digestive aids were not readily available (Korean Food Storytelling 2019).

Sungnyung

In Korea, people drink sungnyung (like tea) to finish off a meal (Moose 1911). It is a traditional Korean drink made from nurungji (leftover scotched rice crust) that forms on the bottom of a pot after cooking rice. Water is poured on this brown crust, and the contents are put to a simmer until the water gains enough flavor of the scorched rice. Sungnyung helps swallowing foods through the throat and digesting food well to comfort stomach and feel happy.

Conclusion

These days as in a global village, many foreigners are interested in Korean foods and diet, because of its history, ethnicity, and healthiness. This chapter answers the question: What is the nature of Korean diet in addition to history, culture, and health? The values of K-diet are respect and consideration, harmony and balance, and healthiness. When defining the K-diet, various components are considered, such as raw materials or ingredients, traditional cooking methods, technology, and fundamental principles and knowledge. However, it would be preferable to establish the definition of Korean food by focusing on the preservation of traditional methods and core principles. The Korean meal table (bapsang) is characterized by servings of bap, kuk, and banchan on one table. The K-diet is composed of bap and kuk and various banchans with one serving called bapsang. Kimchi is always served at every meal. While various cooking methods are used in Korean cuisine, the most representative method was fermentation which enhances both the taste and preservation of the food. The principal aspects of the K-diet include proportionally high consumption of vegetables (namul), moderate to high consumption of legumes and fish, and low consumption of red meat. Banchan is mostly seasoned with various jang (fermented soy products) and yangnyom with medicinal herbs and sesame or perilla oil. The points of taste in K-diet were quite different from those of western tastes. Unique expressions of Korean taste are kan, the right taste (baro-keumat), and siwonhan-mat, which is typical in Korean delicious tastes. In Korean cuisine, doenjang, kanjang, and salt are commonly used seasonings. A couple of representative bapsangs and some representative K-foods among hundred kinds of Korean-foods were also described. This chapter plays an important role in making this connection for those learning about Korean food. Moreover, this is vital to promote the cultural values of Korea (K-value) by bringing together traditional principles and scientific evidence. Because these diversities and healthiness of Korean food, K-diet will be most popular and powerful in the global market in the future personalized food era (Kwon 2019c).

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Cross-Cultural Studies in Wine Appreciation 68

Wendy V. Parr and Heber Rodrigues

Contents

Abstract

The present chapter outlines and discusses published research concerning how people from different cultures or geographical regions vary in terms of their discrimination and appreciation of wine. We begin by providing a brief historical perspective and then discuss cross-cultural studies concerning sensory, cognitive, and emotional responses to wine. In doing so, we report both similarities and

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differences as a function of culture. We also highlight the varying methodologies employed to investigate aspects of wine appreciation from a cross-cultural perspective, identifying difficulties specific to this area of research including those subsumed within the phrase "lost in translation," and those pertaining to validity of definitions of culture in light of increasing globalization. Finally, we discuss how a cross-cultural approach can help advance our understanding of wine appreciation, providing useful information for wine industry marketing strategists as well as for those interested in the science and practice of wine tasting.

Introduction

Recent decades have seen cross-cultural studies become a common feature in the major chemosensory and food science journals (e.g., Chrea et al. 2005; Kim et al. 2013, 2018; Wan et al. 2015a). These studies, many focusing on differences between what broadly might be called Asian consumers and non-Asian or "Western" consumers, alert us to the importance of our experiential histories in influencing how each of us appreciates food and beverages. Although genetic differences cannot be discounted (e.g., Keskitalo et al. 2007), Prescott (2012, p. 144) argues that overall there is little evidence that cultures differ innately in terms of perception of food qualities and basic tastes (sweetness, sourness, saltiness, bitterness, and umami). On the other hand, the culture into which we are born and within which we are socialized is now widely accepted as playing a significant role in how we respond analytically and hedonically (e.g., in terms of liking) to the incoming information from our senses (Prescott 2015).

Precisely how do our experiential histories influence how we respond to food and beverages? Despite a proliferation of research over the last two decades hypothesizing and investigating probable differences in a range of sensory phenomena as a function of culture (e.g., Lee and Lopetcharat 2017; Pangborn et al. 1988), a handful of studies only has delved into the theoretical basis of such differences. The present chapter focuses on cross-cultural research that has drawn on established theory, often from the disciplines of cognitive and/or social psychology, in an attempt at elucidating the ways in which culture or geographical location can influence our appreciation of a specific food product, namely the complex beverage known as wine. We have not attempted to disentangle genetic influence from experiential influence but considered the published research explicitly aimed at investigating wine appreciation as a function of differing cultural socializations.

Defining Culture

For the purposes of this chapter, cross-cultural is defined as pertaining to, or contrasting, two or more cultures or cultural groups. In terms of defining culture itself, most published research investigating consumer preference and sensory analysis as a function of culture appears to define culture, either implicitly or explicitly, in terms of geographic location or origin of the participants (e.g., Saenz-Navajas et al. 2013; Wan et al. 2015a). We acknowledge that in the discipline of Psychology, where culture became an active area of research after the Second World War, recent definitions of culture are more elaborate and include notions of "systems of thought" or "world views" (Imai et al. 2016), with perception, thinking, and language inherently linked to culture. Further, some recent approaches to defining culture such as culture-as-situated cognition theory (Oyserman 2016) argue for a need to move beyond conceptualizing culture as race, ethnicity, or geographical location and to see culture as less static than geographical location implies. Although detailed discussion of current definitions of culture is outside the scope of this chapter, where relevant we draw on recent theoretical argument to help interpret research outcomes. Most importantly, we acknowledge that even if the original source of cultural differences was geographical location, culture is a dynamic concept and open to influence from increasing globalization. Ease of travel, increasing trade across countries, and factors such as health concerns are just some of the variables likely to interact with mere exposure to a product to influence contemporary behavior in relation to wine appreciation and consumption.

Wine Appreciation Research: Methodologies and Theory

Published cross-cultural research specific to investigating wine appreciation, despite being relatively sparse until recently, has involved a range of sensory phenomena and methodologies. In terms of phenomena, studies investigating intrinsic aspects of wine (e.g., Saenz-Navajas et al. 2013; Parr et al. 2015; Valentin et al. 2016) frequently report comparisons between cultures with established wine industries, these often dichotomized as Old World cultures (e.g., France, Spain) and New World cultures (e.g., New Zealand, Australia, South America, South Africa, the USA). On the other hand, investigation of extrinsic aspects of wine such as price, serving glassware, brand reputation, purchase intent, or perceived health benefits frequently has involved comparing responses of Asian consumers with those of Western consumers (e.g., Do et al. 2009; Yoo et al. 2013; Wan et al. 2015b). In terms of methodology and theory, the majority of published studies are of descriptive nature only, limiting theoretical development in the field. There is however a handful of studies reported, notably cerebral representation studies, that draw on established theory from the discipline of Psychology to assist with data interpretation. For the more theoretically oriented researchers, the overarching and fundamental question of interest in cross-cultural research has its basis in psychological science; more specifically, it concerns the degree to which our cognitive processes of perception, conceptualization, and communication about wine, and the associated emotional responses, are culture dependent, and how such culture dependency occurs. This chapter aims to focus on published research that helps us shed light on sources of cross-cultural differences in wine appreciation, including the frequently implicated concept of familiarity. We attempt to delineate how familiarity and availability, in giving rise to cultural expectations, internalized values, memories, and emotional associations, influence our sensory experiences, our purchase choices, and the way we verbalize our wine experiences.

Historical Perspective: Wine and Culture

Wine, an alcoholic drink made from fermented grapes, is of much more consequence culturally than this short definition implies. The grapevine is reported as our oldest cultivated plant (Fehér et al. 2007), and wine has passed through the centuries accompanying memorable moments in world history. No other alcoholic beverage has been as well documented and so widely steeped in culture, this evidenced by its presence in documents from different periods and societies.

Records of wine's cultural importance go a long way back. For example, early references are found in Greece to Dionysus, the God of wine, during the Mycenaean Period. Wine has had a long relationship with religion, its leading role in Christian religious belief exemplified in that the first miracle performed by Jesus Christ is recorded as "the miracle of the transformation of water into wine" or "the miracle of the Wedding at Cana" (Van der Loos 1965). Wine has as well a long history of being associated with feelings such as love. According to Grube (1935), an association between wine and love can be found in writings of the ancient Greeks such as those of Euripedes: "Where there is no wine, there is no love." Grapes and wine have also been instrumental in perpetuating and maintaining identities of cultural groups who move around the world. It is reported that from the sixteenth century, during the period of great navigations, Spanish, Portuguese, and Azorean and later, in the nineteenth century, during the immigration of Italians and Germans in the Americas, these peoples cultivated the grape as a way of maintaining their old traditions and cultural habits (e.g., Carré 1987). In this way, the British, for example, although not wine producers, were able to incorporate wine in their meals and traditions and to further spread grape culture across the burgeoning British Empire. Thus, wine and culture are historically entwined with deducible effects present today.

Wine Appreciation: Empirical Investigations

Many factors influence how food and beverages are evaluated including their perceived safety, sensory characteristics, acceptability, and liking, and wine is no exception. These factors can be classified as intrinsic or extrinsic (Parr et al. 2011; Rodrigues and Parr 2019). Figure 1 demonstrates a classification of factors implicated in wine appreciation.

Intrinsic factors are those pertaining to the wine itself and experienced by tasting and/or drinking the wine (e.g., color, perceived flavors). Extrinsic factors are defined as those quality cues related to the wine but not physically part of it and include characteristics such as brand name, price, bottle shape and weight, label, awards, wine origin, technical methods of production, and so forth (Prescott 2015; Wan et al. 2015b).

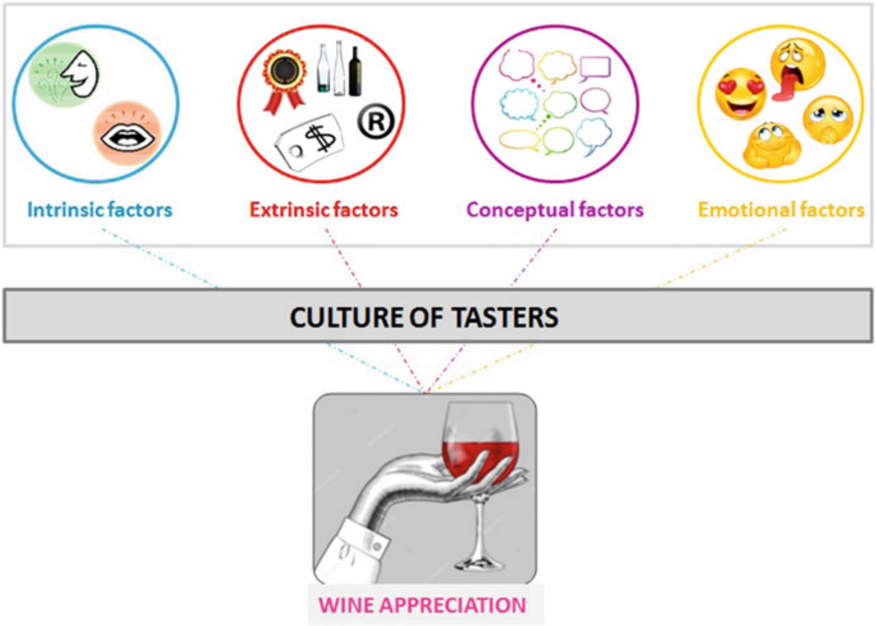

Fig. 1 Classification of empirical research in wine appreciation

In recent years, cross-cultural research investigating conceptual (i.e., thinking) aspects of wine appreciation has broadened the extrinsic topics investigated, with the impact of several sociopolitical movements (e.g., organic and biodynamic methods of production, animal welfare, perceived health benefits or risks, concerns about obesity) coming under scrutiny. These social movements are complex, frequently crossing geographical boundaries and potentially having closer associations with sociodemographic status of participants than with their geographical location given our increasingly globalized world (Abraben et al. 2017; Hidalgo-Baz et al. 2017).

Intrinsic Wine Qualities

Research in this area can be divided into studies primarily investigating hedonics (liking, preference) and those with their major focus on perceived aroma, taste, and in-mouth sensations, along with global aspects of wine appreciation such as perceived quality and perceived complexity. In terms of a theoretical base, research on visual perception has demonstrated cultural influence in terms of what information people pay attention to as well as in terms of cognitive style such as a preference for holistic over analytical processing of a stimulus (Kastanakis and Voyer 2014). It is conceivable that such cultural differences in visual attentional processing apply as well to processing of chemosensory stimuli, potentially influencing olfaction (smell, aroma) and taste.

Hedonic Judgments

The notion that familiarity or mere exposure to an item can influence our preferences has a long history in Psychology (Maslow 1937). Several studies investigating cross-cultural liking and preference for wines have been reported, with assumed participant differences in wine familiarity or exposure as a function of geographical location either explicitly or implicitly implicated in the purpose behind the study. Below we exemplify the type of research and outcomes reported in this area.

Preferences of American and Italian consumers for several varieties of Californian and Italian red wine (Merlot, Syrah, Refosco, and Zinfandel/Primitivo) were investigated by Torri et al. (2012). Results showed that overall the Californian wines were preferred by both Italian and American tasters. In other words, there was no consistent support for the notion of familiarity as a major influence on preference judgements for the red wines employed in this study as demonstrated by the Italian participants' responses.

Williamson et al. (2012) also investigated red wine liking, in this case contrasting responses of Australian and Chinese red-wine consumers. Wines from Australia, Argentina, France, the USA, and China and of several red wine varieties were assessed for liking and purchase intention by Chinese consumers in three Chinese metropolitan areas. Liking results showed the Chinese wine to be poorly rated, with Chinese consumers giving highest liking scores to the Australian wines. The data were compared with those of 216 Australian consumers who also rated a set of red wines, 12 of which were similar to the wines rated by the Chinese. The Australian consumers' liking scores were similar to those of the Chinese consumers with a preference for Australian wines over those from other countries, suggesting that wine familiarity may be implicated in the Australians' liking judgments, and possibly those of the Chinese consumers depending on wine availability in the Chinese market place. This study also reported an interesting result concerning purchase-intention behavior. Results showed that Chinese consumers were driven primarily by price and country of origin, with wines from France and of varietal Cabernet Sauvignon reported as the most likely to be purchased. Hence, in terms of wine origin, what the Chinese consumers liked (Australian wines) and what they reported an intention to buy (French wines) were two different things. Finally, a methodological issue worth noting was reported; Chinese consumers tended to use a more narrow range of scores when rating liking than Australian participants used, the former's responses skewed towards the "like" end of the scale. The authors interpreted this in terms of a socio-cognitive effect, specifically in terms of the desire of Chinese consumers not to give a negative response. Interestingly, when the liking scores for both Australian and Chinese consumers were included in analysis involving trained-panel descriptive ratings to the 12 wines common to both groups, "sweetness" and "red fruit flavor" were the most important attributes driving liking scores for both cultures, while bitterness and sourness were associated with disliking. In short, despite some cultural differences being evidenced, this study reports more similarities than differences among Chinese and Australian wine consumers in hedonic ratings to red wines common to both the Chinese and

Australian wine markets, implicating familiarity as a possible factor driving wine liking. Clearly, a difficulty with this type of study is that for familiarity to be implicated as a source of outcomes, a measure of familiarity in terms of how often each participant consumed or was exposed to any particular wine type is essential. That is, merely being of a particular culture or ethnicity does not in itself guarantee that one consumes the produce of one's own geographical location.

In one of the few cross-cultural studies to investigate both liking and familiarity of the same wines, Parr et al. (2015) asked French and New Zealand (NZ) participants to judge both French and NZ Sauvignon blanc wines. Cross-cultural differences in liking for the wines were minimal but were more apparent in an olfaction (nose only) condition than in a full tasting condition. In terms of direct ratings of wine familiarity, a cross-cultural effect was demonstrated with an interaction between participant culture and wine origin showing NZ participants to be more familiar with the French wines than French participants were familiar with NZ wines. This demonstrates a dissociation between wine liking (more cultural similarities than differences) and wine familiarity (cultural differences). As well, despite not being familiar with NZ wines, French participants on average liked these wines more than the French wines in the study, conceivably a result of novelty, and leaving a rather murky picture of the influence of familiarity per se.

Finally in this section, a recent study reported by Ristic et al. (2019) describes a cross-cultural study (Australia, the UK, the USA) investigating consumers' liking of selected wine aromas using online survey methodology. Although some between-country differences in hedonic responses to the 59 selected wine aromas were demonstrated (e.g., "green" characters in a wine were more acceptable to the UK respondents that to those from the USA), there were many similarities across countries in terms of the aromas reported as most liked (e.g., honey) and those least liked (e.g., smoked meat). Interestingly, several demographic factors (age, gender, consumption frequency) influenced reported liking of the aromas, having greater effects than geographic location of participants, perhaps due to increasing globalization and ease of communication among English-speaking countries.

Analytical Studies: Sensory Characterization of Wines

Several cross-cultural studies have considered how differing experiential histories could influence analytical, sensory responding to wine. Culture, in conditioning how we perceive and think about a product such as wine, could be an important source of behavioral differences (i.e., of between-participant differences in responses to wine).

In an investigation into one of wine's more abstract attributes, namely intrinsic quality, Saenz-Navajas et al. (2013) compared French and Spanish wine consumers with two levels of expertise, consumers and experts. Interestingly, results demonstrated expertise rather than culture as the major driver of quality judgments of French and Spanish red wines. Another study investigating perceived quality of Pinot noir wines produced a similar result, demonstrating that participant culture was not a major driver of differences in wine perceived quality (Valentin et al. 2016). The data, showing more cultural similarities than cultural differences, were interpreted by the authors as suggesting that the wine professionals, irrespective of their geographical location (Burgundy, France vs. Marlborough, NZ), had a shared cognitive construct regarding the important sensory qualities of Pinot noir wines. In other words, the wine expertise of the tasters resulted in them having a shared conceptualization of the wines that overrode any geographically based, cultural differences that could have been expected from the participants due to France and NZ having very different wine-production histories (Mouret et al. 2013).

In contrast to the findings with wine consumers and wine professionals reported above, Saenz-Navajas et al. (2013) reported data from trained panelists where cross-cultural differences in wine appreciation were more pronounced. Spanish and French trained panelists characterized the same 12 Spanish and French red wines that had been evaluated for quality by consumers and experts, on odor only and then on in-mouth properties (e.g., tastes, textural aspects, tactile qualities). There was reasonable agreement across cultures for wine-odor description, but differences in perceived wine balance and sourness were observed in the in-mouth response data, as well as different linguistic terms employed for describing the wines' characteristics. The authors attributed these latter effects to different cultural histories, in particular with respect to the fruits readily available in each of Spain and France.

Color is an intrinsic quality of a wine in that it is part of the beverage itself. In an insightful article, Shankar et al. (2010) considered the notion that the well-established influence of color on judgments of flavor may in turn be influenced by cross-cultural differences based in prior learning and experience. British and Taiwanese participants were compared in a colored-beverage, flavor-judgment task. Data showed that some colors produced cross-cultural, color-flavor effects while other colors did not. In terms of wine, color-flavor influence has been demonstrated in both French oenology students (Morrot et al. 2001) and in NZ wine professionals (Parr et al. 2003), the similar outcomes occurring despite very different study methodologies. In the Pinot noir study of Valentin et al. (2016) reported above, the importance of color as a driver of perceived wine quality judgments was in fact the major focus. Again, there were more cross-cultural similarities than differences among the French and NZ wine expert participants when assessing the importance of color to judgments of perceived quality of French and NZ Pinot noir wine. These study outcomes suggest that domain-specific expertise in the field of wine can override culture-specific differences associated with beverage color.

Extrinsic Wine Qualities

Over recent decades, several studies have demonstrated that extrinsic aspects of foods and beverages can influence what we perceive, what we prefer, and eventually our behavior (e.g., what we choose or purchase). Yoo et al. (2013), for example, reported a marketing study comparing online questionnaire responses of Korean and Australian wine consumers to questions about wine preferences and consumption behavior. The study's major focus was perceived health benefits of wine, but several other extrinsic factors were investigated including wine price, bottle shape, and wine type (red, white, rosé, sparkling, fortified). Results demonstrated several cross-cultural effects, including: (i) a stronger preference for red wine over white by Korean than Australian consumers; (ii) Australians reported taste/flavor as a more important factor when choosing wine than Koreans did; and (iii) perceived health benefits were a more important factor for Koreans than Australians when choosing wine. Preferred wine price was similar across cultures, and bottle shape was not a particularly important factor by either culture. Overall, these data demonstrate that sociocultural influences impact, via top-down cognitive processing, wine purchase and consumption behavior.

Wan and colleagues (Wan et al. 2015a, b) report several cross-cultural studies where influence of type of serving glassware and participant culture on consumers' expectations pertaining to color-flavor associations was investigated. Chinese (Study 1) and American (Study 2) participants rated liking, familiarity, and drink-glass congruency from photographs online of alcoholic drinks (beer, whisky, red wine, white wine, Baijiu) presented in six different glass types (Wan et al. 2015b) as well as their willingness to pay for each drink in terms of amount of money (Chinese Yuan or $US). Interestingly, there was significant cross-cultural agreement between the American and Chinese participants with both groups considering some glassware more appropriate than others for serving wines and liking was associated with drink-glass congruency for both cultures. Familiarity ratings were not significantly correlated with drink-glass congruency for either culture. In contrast, the data for whisky, a beverage less familiar to Chinese than Americans, and Baijiu (a beverage less familiar to Americans than Chinese), and beer showed significant cross-cultural differences in willingness to pay as a function of perceived beverage-receptacle congruency suggesting learning and experience as influencing purchase-intent behaviors.

A related study, investigating conceptualized flavor as a function of glass shape (water, wine, cocktail) and beverage color (red, green, yellow, blue, orange, brown) in participants from the UK, India, and South Korea (Wan et al. 2015a), reported significant differences in color-flavor expectations, with some colors being more influential than others. For example, the British associated cranberry with the color red while the most common flavor associated with red for both the Indian and Korean participants was cherry, presumably reflecting learning as a consequence of culture-specific, food experiences. Cultural differences also occurred in terms of type of glass associated with an alcoholic drink. These data, taken together with those of Wan et al. (2015b), support the notion of culture-specific, implicit and explicit learning phenomena playing a significant role in how each of us is influenced by extrinsic aspects of foods and beverages.

Extrinsic factors influencing perception of wine were investigated across two European cultures, France and Spain, in a study reported by Saenz-Navajas et al. (2014). The study examined the notion that culture influences our perception of a product's quality, presumably because own-country products are more familiar than other-country products. French and Spanish wine consumers, who provided data concerning their wine knowledge and wine consumption patterns, categorized French and Spanish wines in terms of perceived quality. Consumers who had less experience of wine, termed lower wine-involvement consumers, tended to draw on wine origin as the most important quality cue, favoring their own country. Consumers with higher levels of wine knowledge and/or involvement employed a wider range of cues that were available from observation of the wine bottle and its label(s) such as a specific appellation or classification term (e.g., "reserva" for Spanish wine). Again, the data demonstrate that domain-specific expertise can be as influential as cultural differences when appreciating the nuances of complex food products such as wine.

Studies Concerning Cerebral Representation: Thoughts, Attitudes, and Opinions

Researchers investigating conceptual aspects of wine appreciation have considered a range of topics including wine's perceived health benefits (Yoo et al. 2013) and attitudes toward low-alcohol wines (Bruwer et al. 2014). They have as well employed a range of methodologies, many researchers taking opportunities provided by newer technologies (e.g., online data collection).

Cerebral Representation Studies

Cerebral representation methodologies (e.g., Parr et al. 2011) are used to gather data concerning how an individual, or a group of individuals, conceptualizes an aspect of their life (e.g., what they think about the beverage known as wine). In cognitive psychology, the notion of cerebral representation emphasizes the concept of semantic memory which describes the body of knowledge available to an individual. In social psychology, the concept is extended to refer to the collective thinking of a group of people such as their shared beliefs about an item or object (Jodelet 2008). According to Parr et al. (2011), thinking about wine means that we form representations or cognitive concepts of past tastings, ideas, and expectations to which any subsequent sensory experiences are linked. It follows then that the way we think about wines is related to our intimacy with this beverage (expertise level) and culture can play a fundamental role in this (Mouret et al. 2013).

In one of the few published cross-cultural studies, Mouret et al. (2013) investigated social representation of wine as a function of wine expertise and culture of participants. Using a verbal association task in which participants were asked about wine, they compared responses from experts (wine professionals) and nonexperts (wine consumers) from France and NZ. Results demonstrated participant-culture differences: While for French participants wine was related to friendship, red wine, and cheese, New Zealanders considered wine with different flavors as a subject of enjoyment, relaxation, and fun, and also linked wine to food in general. The authors concluded that culture was important in how wine is conceptualized, their data demonstrating specific ways in which participants from France (an Old World wine country) and NZ (a New World wine country) differed in their thinking about wine. Rodrigues et al. (2017) also used cerebral representation methodology in their investigation of cultural differences driving consumers' representations of New- and Old-World wines. The authors compared responses of consumers from Brazil, Czech Republic, and Sweden, using the respective native language of each country. Results demonstrated cultural differences. For “Old World wine,” Brazilians’ representations referred to sensory aspects of wine, sophistication, style, and emotions, whereas for European consumers, elements of history, context, old-wine production processes, aged wines, and tradition were associated with the category Old World wine. In the New-World-wine condition, Europeans associated wine with eco-friendly production, wine region, and international trade, while for Brazilians, this concept evoked the element exotic and the word emotion, along with sensory aspects previously associated by them for Old World wine. The authors concluded that the long history of wine in Europe and the greater wine consumption in that continent influenced European participants to be more precise in their wine representations than Brazilians who have a more recent history pertaining to wine and wine consumption.

To summarize this section, despite limited published research to date, it is clear that important cultural differences can be evoked when people from different geographical areas or ethnicities respond verbally to wine-stimulus words as are employed in cerebral representation methodology.

Studies Reporting Beliefs, Opinions, and Attitudes

Various other methodologies have been employed to investigate a range of topics pertaining to wine conceptualization as a function of culture. Selected studies are discussed below.

Do et al. (2009) investigated attitudes, motives, and expectations of Vietnamese and French people toward wine consumption, the two cultures being selected as having very different wine-drinking and wine-production histories. Results showed that for Vietnamese, symbolic and utilitarian motivations were important (e.g., awareness of status or impression being made), whereas hedonic motivations such as experiential pleasures pertaining to actually drinking the wine appeared much weaker than in French respondents. The authors interpreted these results as in keeping with historical and contemporary aspects of the respective societies in terms of wider conceptualization of wine within each society.

Around the same time, Stolz and Schimid (2008) studied opinions, attitudes, and expectations of consumers from four countries (Switzerland, France, Italy, and Germany) concerning organic wines. Outcomes showed that, despite an overall positive image about organic practices and wines, each cultural group of consumers had different opinions. Whereas for Swiss consumers, positive opinions were found concerning authenticity of the product, the other cultures’ opinions were of neutral nature. In terms of the taste of organic wines, negative opinions were reported by French and German consumers, while responses from the Swiss and Italian consumers were neutral or demonstrated a lack of opinion on the subject, respectively. The authors attributed several factors as responsible for the negative image concerning taste of organic wine, including that organic producers focussed more on grape production rather than on wine processing. As well, it was suggested that the lack of presence of organic wines in specialized wine shops offering premium wines could contribute to consumers getting the impression that exclusive organic wines do not exist.

Another qualitative approach was taken in a study by De Magistris et al. (2011) who analyzed preferences for wine attributes of millennial generation participants (previously called "Generation Y") in two countries, one from the New World (the USA) and another from the Old World (Spain) (According to Lancaster and Stilman (2002), "Generation Y" corresponds to those people born between 1977 and 1999. However, they may also be referred to as "Millenials." With respect to wine, this is the consumer group currently in the spotlight and often comprising "connoisseurs." Results indicated that American and Spanish Millennial consumers presented some similarities but also some differences in their wine attribute preferences. While millennial consumers in the USA attributed more importance to "I tasted the wine previously," Spanish Millennials ascribed more importance to the designation of origin of a wine. Interestingly, when five consumer segments were identified, they could be characterized by traditional sociodemographic profiles and differed only in wine consumer preferences. This indication of cross-cultural differences for Generation Y agrees with recent research, suggesting that members of the same generation are likely to differ *within* a country (Ritchie et al. 2009) and *between* countries (Durvasula and Lysonski 2008). Also investigating opinions and attitudes of young wine consumers, Charters et al. (2011) compared engagement with champagne and sparkling wine of Generation Y consumers from five Anglophone countries (the USA, NZ, the UK, Australia, and South Africa). Results showed differences as well as similarities among the groups. In terms of differences, the UK consumers demonstrated superior knowledge about Champagne brands, while consumers from the other countries were more knowledgeable about wine production methods. The authors interpreted these results in terms of cultural differences impacting the knowledge levels of participants. All studied countries were traditional wine producers except the UK, the country whose participants displayed less understanding of production issues. In contrast, consumers from the UK were more aware of different grape varieties and wine styles. These data show that Generation Y consumers do not hold the same viewpoints and perspectives about wine across cultures, with their historical intimacy with wine production an important differentiating factor. In terms of similarities, for all countries, sparkling wine was considered feminine and a social drink by consumers of all countries.

Chang et al. (2016) explored influence of ethnicity of American wine consumers (along with other demographic characteristics such as gender and age group) on beliefs about wine and health. The wine consumers comprised African American, Hispanic, Asian, and White/Caucasian cultural groupings. Results demonstrated differences in the level of health consciousness as a function of ethnicity, with African and Asian American people more concerned about their health when compared with other ethnic groups. In terms of other ethnic differences, African Americans reported that sparkling wines were healthier than other wine categories, leading the authors to conclude that African Americans may be more convinced by the popular belief that bubbles can help with digestion. This research is particularly interesting in that the authors contrasted beliefs of different ethnicities within the same country, demonstrating that even when born in the same country, ethnic origin may play a role in people's conceptualizations pertaining to food and beverages.

Finally, an interesting cross-cultural study by McIntyre et al. (2016) investigated attitudes of alcohol consumers who chose *not* to drink wine. To understand the participants' lack of wine appreciation, alcohol consumers from five countries, Australia, Canada, the UK, the USA, and India, answered questions online. Overall, the study reported more similarities across cultures than differences. An implicit dimension, not liking the taste of wine, was the major determinant of wine avoidance for participants of all five countries investigated. Indian consumers in particular were influenced by a wine's taste, reporting that "fake" wines were prevalent in India, tasted unpleasant, and were difficult to discriminate from "real" wines when purchasing wine. Several sociocultural effects were reported including the notion that wine is perceived as "European," and the importance of "image" for Indian participants, a similar association of wine and status having been reported previously for Chinese consumers (Liu and Murphy 2007).

Overall, the studies reported above demonstrate both similarities and differences across cultures in how wine is conceptualized, and in terms of how people consider key aspects such as health benefits, sensory expectations, and wine consumption. A particularly interesting result observed concerns the interaction between generation or cohort (i.e., age of participants) and culture, opening up an avenue for future study.

Emotional Response to Wine

The last decade has seen an increase in sensory and consumer studies investigating emotional response to food and beverages including wine (e.g., Porcherot et al. 2015; Silva et al. 2016; van Zyl and Meiselman 2016; Danner et al. 2016; Sulmont-Rossé et al. 2019). From research in Anthropology and Psychology concerning cultural construction of emotions, we know that although cultures share some aspects of emotional response (Eckman 1992), they can differ in what they consider to constitute an emotion, and in which emotions are considered normal or acceptable (Kitayama et al. 2006; Mesquita et al. 2016), these factors potentially influencing wine appreciation. Few studies however have interpreted their data concerning emotional responses to wine or wine consumption by inferring the specific underlying or associated cognitive processes. This overview selectively focuses on published, cross-cultural studies that are theoretically driven, rather than merely descriptive. A further qualification is that it is outside the scope of this chapter to address currently topical issues pertaining to defining and measuring emotional response to food and beverages (Prescott 2017).

The notion that emotional response to wine and other beverages may differ across cultures has its basis in fundamental research such as that demonstrating variability in affective responses to odors (e.g., Ferdenzi et al. 2013), odors being extremely important in wine appreciation (Parr 2003). In their study, Ferdenzi et al. considered the influence of top-down cognitive processes in the form of odor knowledge and familiarity on intensity and valence (i.e., positivity) of affective response to odors by participants in the UK, Switzerland, and Singapore. Using 56 odorous stimuli, the authors reported significant cross-cultural differences in ratings of pleasantness, familiarity, and intensity of many of the odors. For example, mushroom was more familiar and judged to be more pleasant and more intense by the Swiss than by the Singaporeans. On the other hand, there was a less intense response to disgust by the Singaporeans than by the Europeans to durian, a fruit popular in Singapore but less well known in Western countries. The data also showed gender to interact with cultural differences with Swiss men giving higher affective ratings to happiness/ well-being, sensuality/desire, energy, and disgust than women participants, while such gender differences did not occur in the UK or Singapore groups. The authors drew on cultural experience and learning as a likely source of demonstrated cultural differences in olfactory knowledge and affective response, implicating top-down cognitive influence in the form of an associative, verbal network of odors, this network developed on the basis of a participant's past experience. A further, important fundamental result demonstrated was the asymmetrical nature of response to pleasant versus unpleasant odors, with the positive association between olfactory knowledge and affective ratings occurring for pleasant but not for unpleasant odors.

In terms of applied research specific to wine, van Zyl and Meiselman (2015) investigated cultural differences in emotional responses to beverages including wine. Vocabulary has been identified as important in how an individual describes or reports emotional response (Prescott 2017), and van Zyl and Meiselman singled out language as a key aspect of culture for consideration in their 2015 study. In this study and an updated component (van Zyl and Meiselman 2016), participants from English-speaking countries (Australia, NZ, the UK, the USA), Spanish-speaking countries (Spain, Mexico), and Portuguese-speaking countries (Portugal, Brazil) reported their favorite and least-liked beverage and the emotions they associated with each. Results showed that participants from English-speaking countries along with those from Mexico and Brazil produced similar emotional responses to wine, while respondents from Spain and Portugal were similar to each other in their emotional reactions to wine. The authors emphasized the importance of considering language in relation to reported emotional response evoked by beverages although did not elaborate upon precisely how culture affects language use in relation to emotions evoked by beverages.

In an innovative study with a clear cognitive orientation, and using focus-group methodology that included participants actually tasting beverages, Silva et al. (2016) investigated how Dutch and Portuguese conceptualize and respond emotionally to wine, beer, and nonalcoholic beer consumption across various contexts. The authors implicated two processes as determining conceptualization, namely identification of the product and generation of associations toward the product (e.g., healthy, makes me feel happy). With the premise that the Dutch were more closely linked with beer production and consumption, while the Portuguese links are with wine, the authors hypothesized likely cultural differences in conceptualization of beer and wine as a function of culture. Results showed that Dutch and Portuguese overall conceptualized beer and wine similarly, with differences in conceptualization more related to beverage type than to culture. Wine was conceptualized as associated more with social attributes such as communication and celebration than beer, and linked to emotional associations of calmness, loving, and fulfilled. Beer on the other hand was associated with emotional responses of energetic, adventurous, and free. One of the few cross-cultural effects reported was that special beers were singled out by the Dutch participants who conceptualized them as closer to wine than to beer, associating them with emotional terms happiness, comfort, and delight.

In the study investigating hedonic responses of wine consumers from Australia, the UK, and the USA reported recently by Ristic et al. (2019) and described in the section "Hedonic Judgments" above, emotional responses to nine selected wine aromas were also investigated via the ScentMove^{TM} scale (Porcherot et al. 2015). Participants rated how strongly an aroma made them feel in relation to six groups of emotions (relaxed, nostalgic, happy, disgusted, romantic, and energetic). Several cross-cultural effects emerged. For example, emotions evoked to "strawberry" and "chocolate" were similar for the USA and the UK respondents while "pepper" evoked similar emotional responding in Australian and the UK consumers. As with the hedonic data reported above, variables other than a respondent's country (e.g., wine consumption frequency, context of consumption) were major influences on the dominant emotions evoked to the various aromas.

In summary, although the study of emotional response to beverages is in its infancy, it is clear from the studies reported to date that culture, and the socialization and cognitive/learning processes inherent in this term, is an important individual-difference variable, determining how each of us appreciates a wine. From a theoretical perspective, many of the reported results support the notion that our cognitive processes (perception, memory, classification, judgment, language) are linked intimately with our emotional processes when we taste wine, allowing an individual's sensory-driven experience to take on a global dimension or totality (Table 1).

Methodological Issues of Significance to Cross-Cultural Research

While many methodological aspects can influence validity of a study's outcomes, inherent in cross-cultural research are several extra considerations. Two of these we highlight below.

Lost in Translation

Language and thought are closely associated cognitive processes, with the ways in which perceptual and thought processes are related to language long a topic of interest in Psychology (Whorf 1956). It follows then that when comparing verbal and behavioral responses from people of different cultures, researchers need to consider not only linguistic equivalence (vocabulary equivalence) but functional and cultural equivalence in all terminology employed within data collection instruments and instructions to participants (Pena 2007). Rajan and Makani (2016), in their review of methodological and theoretical aspects of translation in cross-cultural studies, raise concerns not only about lack of attention to linguistic equivalence,

Table 1 Summary of published studies on cross-cultural aspects of wine appreciation: type of participant, region of origin of participant, methodology, and main result

Authors	Year of publication	Type of participants	Culture of participants	Major result
Intrinsic factors				
Torri, Noble & Heymann	2012	Wine consumer	USA and Italy	No consistent support for the notion of familiarity in cultural differences
Williamson, Robichaud & Francis	2012	Wine consumer	Australia and China	More similarities than differences among both cultures were reported
Parr et al.	2015	Wine expert	France and New Zealand	More similarities than differences. Dissociation between wine liking and wine familiarity for French participants
Ristic et al.	2019	Wine consumer	Australia, UK, and USA	Demographic factors had greater effects than geographic location of participants
Saenz-Navajas et al.	2013	Wine consumer and wine expert	France and Spain	Expertise rather than culture as the major driver of quality judgments in wines
Valentin et al.	2016	Wine expert	France and New Zealand	Expertise rather than culture or geographical location as the major driver of quality judgments in Pinot noir wines
Saenz-Navajas et al.	2013	Trained panelist	France and Spain	Cultural differences were found due to different cultural histories
Extrinsic factors				
Yoo et al.	2001	Wine consumer	South Korea and Australia	Wine purchase and consumption behavior were impacted by cultural influence via top-down cognitive processing
Wan, Zhou, et al.	2015	Wine consumer	China and USA	Culture-specific, implicit and explicit learning phenomena play a significant role in extrinsic aspects
Wan, Woods, et al.	2015	Wine consumer	UK, India, and South Korea	Culture-specific, implicit and explicit learning phenomena play a

(continued)

Table 1 (continued)

Authors	Year of publication	Type of participants	Culture of participants	Major result
				significant role in extrinsic aspects
Saenz-Navajas, Ballester, Peyron, & Valentin	2014	Wine consumer	France and Spain	Expertise can be as influential as cultural differences
Conceptual factors				
Mouret, Lo Monaco, Urdapilleta & Parr	2013	Wine consumer and wine expert	New Zealand and France	Social representation of wine differed as a function of wine expertise and culture
Rodrigues et al.	2017	Wine consumer	Brazil, Sweden, and Czech Republic	Level and history of consumption had greater precision effects than cultural aspects on wine representation
Do, Patris & Valentin	2009	Wine consumer	Vietnam and France	Historical and contemporary aspects of the cultures imply a broader conceptualization of wine for both
Stolz & Schimid	2008	Wine consumer	Switzerland, France, Italy, and Germany	Different opinions about organic products were demonstrated depending on the culture of participants
De Magistris, Groot, Gracia & Albisu	2011	Wine consumer	Spain and USA	Both consumer segmentation and culture play a significant role in conceptual aspects
Charters et al.	2011	Wine consumer	USA, New Zealand, UK, Australia, and South Africa	Cultural differences impacted the knowledge levels of participants
Chang, Thach & Olsen	2016	Wine consumer	Ethnicities in USA (African, Asian Hispanic, and White/ Caucasian	Ethnic origin (subcultural category) may play a role in people's conceptualizations
McIntyre, Ovington, Saliba & Moran	2015	Wine consumer	Australia, Canada, UK, USA, and India	More similarities across cultures than differences were reported

(continued)

Table 1 (continued)

Authors	Year of publication	Type of participants	Culture of participants	Major result
Emotional aspects				
van Zyl & Meiselman	2015; 2016	Wine consumer	Australia, New Zealand, UK, USA, Spain, Mexico, Portugal, and Brazil	Language was considered important in relation to reported emotional response evoked by wine
Silva et al.	2016	Wine consumer	The Netherlands and Portugal	Differences in conceptualization more related to beverage type than culture
Ferdenzi et al.	2013	Wine consumer	UK, Singapore, and Switzerland	Cultural experience and learning as a likely source of demonstrated cultural differences
Ristic et al.	2019	Wine consumer	Australia, UK, and USA	Variables other than geographic origin (e.g., wine consumption frequency, context of consumption) were major influences on the dominant emotions evoked

potentially threatening content validity of data, but also about ethnocentricity. Discussion of these issues in detail is beyond the scope of this chapter, but it behoves all cross-cultural researchers to be aware of such potential problems. One major aspect to be mindful of is that linguistic equivalence does not necessarily imply conceptual/functional equivalence and/or cultural equivalence for many reasons (e.g., salience, familiarity). Pena (2007) defines functional equivalence as ensuring that instructions to participants and text within data-collection instruments will elicit the same target behaviors from the various linguistic groups. Cultural equivalence concerns how participants of various cultures will interpret the words: i.e., Will translated text tap into the same cultural meaning for each linguistic group? Methods exist for improving functional equivalence (e.g., dual-focus approach), and where possible involving researchers with the relevant bilingual and multilingual competencies should be advantageous in all cross-cultural studies, minimizing the risk of ethnocentricity and ensuring cultural and functional linguistic equivalence. As well, projective techniques from psychological research may offer an alternate methodological approach, one that minimizes language differences.

Defining “Culture” in an Increasingly Globalized World Context

Most published research that employs the term “cross-cultural” in the title reports studies involving national (e.g., ethnic differences, also called “sub-cultural” – see

Sobal (1998) for a review) or international comparisons of individuals, defining culture in terms of individuals' ethnicity or geographical location. Given our increasingly connected world, it is not surprising that some researchers are considering definitions of culture that venture beyond ethnic origin and geographical location. Culture-as-situated cognition theory (Oyserman 2016) exemplifies this approach, arguing that individuals can shift between cultural mind-sets, depending on context. Nonetheless, it remains that despite those recent developments such as the ease of international travel and the rise of the internet there remain significant differences among people from varying cultures in terms of the foods and beverages they consume regularly (Albala 2011).

Internet Data Collection

Recent years have seen increased data collection in the field, faster data collection, and a change in the dominant methodologies employed, presumably due to the options afforded by digital technology. The use of the internet to facilitate cross-cultural data collection can be seen by comparing two special issues, each in a renowned, scientific journal, and dedicated specifically to cross-cultural research on food and consumer science: the pioneer in 1998 (Tuorila 1998), and a second 20 years later (Rodrigues et al. 2019), this recent special issue presenting several studies involving internet data collection.

Summary: Contribution of Cross-Cultural Research to Understanding Wine Appreciation

Cross-cultural research involving wine and wine tasting, employing a range of methodologies and investigating a range of topics, is beginning to provide evidence of the importance of our experiential histories in influencing how we appreciate wine. In particular, several of the studies discussed above demonstrate the importance of wine tasters' top-down cognitive processing, in other words their prior experience, in how they conceptualize and appreciate wine. Notable findings to exemplify this include those reporting both similarities and differences as a function of culture. In terms of cultural similarities, the importance of wine expertise in minimizing potential cross-cultural differences in wine appreciation was demonstrated by Parr et al. (2015) and Valentin et al. (2016). Important findings where differences were demonstrated include: differences in opinions of consumers across several European countries concerning organic practices (Stolz and Schmid 2008); demonstration of differences in rating scale usage by Chinese and Australian consumers (Williamson et al. 2012); use of different terminology to describe red wine characteristics by French and Spanish trained panelists (Saenz-Navajas et al. 2013); and cultural differences in consumers' responses to beverage serving glassware (Wan et al. 2015b).

Several studies demonstrate also the limits of culture's influence, especially when culture is defined in terms of geographical location or ethnicity. For example, studies involving wine professionals demonstrate clearly that domain-specific expertise (i.e., wine knowledge) can override cultural differences. In their study concerning perception of mineral character in wine, Parr et al. (2015) demonstrate that wine professionals from very different cultures (France, NZ) perform complex oenological tasks similarly, presumably sharing a cognitive construct concerning the abstract notion of minerality in Sauvignon blanc wine irrespective of their vastly different cultural histories.

Further, inconsistent results in several studies where familiarity is implicated as reflecting cultural experience (e.g., when Californian and Italian wine consumers judged Californian wines as more likeable), conceivably occurred due to cultural influence factors wider than geographical location. Culture-as-situated cognition theory (Oyserman 2016) takes such factors into account, arguing that individuals can shift between cultural mind-sets, depending on context. Hence, an Italian wine consumer who regularly drinks international wines may be of Italian "culture" but when in a wine-tasting context may function cognitively by drawing on mental representations of wine that have developed via socialization into a multicultural wine world. In other words, cultural distances are not only geographic but may be ethnic and may even relate to an object of "global dominance" as is the case of wine and health.

Conclusion and Directions for Future Research

Future research, both basic and applied (e.g., marketing), could be advantaged by attention to several aspects. First, researchers need to move beyond merely describing cross-cultural effects, and to focus more on understanding the specific nature of culturally driven, top-down influence by drawing on theories of perception, cognition, and emotion to interpret data. This in turn will deepen our understanding of wine-tasting phenomena as a function of culture. Second, there is a need for an increase in theoretically driven studies. Exemplifying the need for more theory in the research field is work drawing on the assumed intervening variable of familiarity as an explanatory concept for study results. However, familiarity is a more complex concept than many authors investigating cross-cultural phenomena have considered. Our regular exposure to certain wines rather than others conceivably leads to development of mental constructs, these in turn giving rise to expectations concerning fundamentals such as "What actually constitutes a wine?" through to "Is this a quality wine?" in more experienced wine drinkers. However, familiarity as largely determined by geographical location and repeated exposure has limits in terms of its influence, with familiarity interacting with wine domain-specific expertise and other forms of socialization. Third and of major importance, culture as a variable requires clarity in terms of definition in any particular study, not least because cultural socialization and our cognitive and emotional processes are inherently linked. Further, given an increasingly connected world, geographical location per se conceivably may become less relevant than other factors such as sociodemographic status in determining individual differences in how we appreciate food and beverages.

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Part XIV

Trends in Eating

Past, Present, and Future of the Food and Drink Final Market

69

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Contents

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Abstract

We present the past, present, and future of the food and drink industry from a final consumer market point of view according to three highly complementary components: the final product design, the selling mechanism, and the product pricing. We show how much these have changed in the past and how they will change even more in the future.

Last century history exhibited two stages. We moved from a "behind the counter" selling of standardized "Basic Goods" at a price per kilo in the 1890s to highly differentiated "Packed-Dishes" sold in self-service at a price per pack in the 1950s. This present model is now challenged by the industry of the future. One possible scenario may be customized "Service-Diet" that will be sold to any individual on smart platforms at the price of a subscription and home delivered.

Introduction

This chapter has a retrospective and prospective aim. Its scope being industrial food and drink, it intends to project the reader toward some possible futures, in one or two decades from now, with a long-term historical perspective.

It focuses on changes in the shape of the *final consumer market* (also called *end market*) where consumers shop and buy food and drink. Through retailing, the end market is linking the whole food extended value chain and the consumer. This focus is justified by a conviction: as in many other industries *the past and ongoing changes on the food and drink final market had and will tremendously transform the whole food system*. To understand the changes in both retrospect and prospect, we will focus on three key components of the final market: (i) the *nature of the products offered*, (ii) the *shopping, buying, and delivery mechanism of these products*, and (iii) their *pricing principles*.

To facilitate the understanding of the dynamic of transformations and their specific patterns in retrospect and prospect, we shall distinguish periods. In line with the economic history literature, and at a cost of large simplifications, we will label them "Industrial Revolutions" (see Table 1). We adopt the route according to which there had been three successive Industrial Revolutions until now, that we are

Table 1 The four industrial revolutions (general patterns for all industries)

	First Industrial Revolution 1700–1860 *"Machine Age"*	Second Industrial Revolution 1870–1950 *"Fordism"*	Third Industrial Revolution 1950–2016 *"Toyotism"*	Fourth Industrial Revolution 2016– > … *"4.0"*
Products	Manufactured goods are invented and extend their scope	Goods are standardized and get cheaper	Goods are differentiated in lines, branded, frequently renewed	Goods are now parts of personalized services, sold as experience
Manufacturing challenge	Apply science and technologies to nature "machine age"	Mass production, "scientific organization of work" in production line	Design, produce, and sell differences, lean manufacturing, just-in-time, kaizen	Design, produce, and sell individualized experiences, interconnect agile elements
Extended value chain **Logistics** **Supply chain**	Trade merchants	Vertical integration B2C markets are outside the extended value chain	Vertical externalization, B2B markets and subcontracting develop	Platforms develop new B2B and B2C matching mechanisms, integrating the consumer as the key element of a now global extended value chain
Typical energy, technology, commodity, industry ***In food***	Coal, Steam Engine, Flying Shuttle, Metallurgy, Textile *Food Smoking, Salting, Drying*	Oil, Electricity, Telegraph, Telephone, Car, Mechanical, Chemistry *Genetic Engineering, Sterilization, Fermentation*	Nuclear, computer, robots, operational research *Food packaging Cold chain, flash pasteurization*	Big data, AI, internet of things, iPhone, platforms *Biotech*
Key figures and companies	P.S. & E.I. Du Pont de Nemours (DuPont)	Henry Ford, Alfred Sloan (GM)	Taiichi Ohno (Toyota), Shigeo Shingo	Jack Ma (Alibaba), Larry Page, Sergey Brin (Google), Jeff Bezos (Amazon)
Zeitgeist ecosystem	Urbanization, First colonialism	World wars, mass consumption	Economic growth, adverts and brands	Global warming, online social media and networks

presently living the end of the third one, and that we are just entering the fourth, which is our primary concern here.

The **First Industrial Revolution** (hereafter "1st IR") will not be covered as such in the following chapters. It has been, between 1750 and 1880, the time of industrial take-off, the age of the emergence of industry "as a fact" (Musso 2017). During this period, final demand for food and drink moved from rural self-sufficiency to urban mercantile demand, due to the development of industrial work and to the arrival of masses of people in cities, allowed by huge productivity gains in agriculture, due to technological innovations upstream agriculture, mechanization or nitrogenous fertilizers. (When writing *The Wealth of Nations* in 1776, Adam Smith witnesses an industry which is still in its infancy. David Ricardo, John Stuart-Mill, or Karl Marx, writing their major books respectively in 1817, 1848, and 1867, are among the best observers of the period.) Food industry large transformations happened during the eighteenth and explode during the nineteenth centuries, as in the production of cereals, sugar beet after 1812, or potato cultivation. Downstream agriculture and livestock, technologies changed the way food and drink were produced, preserved, packaged, transported, stored, delivered, and, with the development of household appliances, cooked and consumed at home. (These technologies include the gas cooker or the milk powder (1802), the refrigerator (1805), the tin can (1817), the chocolate bar (1836), the meat extract (1836), the chewing gum (1848), the corned beef, the electric hotplate (1859), fish and ships restaurants (1860) nicely described by John Walton (Walton 1992), baby food (1866), freeze-meat (from Australia, in 1861), refrigerated ships for long distance meat transportation (first from Argentina, in 1876), school cantina (after 1869 in France, after 1879 in the UK). The development of wine and beer consumption, all along the nineteenth century, and the consequent political and social fight against it, came with innovations in non-alcoholic drinks. First came tea and coffee, then sodas, born in France (1863) and developed in the USA (after 1886). In 1887, the first food and drink vending machine is patented in Germany. Instant coffee, first conceived in 1890 in New Zealand, find a stable form in the USA in 1901. By then, the 2nd IR is already started.)

The **Second Industrial Revolution (2nd IR)** will be covered in detail in section "Nature of the Final Product, Selling Mechanisms, and Product Pricing: Three Complementary Components of the Final Market." It had been, after 1890, the time for *standardization* of processes and products. It developed to the end of the Second World War. It is known as *Fordism*, after the huge commercial success of the Ford car model T, but it could have rather been called "*Yardism*" in reference to the Union Stock Yards of Chicago, where transfer lines and mass-products where invented. In the car industry, standardization soon appeared to be compatible with product differentiation. Multidivisional large vertically integrated companies became the business reference of the period. Standardized or basically differentiated final food and drink products were often ready-to-cook at home. They were offered and delivered in bulk, sold in neighborhood small specialized shops, priced per kilo, dozen, or liter, as flour, milk, meat, or sugar. Coca-Cola sodas, or Kellogg cornflakes emerged during this period.

What we will call here the **Third Industrial Revolution (3rd IR)** is the one of massive product differentiation according to consumers segments. It emerged during the 2nd IR, but spread and became the dominant design in food and drink industries after the Second World war. In the Car industry, that was still used as the benchmark, the disruption came from Japan, with what is known today as

Toyotism. The key words are modular and delayed product differentiation, and vertical de-integration.

The still present food system emerges during this period. Upstream agriculture, mechanical, chemistry, and seeds industries are progressively "toyotized." Downstream of agriculture, first transformation industries "dismantle" and "crack" agricultural and livestock products to produce, worldwide, in a Fordism way, standardized *ingredients*. Further downstream, processing food provision ingredients on B2B markets, adopt Toyotism principles. Using standard ingredients, they combine, transform, and package for producing lines of differentiated, packaged products, ready-to-sell, and ready-to-eat. Hundreds of thousands highly differentiated branded foods, beverages, and meals, often renewed, were created and produced. Today, differentiation still is the key driver of food and drink growth and profitability.

These differentiated ready-to-eat products could not be sold in behind the counter small shops. They are typically sold in self-service hypermarkets "all-under-one-roof." These are *physical brick and mortal places* with spacious dedicated parking lots in the vicinity. The final consumer comes to these places with its car for choosing, buying and bringing back home the self-selected products. The consumer shopping task is now to walk along shelves to identify, choose, pick, and place in her cart, the products fitting her profile, or market *segment*. Self-service companies transformed the very purpose of the final market and developed totally new and profitable pricing policies.

This coming **Forth Industrial Revolution (4th IR)** may happen in the future to be as important as 3rd IR. On the final food and drink market, as in every industry, comes a new time and new big players called *multisided platform* (Evans and Schmalensee 2016). The largest in the USA are the GAFAM (for Google–Apple–Facebook–Amazon–Microsoft). These *multisided platforms*, in a way that is not predetermined yet, may revolutionize the way final food and drink are shopped, bought and delivered; and then the way they are designed, produced, made available, and the consumed.

The key p*rospect goal* of this chapter is to show, in food and drink business and consumption, the potential for economic transformation of the *multisided platforms*, together with the digital technologies, and the new distribution logistics that come with them.

In this chapter, we shall analyze successively the past 2nd IR, the present 3rd IR, and the coming 4th IR, through three of their components: *the nature of the final product, the shopping and selling mechanism, and the pricing of the product*. The coming section of this chapter (section "Nature of the Final Product, Selling Mechanisms, and Product Pricing: Three Complementary Components of the Final Market") presents the content of each of these three elements. In three of the following sections (The Second Industrial Revolution and the 'Basic-Good' Product," "The Third Industrial Revolution and the 'Final-Dish' Product," and "Conclusion"), we will detail these three elements in the food and drink industry for each of the covered Industrial Revolutions. Doing so, we will describe the coherence of each historical IR, but also both its limitations and drivers announcing the next one

(Table 3 synthetizes these limitations and drivers). Between the 3rd IR and the 4th IR presentation, we will insert (section "4th IR, Selling 'Experience' Online: Between Wahoo Effect and Long-Term Diet-Subscription") a description of the new information technologies that support matching platforms and the whole coming business model that comes with it.

Nature of the Final Product, Selling Mechanisms, and Product Pricing: Three Complementary Components of the Final Market

In this section, we present the precise contents of the three components of food and drink final markets that we will then use to analyze the past 2nd IR, the present 3rd, and the coming 4th IR.

Nature of the Final Product (Table 2)

A few classic tools taken from economics and management sciences will be used to define and analyze the food and drink products during each of the three covered IR. We will focus on six elements (Table 2).

Table 2 Nature of the final product during three Industrial Revolutions

	2nd IR "Fordism"	3rd IR "Toyotism"	4th IR – "4.0"
Type of the product sold	Basic good	Dish good Consumer packaged goods	Experienced service, diet service?
Usage of the product	Ready-for-cooking	Ready-for-eating	Ready-for-experience, ready-for-diet
Value-driver scope of characteristics	Limited, basic needs, intrinsic characteristics	Convenience, desires, trademarks, symbolic characteristics, advertising	Experience, meaning, personalization, numerous and complex requirements, non-incorporated characteristics
Information coming with the product	Incorporated in the product	Package	Promises of experience
Dominant design and differentiation supports	Standard seasonal or local	Client and purpose segment differentiation	Experience and diet personalization
Production and extended value chain pattern	Agriculture and first transformation, high-volume, low-margin	Standard ingredients with downstream differentiation, still high-volume	Deep (up to agriculture) or delayed personalization?

– *The Type of the product*. Here, defining the “type” of a product first answers two questions: is it a good or a service? Is it a commercial good or not? A meal in a restaurant is a service, a can of soda bought in a shop is a good. Drinkable water, in some countries or centuries, was a non-market good. The “type” of the product also means here its scope. For a commercial good, it answers the question: what is for sale, and what is actually priced? The scope of a product changes as bundling or debundling strategies appears as ways for product innovation and differentiation (Venkatesh and Rabikar 2006; Venkatesh and Vijay 2009; Ghosh and Subramanian 2007). According to its scope, a product may be a set of products bought and priced separated (as a plain yogurt and a pack of sugar), or they may be bundled in a sweetened yogurt, bought and priced as a single product. The degree of processing is also describing the type of the product, ranging from unprocessed fruits or vegetable to hyper-processed food.
– *The Usage of the product*. Of course, the functional usage of any food or drink is to satiate, nourish. But the usage is also to quench desire and give pleasure. These are classic needs. Convenience is another dimension, explaining the hyper-processed food supply. As time is precious but time is also money, the “make or buy” trade-off between home cooking and industrial kitchen is frequent in food and drink final choices. We shall use the term “ready-for. . .” to define this trade-off: “ready-for-cooking,” “ready-for-drinking,” and so on.
– *The Value-Driver Scope of Characteristics (also called Attributes)*. What does consumer value when he is choosing food and drink, what is he ready to pay for? Nutrient content, hedonic characteristics, presence (or absence, as gluten free) of ingredients, organic ingredients, place of origin, brand, animal welfare, fair trade. Some value-driver product characteristics are incorporated in the product, they are “intrinsic” (as salt or milk), some are not (as carbon footprint or animal welfare); some characteristics are functional (convenience). Some characteristics have a negative value (as pollution). Some consumers may value characteristics that others do not.
– *The information coming with the product*. Some useful information for the consumer are product intrinsic, accessible through consumer senses, when shopping or when consuming, other are not. Hidden information may appear on the package, in a more or less regulated way, as the list of ingredients, the list of nutrients, the origin, and so on. Others are commercial information, such as the brand. The price is also an important information. Economists of the 3rd IR have focused on information asymmetries that are in disfavor of the consumer. They have coined the concept of “lemons” (Akerlof 1970) to qualify a defective product that is not recognizable as such by the buyer; the concept of “search goods” to define products with some characteristics that can only be ascertained upon consumption, the concept of “credence good” a product whose claimed characteristics is impossible to the consumer to ascertain (Darby and Karni 1973). Michael Spence defined the concept of “signals” to qualify an information which is credible for the consumer (Spence 1973, 2002), and analyzed the conditions of credibility. Some question the role of brand in signaling quality (Waldfogel and Chen 2006).

- *The Dominant Design and Product Differentiation Supports*. In a given food and drink category, a "dominant design" often exist (Teece 2007). It defines an existing product used as a benchmark, for the other products of the category, in particular when they are differentiated. The dominant design description includes the full production process, the nature and usage of the product, and its price. The *differentiating support* lists the processes and characteristics used for product differentiation. Today, together with the segments of targeted clients, and the pricing strategy, they define the "value proposition" of a business, that is, the strategic logic of differentiation. As we are embracing here a long-term point of view, the dominant-design perspective also refers to the global ecosystem of the period: technologies, norms, networks, infrastructure, zeitgeist, and so on. As an example, the car development during the 2nd IR has first needed cheap and reliable cars, but also petrol extraction, gas station networks, drivable roads. The car dominant design then generated suburbs, individual housing, commercial zones with parking lots and large stores offering transportable by consumer goods, and so on.
- *The Production and Extended Value Chain Pattern*. Agriculture has been and remains at the core of food and drink extended value chain. But the food system is extensive and complex. Upstream of agriculture is fertilizers or water, but also machinery; Downstream of agriculture is processing industry and distribution. The extended value chain describes the way private and social value is created, and private and social costs are generated. It may create or destroy value as such, irrespective of the intrinsic quality of the final product. It is creating value when consumers are ready to pay hand-made products, or local production, or fair trade. It is destroying (social) value, when it generates negative externalities such as CO_2 emissions or eutrophication.

Shopping, Selling, and Delivery Mechanism (Table 3)

For a given consumer or family, the shopping process covers a long sequence of decisions, including exploring the available products, discovering a subset of these products, collecting information and recommendations, testing and comparing, choosing, structuring (implicitly or explicitly) a routinized diet, choosing a pricing pattern, buying, paying, bringing the products back home and store them, before the cooking and eating moments, preceding wasting and recycling.

Today, the economics literature on market mechanisms is wide and prolific, stimulated by recent sophisticated issues and the emergence of new players. Transformation are happening in business to business markets (B2B), such as wholesale electricity market, frequency spectrum, or B2B industrial supply, with new operators such as Alibaba. Final demand is also concerned (B2C) with platforms such as OpenTable for in restaurants. Consumer to consumer (C2C) new markets are also developing, such as eBay or Airbnb. Advanced analysis of selling mechanisms (Krishna 2013 and Vulkan et al. 2013) are now focused on platform (Roth 2016;

Table 3 The shopping, selling, and delivery mechanisms during three industrial revolutions

	2nd IR "Fordism"	3rd IR "Toyotism"	4th IR – "4.0"
Final market purpose	Procurement, for basic needs	Matching differentiated products and client segments	Matching information for experience and diet personalization
Shopping and Selling mechanism	Small specialized shops, repeated transactions	Self-service, Anonymous clients	Platform, from wahoo to long-term contracts
Transaction costs	High, slow decision-making (system 1)	Low, fast decision-making (system 2), but TC increases with product proliferation	Fast and slow may be reconciled, initial engagement required to co-create
Delivery process	Shop proximity, buyer walking carriage	Buyer's car	Home delivery, "Uberization," nomadic availability
Final client source of information (on products)	Direct contact, product delivered in bulk	Packages on shelves	Platform, social media
Extended value chain source of information (on client)	Poor, simple, global, not very used	Buying behavior by client segments	Capture the "customer journey," close to global individual human experience, privacy lost issue
Source of trust	Products and "who-to-who" market relations	Anonymous relationship, brands	Platforms as a social network, virtual "who-to-who" relations
Buyer behavior in context	Rational and slow Time wasting	Routinized fast	Slow with AI assistance Fast wahoo
Antitrust issues	Monopoly vs. small businesses	Monopoly in distribution, product information	Platform market power

Rochet and Tirole 2003; McAfee and Brynjolfsson 2017; Evans and Schmalensee 2016). In the following analysis of the past, present and future of the final food and drink final markets, we will focus on eight key elements of the selling mechanisms.

– The *final market purpose* of the mechanism describes what it is here for? It may be for a mere function of revealing a competitive price clearing supply and demand on a market for a homogeneous commodity (could be a market for an ingredient). It may be for a sophisticated matching procedure where highly differentiated products are facing strong identity consumers. Such mechanisms are for already existing products. In some markets, and food and drink may happen to be as such in the future, bespoke, tailor-made mass products ask for smarter market mechanisms that are here for co-creating products between an opened but specific demand and of "non-existing" but ready to personalize supply.

– The *process*, the market *mechanism* of shopping and selling itself, the part precisely labeled as the "market institution," answer the question: how does the shopping matching process between products and consumers actually works? The answer may range from an informal series of bilateral bargaining, as in a bazar, to complex auctions mechanisms, or network interactions. Pricing may be an important part of such mechanism, but pricing may also be designed out of the market mechanism (cf. price policy below). Nowadays, posted prices in self-service is the dominant shopping and buying mechanism in food and drink final markets, it has not always been the case in the past, and this may dramatically change in the future. One important feature of a final market mechanism is to know whose parts are actually (and nowadays virtually) present during the transaction. Typically, a bilateral bargaining requires the two sides of the market to be present. By contrast, a posted-price self-service only requires the buyer to be physically or virtually facing the products. Nowadays, a platform may organize virtual presence – with AI or not, explicit or not – implying several parts, typically the many possible sellers, the many possible buyers and the platform itself. All these stakeholders may non-anonymously communicate.
– *Transaction costs*, or "frictions" in exchanges, describe all sort of costs, for any "side" of a market, generated for coordination, incentives or matching efforts. Behind the counter selling is a labor-intensive process as it requires human sellers' expertise and help, and as it generates queues for clients. Specialized shops require clients to trip from one shop to another. Transaction costs may range from time consuming, to attention need, and to money spent in finding the right product, or the right supplier, or the right client. Transaction costs also include the costs of getting an inadequate product. First introduced by Olivier Williamson, after Ronald Coase intuitions (both Nobel Prizes in economics), the concept of transaction costs is essential to understand the long-term transformations of market mechanisms, and the "make-or-buy" trade-offs all along the extended value chain. Efforts to reduce frictions and make coordination easier, deeper, and more convenient explain a large part of the industrial dynamics, new product development, new real or virtual shopping spaces, and new pricing ways.
– *The delivery* process describes the way the consumer gets its food and drink at home. The questions are, "Who is delivering the food, when, and how?" "What are the respective roles of buyers and sellers in delivering?" For example, Ikea (Magretta 2003) was the first in the furniture industry to sell and deliver in large shops, asking consumers to come to out-of-town shops with own cars, shop, buy, and then immediately leave with the bought products. One of the consequences of such a delivery pattern, besides the availability of any products for sale, is that furniture is sold in spare parts, in easy-to-carry and get-in-a-car boxes. Another consequence is that the furniture has to be self-assembled by the consumer. It is interesting to note that in the furniture industry, home delivery and seller assembly

historically came first. Delivery includes a synchronization issue. For both sides, supply and demand, storage is a costly way to relax this coordination problem. Zero stock is a management issue within the food system, it is also an issue in the relationship between the food system and the final consumer.

– The *final client source of information* when shopping and choosing among existing products or among possible providers of non-existing products. Today, and before the arrival of internet, packages on self-services appeared to be the quasi-unique source of information on self-service markets. Advertising is important indeed, but it is indirectly incorporated in the market, or it appears on other markets, such as TV or magazines. What was before and what will come after?
– The *extended value chain source of information* is, compared to the previous point, the symmetric flow of information. How the final market informs the extended value chain concerning consumers' behavior, preferences and desires? This question is crucial for designing, pricing, matching products, as soon as they are differentiated and consumers specific (Hayek 1945). This flow of information is an important component of the way product innovation operates. The issue here is in which extent the final market may be used as a way to reach consumers, understand their preferences, interconnect them, predict their behavior, guide, monitor, and encourage their shopping choices.
– The *source of trust*. The question here concerns credibility. Do I believe what my senses receives (Is it really natural?), what I read (Is it really organic?), and what stakeholders say they do (CO_2 traceability)? Trust is long ago recognized by economists as the "oil of business." Kenneth Arrow, another Nobel Prize recipient, pointed it out: *"virtually every commercial transaction has within itself an element of trust (...) it can be plausibly argued that much of the economic backwardness in the world can be explained by the lack of mutual confidence*" (Arrow 1972). Building trust may drastically reduce transaction costs and increase the amount of available useful information and transactions. In many countries today, such as France, the lack of trust is one of the key problems in final food and drink markets. Restoring trust is a key issue in the future.
– *Buyer behavior in context*. Economics is getting more and more "behavioral" (Tirole 2017). Key contributions to the discipline have been done in this direction. Among the most decisive contributions let us put forward the Daniel Kahneman and Amos Tversky introduction of psychological variables into economic analysis, contribution for which the former was awarded a Nobel Prize (Kahneman 2013); See also Dan Ariely's books, particularly the recent one (Ariely and Kreisler 2017), and Stefano DellaVigna (2009). One of the most useful concepts of this contribution is to distinguish two sorts of human behavior; one fast and one slow, labeled as "system 1" and "system 2." Fast system 1 is an automatic process to think and decide, it is spontaneous heuristic, intuitive, effortless, and emotional. Slow system 2 by contrast, is a controlled process which is deliberate, of a reasoning mode, effortful and supposed rational. These two modes are context dependent. It is then relevant to question the type of behavior that is used in a given market environment. Attention, emotions, risk aversion, preference weighting, heuristics of decision, procrastination, exploration versus routine

trade-off, selfishness versus other-regarding trade-off, present versus future trade-off, are among the issues at stake in shopping behavior (search, discover, try, compare), and in buying behavior (choose, pay, bring back home) in various market environment.

– *Antitrust issues*. Since the beginning of the 2nd IR, the regulation of market competition is a key issue for government. The Sherman Antitrust Act of 1890 considered monopolies as a market failure the has to regulated as such, to protect consumers and small businesses. The 3rd IR raised the problem of product differentiation as a source of market failure (Robinson 1933; Chamberlin 1933). The 4th IR is reviving the monopoly question with the increasing role of platforms.

Pricing (Table 4)

By *pricing*, we not only mean the *level* of a price, but also the *purpose, metrics*, *algorithm (or mix or formula)*, *dynamics, and communication* of price. (A comprehensive analysis of these elements during the 3rd IR may be found in Nagel and Müller (2016).) Altogether, these seven constituents are describing the general frame in which, during a given period (IR), each business is defining its *price policy* to create and capture value in a more or less competitive environment (may be a price taking de facto policy in a pure competitive market context).

– The *making of the price*. Answers the question: from where the price is coming from? Adam Smith classic answer in competitive market environment is “from the invisible hand of the market.” But on imperfect competition with market power, pricing becomes a strategic variable. Note that the making of the pricing may also be influenced by public regulation.
– The *purpose of the price*. Answers the question: what is the price used for? What is its function for the consumer and for the seller? As such, it is closely linked to the purpose of the market mechanism, as price may be seen as a tool for market efficiency. A classic answer to the question, taking the supply side point of view, put forward the trade-off between unit profitability and market share. Pricing is here a strategic issue (Magretta 2003). Another possible answer is that the price is part of the matching process and therefore determine both what products are produced (in quantity and quality) and who gets the products produced (Roth 2016). Roth was awarded the 2012 Nobel Prize for his contribution to the matching mechanisms. Another possible answer is that a purpose of the price is the distribution of value along the food system, and with the consumers (a main antitrust concern since the Sherman Act). Note that the purpose of the price is closely linked to the purpose of the market mechanism: market clearing for a commodity market or sophisticated matching for highly differentiated supply and demand. The price may also have an incentive purpose, in particular when pricing services. As today many final goods are becoming services, and as long-term contracts such as subscription occur, the incentive purpose is increasingly important.

Table 4 Pricing products during three industrial revolutions

	2nd IR "Fordism"	3rd IR "Toyotism"	4th IR – "4.0"
Making of the Price	Invisible hand of the market	Visible hand of businesses	Platforms, free try, large bundles of services
Purpose of the Price	Competitive price	Discrimination price and matching segments	Create value, incentivize
Level of Price	Competition Public regulation	Price discrimination allows value capture	Personalized product design allows value creation and capture
Pricing metric	Per weight, volume, then standard pack	Per differentiated pack	Per global diet (or other metrics)
Pricing formula	Cost plus	2nd transformation and retailing price policy	Platform price policy, multi-criteria
Pricing dynamics	Seasonal, local, market equilibrium	Dynamic business price policy	Individual price contracting
Pricing communication	Obvious	Obscure	?

– The *level of price* objectively (and somewhat subjectively) answers the question: is it expensive? Along the extended value chain, the level of prices for intermediate goods determines the allocation of value among the many stake holders, from agriculture to the final consumer. Price elasticity measures the link between the amount bought and the level of price. But when products are differentiated, the price level is also used as a quality signal and positioning in product lines. Antitrust issues during our period care both about too low prices (predatory pricing) and too high monopoly prices, as they care about price discrimination (Varian 1989).
– The *metric* of a product answers the questions: price per what? The price metric is closely related to the *product design*, in particular to the scope of the product. It is also linked to the logic of product differentiation. Here, some example may ease the understanding. A car may be priced using a metric of "a car is a good": the buyer will then own the car. But the same car may be priced using a renting metric. It is now a service prices "per day," or "per kilometer." The same car may also come with a driver, as for an Uber trip. The metric is then "per kilometer at a certain hour of the day," or "per person." Michelin, one of the world's largest tire producer, recently changed its pricing metric for trucks tires from selling "tires" (sold as goods) to selling "safe miles" (sold as a service). Xerox initiated this process of price "servicization" during the 1970s. In food and drink, the metric of a soda can be "per 12 cans," or alternatively "per lunch" or "per hour" with free refilling.
– The *algorithm* of pricing (also called *pricing formula or metric mix*) describes how a price is precisely computed when several metrics are simultaneously used for pricing a given product. It answers the question: what do you pay for? It may

be the sum of a fixed part (an "entry" price for example, as a yearly membership) and a variable part (per quantity actually used: "per hour" for example). The mix of several metrics may require more or less complex formula. It refers to what economists are naming "non-linear pricing" (Wilson 1993). They clearly are a key issue for wages and salaries or for subcontracting in B2B relations. (On pricing on the job market, see for example in David Kreps recent book (Kreps 2018).) On the final market, for products that are *servicized* the algorithm pricing design is getting crucial. For example, Renault used to price its Zoé – an electric-car model – by mixing two metrics: one is pricing the car itself, and the other is pricing the batteries, which are specific and intimately incorporated in the car. The car is sold and the batteries are rented. The pricing formula offers a "menu of contracts," that is, price choices depending on the duration of the contracts, the distance traveled, and so on. The contracts chosen by the consumer, for the same product, depends on its motivations, expectations, and desires. In the food and drink industry, pricing in restaurants is based on such formula: "à la carte," "menu." Happy hours are another variant. They are important drivers of customers' choices, as pricing algorithms include an important *motivation* component, offering evidences that pricing may be used as a tool for *value creation*. It may be used as such *before buying*, as an incentive for products selection on the market; or *after buying*, as an incentive to use the the product intensively or not (such as how much of a soda would I consume if it is sold by glass or if it is "free refilling" included in a pack). Designing a price algorithm is a way to *align* consumption to a given desired objective. The pricing formula may be the fruit of a bilateral negotiated contract between human beings or between the consumer and some online AI (Table 4).
– The *pricing dynamics* means the changes of a price through time for the same or a similar product. It answers the question, "What will be the price tomorrow?" This important field covers a large scope of pricing strategies and tactics (Nagel and Müller 2016). In the food and drink industry, it may be for example price seasonality, "happy hours," sales, discount, and introductory price. Technically, a dynamic pricing strategy (often part of yield management) is a combination of both a *static price discrimination* and a *dynamic price discrimination*. Airline business had pioneered this pricing strategy.
– The *pricing communication* covers the final buyer information about price level, metric, formula, and dynamics. Exhibiting a price markdown with visible "before" and "after" prices is an example of pricing communication. Isolate the taxes in a final price is another example.

The Second Industrial Revolution and the 'Basic-Good' Product

Context and Key Patterns of the 2nd IR

The **Second Industrial Revolution (2nd IR)** had been, after 1890, the time for *standardization* of both processes and products (for classic presentations, see Ford 1922; Chandler 1962, 1977, 1990). It developed till the end of the Second World

War. The Union Stock Yards of Chicago, '*Yardism*' initiates and played a central role in this 2nd IR, developing a new way to produce mass products (Sinclair 1904, Arnould 1971; Barrett 1990). The identity of this 2nd IR is found in the invention of the Scientific Organization of Labor (Taylor 1911), a new way to analyze the worker in order to increase his productivity, to develop new tools (as the transfer chain) in the labor process, and to rationalize methods of factory organization. Standardization soon appeared to be compatible with a certain degree of product differentiation that, after Alfred Sloan at GM, became a key strategy of the period, fitting the new multidivisional vertically integrated large companies. Standardized final food and drink offered and delivered in bulk, sold in neighborhood small specialized shops, and ready-to-cook at home. They were priced per units such as kilo, or liter. Some food and drink companies – such as Graham crackers, Coca-Cola sodas, or Kellogg corn-flakes (Wilson 1993) – where already inserted between agriculture and the final consumer as large and powerful stakeholders, and offering ready-to-eat (or drink) products.

The key concept of the 2nd IR is then product *standardization*. In the food and drinks industry we will call the final products of this period *ready-for-cooking Standard Basic Products*. Note that the duration of this 2nd IR is very different from one country to another. (We shall avoid to use the word "ingredient" to describe the 2nd IR, reserving it to qualify standard intermediate products of the 3rd IR.)

The Nature of the Product During the 2nd IR: The Standardized "Basic Food" Sold in Bulk

A typical "Final-Basic" food or drink of the 2nd IR is a *good*. It is *standardized* and *ready-to-cook*, sometimes after only a very short home process, helped by the, then emergent, household culinary equipment, such as fridge, hob, or oven. The Basic food is close to agricultural raw products, often minimally processed by industry, when dismantling of agricultural products is necessary (e.g., for meat), or when processing is required to preserve and maintain quality, or to keep seasonal products available all year long.

These Basic products are typically sugar, flour, milk, powder milk, butter, oil, poultry, butter, beer, or eggs. In the USA, some products may already be assembled, processed and packaged by a then emerging secondary industry, announcing the next 3rd IR. This is the case for Heinz ketchup or Coca-Cola soda, Kellogg cornflakes, biscuits, canned vegetable, or corned beef. Hygiene and safety, as the preservation of nutrition quality are the then most important characteristics issues. Public regulators and stakeholders are worried, but scandals occur, generating strong negative or hostile reactions against the industrialization of food and drink (Sinclair 1904). Simultaneously, the functional roles of carbohydrates, lipids or proteins are uncovered, and the concept of calories is redefined and used for food (Hargrove 2006). The process of standardization of products generates homogenized and rather tasteless products (such as cornflakes, or corned beef). These products will soon require some universal "improvers" (such as ketchup or mayonnaise). Standardization also emerge as a legal regulation issue, aiming at developing productivity gains through scale and scope in agriculture and industry (Chandler 1962, 1977, 1990). Notably, the US 1906 *Pure Food and Drug Act* enforces federal standards that helped to integrate a nationwide market for major companies. The *Meat Inspection Act* had the same purpose of creating a nationwide unique health and safety regulation in the meat industry. 2nd IR was indeed, and in many ways, the time of products and processes standardization.

Shopping, Selling, and Delivery Mechanism During the 2nd IR: A Specialized Small Shop with "Behind the Counter" Mechanism

The 2nd IR final products are sold in a multitude of small specialized businesses (a greengrocer, a butcher, a dairy, etc.). These businesses receive and store IR in bulk or, if processed, in then poorly informative packs. The sales process is performed by the owner, or an employee, "*behind the counter.*" The seller weighs and packages the Basic food in anonymous paper craft wrappers, crates, or bags, or disposes them in the buyer's basket.

For customers, shop owners and employees are the primary source of information concerning the quality of products or their use. But as the products are standardized, and as the number of items is limited, the quality issues mostly concern the alignment of the products on standards, for hygiene, security, and conservation issues. The consumer may also be interested in a few bits of basic information: grade, category, freshness, origin, and, of course, the price that we will describe later. The shop owner holds the information and distributes it at his own will, that is, in his own interest. Credibility, or seller trust, is based on local reputation, based itself on the repetition of personalized "who-to-whom" nominative exchanges with regular and identified customers. As product is sold in bulk, it is as such a source of direct information. The consumer may see the product and, on request, feel it, touch it, or even taste it. Finally, as customers may queue behind the counter, they may be happy to chat in the shops and in its neighborhoods. Therefore, they circulate information horizontally. Every customer is known to the seller and to the community, each one also has a reputation.

In the USA, in the food industry in particular, the 3rd IR started very early, typically with the development of self-service grocery, that we shall use, together with the diversification of food and drink as key markers of the 3rd IR. Clarence Saunders opened his first Piggly Wiggly store in 1916. The concept was patented and, as it was a success, many franchises followed. In Europe, self-service did not develop before the1950s and 1960s, and they came with the explosion of product differentiation. Therefore, the three IR presented in this chapter are more a sequence than a timeline and dates shall only be seen as example.

Pricing Products During the 2nd IR: The Basic Product "per Kilo" Metric

The main *metric* of pricing of a basic product of 2nd IR is *per unit* of bulk, typically "per kilo," per liter, "per dozen." These prices may be – according to different local regulation of the time – *posted*, but they also may be on request, limiting competition among shops, and allows price discrimination. When posted, prices are per unit, on a board which may be visible from outside the store, for regulation or commercial reasons. In such a context, level pricing policy for the shop owner is *cost-plus* type for most of the products, as very low product differentiation limit other approaches. Price discrimination possibilities only exist at a very small scale, because of standards and common knowledge. The price may sometimes be discussed in bilateral negotiation, with possible quantity discounts. The price algorithm is then a simple equation including quasi exclusively the wholesale prices that are passed on, sometimes the seasonality and the scarcity of fresh products.

Although sellers' revenues are generally poor, the friction costs of distributing bulk products behind the counter are high. They include in particular for the seller a careful and constant handling of the bulk products, a direct and individualized relationship with each customer; and for the customer long waiting list, precisely prepared shopping lists, including quantities. But the biggest transaction cost of this distribution model was not entirely visible for the contemporary. Anticipating what will follow, we now know that the biggest transaction cost was that behind the counter small shops where constraining the potential of product differentiation that food industries were soon ready to propose, and consumers soon ready to buy at higher price, but also higher value. Nonetheless, showing that transformation processes are often long and sometimes blind and myopic, self-service was indeed introduced during this period, not to allow product differentiation but rather to reduce current transaction costs, and reduce prices in low-end shops. In these fist self-service shops, products were displayed on the ground, in bulk, and consumers were invited to help themselves.

Impact on the Extended Value Chains and Consumer Behavior

Upstream, the small shops are provided by producers, wholesalers, or directly by farmers. Wholesale B2B markets are developing, implementing new formats, new competition mechanisms, and they quickly internationalize. Second transformation firms of the next Industrial revolution are emerging, as Coca-Cola, started its business in 1886. It will become the main sugar buyer, retrograding the sugar industry in B2B exchanges, the product becoming an ingredient for secondary transformation, no more a basic final product. The percentage of sugar sold as a basic product, steady declines since the 1890s, from 90% to 16% today, 84% being now incorporated as an ingredient in the secondary transformation processing businesses. One of the most popular products of the 2nd IR is now a B2B ingredient, listed as such on the packaged product.

Drivers and Limitation of the 2nd IR Model (Table 5)

The 2nd IR coherence is embedded is the notions of *standardization* of products, processes, and work. *Productivity gains* in agriculture were transmitted to the final

Table 5 From one industrial revolution to the next: limits and drivers in food and drink systems

	2nd IR "Fordism"	3rd IR "Toyotism"	4th IR "4.0"
Internal coherence and growth dynamics	Standardized agriculture, using mechanical and chemistry, generates huge productivity gains home cooking appliance	Standardized agriculture, using mechanical and chemistry, generates huge productivity gains. home cooking appliance	Platforms expand proposing customer specific solutions priced with subscription global diet quality concerned client
Limitations	High competition for standardized products reduces profits Working women reduces available time for shopping and home cooking	Self-service transaction costs increase as products proliferate, and trust in pack information decreases Social status segmentation decreases	New technologies are underused. Value creation is the biggest difficulty, requiring a new Ecosystem. The global warming issue is getting more urgent. Other-regarding preferences are essential. Product personalization requires consumers acceptance, trust and involvement
Drivers toward the next IR	Personal cars are available for shopping far from home in large quantities. Higher purchasing power allows more transformed products Processed food is cheaper Self-service retailing is available and allows product differentiation.	Thanks to new IT, platforms are successful in zero marginal costs industries. Demand for individual assistance develop to match complex preferences and products that do not fit traditional segmentation anymore. Potential value is identified in developing home delivered personalized convenient diet	Demand for pluralism and alternative business food models pushes diversity, local, alternative markets. Need for physical relationships Possible failure of big data and AI to develop valuable diet online assistance

consumer through competition all along the extended value chain. Consumption increases in quantity, but remains traditional in terms of cooking habits and dishes chosen. The limitation of this 2nd IR model, and therefore the drivers toward the 3rd IR came very early, in particular in the USA, with the emergence of a first wave of product differentiation in large multidivisional firms. The rise of female paid work progressively changed the nature of expected products, toward more transformation, and explains the coming of "ready-to-eat" food after "ready-to-cook." An important share of home-cooking activity moved upstream to the industry and explain the development to come of the secondary food and drink transformation. Finally, the increase in the number of motor vehicle and home equipment such as fridge, allowed the coming development of more distant, but larger retailing stores, less frequently visited for more quantities bought.

The Third Industrial Revolution and the "Final-Dish" Product

Context and Scenarios of the 3rd IR

The **Third Industrial Revolution (3rd IR)** came after 1945 as a new economic model, changing not only the inside of factories, but the extended value chain. This model is called "*Toyotism*." The model had been prepared by technologies and organization models that emerged earlier, in particular in the USA (such as operational research or automation), but it first came from Japan in the car industry, where it had been successfully designed and experienced in the Toyota automotive company. Its key character is Taiichi Ohno (1988), the Toyota manager who developed the *Toyota Production System*, the principles of lean manufacturing, tight flows, outsourcing, quality, and continuous improvement. It allows huge product differentiation, fast product renewal cycles, and continuous costs decrease.

At the extended value chain level, the 3rd IR characteristic is the externalization of activities, large firms being vertically de-integrated. B2B markets multiply as intermediate suppliers and sub-contractors develop (Aoki 1988). The food system then acquired its present pattern, with a "Fordism style" standardized upstream, in agriculture and its mechanical, chemistry, and seeds upstream. Then the first industrial transformation firms "dismantle" and "crack" agricultural and livestock products to produce standardized *ingredients* sold on world commodities competitive globalized markets. Downstream, thanks to vertical de-integration process, powerful second processing businesses food businesses are acquiring ingredients on B2B markets, combining them, producing, and packing delayed differentiated lines of products that are frequently redesign renewed products according to final consumers segments. These differentiated packaged products are ready-to-sell, and ready-to-eat dishes.

Differentiation then became the key for competitive advantage and profit. For this, products of a given self-service shelf had to be sold to different consumers with premiums or rebates compared with the Dominant design of the category, replacing the standardized price and product of the 2nd IR. Value creation and capture came with a new way of designing products, selling mechanism and pricing: price for differentiated packs sold in self-service.

In food and drink, the typical 3rd IR *final product* is produced from many *standardized ingredients, it is branded, delayed differentiated, according to consumers segments and usages, they are ready-to-eat*. They are *ready-for-sell in self-service real shops***.**

The Nature of Final Product During the 3rd IR: A Differentiated "Final-Dish" Ready-to-Eat, in a Pack

A typical "Final-Dish" of the 3rd IR is a *good*, it is highly *differentiated* and it is *ready-to-eat*. Such Final-Dish is disposed for sale in the form of an individualized package which is heavily loaded with multiple information (text, photographs, logos, etc.). Information range from brand and marketing messages to strictly regulated legal information, such as the expiry date, the list of ingredients, the list of nutrients, allegations or claims. Final-Dish has been assembled, transformed, differentiated and packed by second transformation businesses. The design of packaging became one of the main activities of the second industrial processing businesses. It is made from an assembly of several (sometimes dozens) of ingredients which are traded on B2B markets between the primary processing industry now separated from the developing secondary processing industry. Since the 1950s, these secondary processing industries are, together with mass retailing, the main actors of the 3rd IR. Examples are fermented drinks, frozen pizzas, breakfast cereals, mixed salads, and chocolate bars.

Today, 85–90% of food and drink bought in developed countries have been *processed* in the primary and secondary processing industries. As it is the law, standard ingredients used for any differentiated final product are listed on packages. The nowadays food and drink system (see Esnouf et al. 2013; Colona et al., Chap. 4; and Soler et al. Chap. 5), build during the 2nd and 3rd IR, is then a chain articulating an upstream Fordism style producing standardized ingredients with a downstream Toyotism style producing lines of highly differentiated final products. Downstream, the 3rd IR have seen the development, all over the world, of hundreds of thousands highly differentiated branded food, beverages and meals, ready-for-eating or drinking. The second transformation food companies, (many of them born during the previous period), as Nestlé, Unilever, PepsiCo, AB inBev, Coca-Cola, Mars, Danone, Kraft Heinz, or Mondelez changed the nature of available food and drink, exploding, with the help of marketing, the logic of *product differentiation*. Differentiation became the key driver of food and drink growth and profitability and still is. Mostly international, these industries enlarged worldwide the scope of available products everywhere. In France for example, since 1960, consumption of prepared meals has increased by 4.4% per year in terms of volume per inhabitant (Larochette and Sanchez-Gonzalez 2015).

Shopping, Selling, and Delivery Mechanism During the 3rd IR: Self-Service in "All-Under-One-Roof" Hypermarkets

These packed and differentiated ready-to-eat products had to be sold in a new and different way. In developed countries, they are typically sold in huge self-service hypermarkets "all-under-one-roof" *physical places* with spacious dedicated parking lots in the vicinity. In the USA, these self-service chain stores – after the sales mechanism had been created in 1913 by Clarence Saunders, in its Piggly Wiggly shops – came as soon as 1930s in King Kullen shops, but we will date their world effect on food supply in the post 2nd World War. (It is known as the first shop to fulfill all five criteria that define the modern supermarket: self-service, separate departments, discount pricing, chain marketing, volume dealing.) The final consumer comes to these places with its own car, once a week or more, for shopping, buying, and bringing back home the self-selected products. As product differentiation is based on a logic of consumer categorization in *segments*, the typical consumer shopping task being now dedicated, for every individual, to walk along shelves in order to search, identify, compare, choose, pick, and place in her cart, the products that are fitting her desires and profile among thousands of other posted price products. Self-service retail supermarket chains then became the key link between the food system and the final consumer. For its major part, "Final-Dish" is sold in large retail outlets under a regional, national or international brand. To keep the list in the USA, C&S Wholesale Grocers, McLane Company, Sysco, United Natural Foods, US Foods, Loblaw, Kokubu & Co or Metcash in distribution; Akbertsons LLC, Ahold Delhaize, Kroger, Aldi, Lidl, and Dollar are among the "big players," drivers of this period that we are still living on. These companies transformed the very purpose of the final market, the function of delivery procedures, and allowed new pricing policies.

These retail outlets businesses acquire, store (for a very short duration), and sell the packaged products, organizing the whole upstream extended value chain flows in a "pull logic," and just-in-time management. The package products are received "ready-to-sell," arranged in containers as to be immediately displayed on shelves.

The old 2nd IR counter has disappeared. *Merchandising* specialists display on shelves and aisles thousands of products for sale to stimulate consumers attention and and ease product-consumer matching.

Self-service means that the customer has to define her own route, time, and attention among the products exposed for sale. Formally, economists describe the context facing a customer shopping in a self-service as a series of "ultimatums." Each item, in its unique packaging, comes with a price tag, the way it communicates its posted-price. Each product-and-price couple is a bid process of a "take it or leave it" form, which is the very definition of an ultimatum. The *shopping cart* is the consumer's place for stacking selected products. The customer is not anymore facing any human seller, the in-store shopping route is left to her convenience, each coupled product-price is "selling itself."

In this context, for a given consumer, *differentiated* products are piling up in her shopping cart. Each individual cart content is *personalized*, and the personalization process is realized in an unguided way. Cumulated shopping carts delineate the *diet* of the household. Therefore, shopping in a supermarket poses a twofold difficulty for the buyer: one appears in each shelf, as the question of selecting individual products among a large set of differentiated *substitutes*; one is the issue of composing a balanced diet, from *complementary* products selected in different shelves.

The package information is now the unique source of information, either to find an already consumed product, or to decide to try a new one. Differentiated products are complex, highly processed, and they include multiple ingredients, but, as packaged, they are no longer accessible to the consumer senses. More and more, the final buyer is getting concerned with a large series of characteristics to choose among differentiated products. Among others are prices, hedonic qualities (inaccessible directly but signaled), convenience, ingredients, nutrients, environmental and societal impacts, place of origin, and so on. For choosing, the consumer relies on packs including more or less credible information such as brands, marketing claims (e.g., "traditional recipe," "gluten free," or "organic"), or regulated, mandatory or voluntary, details including the list of ingredients, nutrients, place of origin, or expiring date. As packed products appear on shelves, and as consumer does not have much time and attention, the front-of-pack, which is visible without touching the product, plays a major role in the process of choice. The front-of-pack captures attention and allows fast, routinized or spontaneous, intuitive, effortless, and emotional choices, that Daniel Kahneman labeled "System 1" (Kahneman 2013). The back-of-pack – because the customer has to handle the package to look at it – is used for deliberate, slow, accurate, detailed, and more rational information, defined as "System 2." This process needs time and efforts, and it is obviously out of the question for any customer to acquire all the available information on packages during a shopping tour. But consumers have no other source of information inside the self-service, as they seldom talk to each other, and as professional assistants are scarce, and poorly informed (Table 5). (And of course nobody around has any power on prices.)

All this information is useful for choosing among substitutes, less for choosing among complements. Note that the RDA (Recommended Daily Allowance) back-of-pack (or front-of-pack in some occasions) is a nice decision aid of both infra- and inter-shelf choices, as it proposes a sophisticate link between a pack, a size and a diet. But, even for an implied consumer mobilizing all the cognitive resources of her System 2, the needed computation for an efficient usage of this tool is out of reach. The global diet issue is clearly a significant limitation of self-services. The coming 4th IR disposes the tools to remedy that constraint.

Pricing Products During the 3rd IR: Price Discrimination on Each Shelf

In self-services where packed products are offered, price is a key shopping behavior variable. It plays much more roles in consumer decision that it used to in the previous stage. The pricing *metric* used for a sold in self-service is "per package". (The pricing metric 'per kilo' or 'per litter' of the previous Basic products is often maintained by the public authorities that impose its presence on shelves. But this information, like ingredients or nutrition facts, are written in a small font and captures little attention.) Each price, for each product package, has been carefully designed to appear attractive on its shelf, in the middle of other products, for the targeted consumers' segment. Here stands the *matching* issue between differentiated products and segmented customers. As each pack is ready-to-eat with only a quick preparation, and as it is conveniently storable, it may fit many coming lunches. It has to be picked even It may be picked without a given specific use in mind.

Targeted to fit immediate desires for targeted profiles, each product is designed to fit a business pricing policy. The price *metric* may come first ("design to price" management). According to the segment, pricing metric may be a pack, or the portions it contains, as the portion size is a critical issue for product and price design. A line of pre-sized packages for the same product may include several sub-packages per serving, allowing self-selection quantities price discrimination.

When a dominant design exists in a given category (that may be a shelf), the pricing refers to a dual logic (Nagel and Müller 2016). The price of the standard *reference product* gives the basic, from which products are *differentiated,* by adding the willingness to pay for extra characteristics for premium or targeted products, and subtracting negative willingness to pay for missing or downgraded characteristics of discount products. Differentiated products are then priced and designed according to a meticulous customers' *segmentation*, based on values and willingness-to-pay for offered products lines.

Products and prices differentiation are designed as to spontaneously induce any customer of a given segment to *select*, even with little attention and effort, the right products (for her), and to avoid others. This *matching* process is the one which is at stake while the customer follows her, apparently erratic, shopping path from shelf to shelf. Discriminated prices must be clear, easily and conveniently visible, and highly distinctive as, in self-service, price is a powerful signal for spontaneously matching customers segments and differentiated products. Prices are also used as "fences," avoiding customers to move from one segment to another, and then preventing consumers from going down-market, below their segment.

Price regulation issues had been, from the beginning, an important issue concerning chain supermarket stores. In the USA, the Robinson–Patman Act was passed as early as 1936. It prohibits anticompetitive practices and, in particular, price discrimination. It was explicitly designed to protect small retail shops against chain stores and fixed minimum price for retail products. It is interesting to note that, at the origin, the identified danger coming from supermarkets was low prices and not higher prices due to product differentiation. The upstream power of supermarket chains, seen as monopsony came soon at the same time – if was academically described by the British economist Joan Robinson in 1933 from Cambridge university (Robinson 1933) and it is still an issue and a strong argument nowadays against chain stores.

Hypermarket self-services are born and developed in a context where every household was supposed to have a car. Home delivery is user-made with personal car. This was an initial sine qua non condition for hypermarket development. It is a strong limitation today, especially in mega urban areas where home shop-delivery is developing as part of a future model.

Impact on the Extended Value Chains and Limitations Systems and Limitations of the 3rd IR Model (Table 5)

Let us note, anticipating the ongoing 4th IR, that the free matching process of self-service, entirely in the hands of the shopping customer, wandering from shelf to shelf, is presently reaching its limits under six drivers. (i) Product differentiation is still deepening and intensifying, exploding the number of *substitute* products. With such an abundance of quasi-dedicated products, suitable for fewer consumers, the matching process is no more a fast, effortless, pleasant and easy process in self-service environment. (ii) For a buyer, variables at stake are numerous: the global food and drink budget; the taste of each eater; the variety of plates and menus in time; the nutrition constraints and specific individual health profiles such as allergy, gluten-free diets; environmental impacts such as CO_2 emission, fresh water use, or eutrophication; ethical or religious considerations such as animal welfare or halal food; the origin of ingredients, such as local, regional, or traditional farming. (iii) Beyond the choice among substitutes in each shelf, the issue of a balanced composition of a global diet is getting more important for consumers, but this process is difficult to implement in a self-service environment shop, where the quality contents of the entire shopping-carts is is difficult to grasp, while global, structural content diet is the key entry for good nutrition. (iv) Hypermarkets home delivery system is time consuming; it requires the use of a car with often difficult handling; it is time discontinuous, requiring buying in advance (therefore expectations and storage); it is limiting the use of fresh food. (v) Self-service has a lot of indirect transaction costs and negative externalities, such as traffic jam. (vi) Global food budget is difficult to ascertain and control

The 3rd IR food system developed product differentiation as a downstream business in the global supply chain. But nowadays, as an important part of the environment impact comes for the upstream agricultural and ingredients businesses, part of new product differentiation sources of value are based upstream the ingredient stage, such as geographic designation of origin, sustainable agriculture qualification, organic products, or animal welfare. A growing part of the consumers are finding the *alignment* between available differentiated products – even if thousands are available – and their deepest longings, inadequate. The satisfying matching in self-service, with its corresponding food system, may happen to not exist anymore. A new way of selling is required, allowing a new way to create value, in a better alignment with individual and social requirements, taking into account new desires, a global diet view, and new societal and environmental constraints.

Table 3 synthesizes the coherence of the 3rd IR model. Delayed differentiation, using standard ingredients is the major logic in the extended value chain, in close link with self-service retailing. This model may not survive the consumer changes, the huge environmental pressure, urban transformation, the new available technologies, and the new big players entrant that are platforms.

4th IR, Personalized Online Shopped "Client-Solution" and "Client-Experience": From Full Diet-Subscription to Instant Wahoo Effect

Context and Key Patterns of the 4th IR

The upcoming fourth industrial revolution **(4th IR)** will be as important as the 3rd IR. After standardized mass goods (2nd IR), after segments differentiated goods made of standardized ingredients (3rd IR) and sold in self-services, may come a time with new digital technologies, new urban logistics, and new players called *multisided platform* (Evans and Schmalensee 2016). The largest among these platforms are well known: in the USA the GAFAM (Google (now Alphabet)–Apple–Facebook–Amazon–Microsoft), and in Asia the BATX (Baidu–Alibaba–Tencet–Xiaomi). Many others exist or emerge. In food and drink, these platforms may be partitioned in two groups: those who are presently or potentially in the selling business – to final demand, as Google, or between companies as Alibaba –; and the social network, as Tweeter. Most of them are *multisided platforms*: their activity is to match actors, that may be multiple. For example, Apple is selling devices as iPhone or iPad, directly to consumers, or to telecom operators. On such devices, the final consumer makes phone calls, even if this is now a marginal use. With a device, the final consumer finds apps, buys them, and uses them. Apps developers are then one “side” of the Apple platform. But all subscribers, or simple users, of such apps are part of Apple “sides.” Many apps developers are using advertisement as an important part of their business model, then advisers are another “side” of the platform. Video games, PC operating systems, newspapers, credit cards, job boards, nightclubs, and search engines are examples of multisided platforms. Evans, Schmalensee (2016) enumerates Facebook as a six-sided platform: friends (senders), friends (receivers), businesses (senders), businesses (receivers), app developers, and advertisers. As we shall see, the pricing policy of a platform is particularly enlightening, as prices for some “sides” may be negative. What will happen is food and drink with the platform revolution is not predetermined yet. But it may revolutionize the way final food and drink are shopped, bought, delivered, and consumed; and then the way they are designed, made available, and priced. They might also, again in direction and magnitude that are not predetermined, change the food system up to agriculture and its providers.

When the terms *Industry 4.0* was proposed by German manufacturers during the 2011 Hanover Fair to label the coming 4th IR, the expression was first to be understood as a technological industrial challenge, located in the production sphere. The question was *how* to mass-manufacture “one-unit size” series for personalized goods? The question concerned all industries, including agriculture, where sustainable farming, to reflect specific and versatile local features of soils or climates, may involve most digital technologies that we will describe later. But the finding in Hanover was different. First, it was that the required technologies for “one-unit-size” series were already existing and used in many industries. When it was not, introducing cyber-physic systems or 3D printing in factories was within reach. But the German manufacturers understood that the “industry 4.0” real challenge was to be found elsewhere. Much more than how to produce, it was tacking the core of the value-creation process, in the changing nature of the link between the final consumer and the extended value chain. The challenge was how to create and capture value with the new “one-unit-size” series capability. Therefore, the challenge gets *strategic*. The German manufacturers discovered, this new question in mind, that the now crucial linkage between the production system and the final demand was endangered to shift from traditional dealing – self-service chains in food and drink – to the platform new big players.

What GAFAM or BATX companies were offering new on the market, and in particular the final one, was an intimate, dynamic, and personalized link with every single consumer. In food and drink, it is directly threatening to *squeeze out* traditional self-service supermarkets, offering, through a smart phone or any sort of terminal, totally new products, that are *services*: deep and individualized *matching processes* between desires and products. Thus, the core challenge was understood to be informational. Online captors may scrutinize individual behavior and then preferences, platforms may ideally locate in the extended value chain to valorize internet of things, data collection, social networks, artificial intelligence, to transform the processes of value-creation and value-capture into a new *reversed* logic. Indeed, the key flow of information, in food and drink as in other industries, is now going to be from the client to the food chain, not the opposite anymore. This may permit to move toward valuable product individualization, product interconnection – which is in food and drink a global diet view–, continuous home-delivery as a service, and new incentive pricing such as subscription.

We may then support in the following of this section that in the future, the food system may transform from its final market, as virtualized music or movies already did, or as gradually non-dematerializable products such as medication or clothes industries are doing. From the new point of view for value creation, what the 3rd IR did not accurately do was *listening and understand desires for co-creating, and deliver* the most fitting product, both in their rational entireness, matching Kahneman System 2 in food and drink refers to the product as the full diet, including health, well-being, budget, environmental, or societal impacts – this is called “client-solution”; and in their fast System 2 heuristics, including punctual hot desires for wahoo effects – this is called “client-experience”.

Available Technologies

Technologies are a permissive factor at the origin of each IR. The technologies are at the origin of multisided platforms, the core of 4th IR, the new way allowing to not only *market* personalized products, but also to *design* and *price* them. David Evans and Richard Schmalensee (Evans and Schmalensee 2016) identify *six digital technologies*, complementary, that are coherent and allowed the emergence of the *platforms* that may, together with the new urban logistics, structure the food and drink industry of the future. These technologies, which Evans and Schmalensee describe as “turbo technologies of change,” are as follows. (i) Increasingly powerful electronic **chips** (those of the iPhone 8 were 300 times faster than those of the IBM PCs of 1981). (ii) The **Internet**, which is the physical part of the “network of networks” that is crossing oceans and countries since the 1960s and is opened to commercial traffic since 1993; using standard communication protocols, interconnecting IT products around the world. In 2015, 3.25 billion people had access to the Internet. (iii) The **Word Wide Web** makes it possible to join 173 million different websites. Google is indexing them in its Browser. Each site offers contents and services, including artificial intelligence. (iv) **Broadband** communication is connecting sites and terminals via fixed connections – coaxial cables, fiber optics – and mobile connections: 3rd generation "3G" after 2001, 4G after 2011, and now 5G. (v) Standardized and compatible programming languages allow **information systems** (OS) to be available for writing software and apps, enabling division of labor (and then high productivity) in the app design business. Such languages have increased the power of chips tenfold. (vi) The **cloud** brings together 5.5 million servers connected to the Internet. These servers store content, resources and data, available at any time in any place for immediate usage. Amazon and many others are providing storage and processing as a service. To these six digital technologies, we may add **sensors** that are allowing interface with the human and physical world, and **artificial intelligence** that, coupled with human intelligence, multiply our capabilities. Physical technologies, among them **3D printing**, **new materials** (composite or biological), **robotics** and **biotechnologies** are also part of the 4th IR.

The Nature of Product in the Coming 4rd IR: Personalized Client-Solutions and Client-Experience, with New Valuable Characteristics

We identify two challenges concerning the future nature of the product. One concerns the type and usage of the new products, the other the scope of characteristics, implying in depth the transformation of the food extended value chain.

The type and the usage of products will change because products will now be individually co-designed with the consumer, will offer services presented as "consumer spot experience" or "global solution," will be interconnected and smart. The new usage, after "ready-to-eat" products of the 3rd IR, will be "ready-for-diet" or "ready-for-experience." We saw that consumers have a double way of choosing food and drink, slow and fast, or Daniel Kahnman System 1 and Systems 2 (Kahneman 2013). We suggest that the nature of new products will follow these two sides of the human brain. On the Fast side, consumer is expecting sheer delight, daily renewed, personal experiences to share, including wahoo effect that creates high value and is easy to capture. Digital platform may stick to this "heuristic" way of choice, through "pushes," "buy in one-click," "immediate nomadic delivery," and products designed for spontaneous impulse purchases. On the slow side, consumers are expected to think rationally. In food and drink, this System 2 clearly refers to a global and long-term diet point of view, including many characteristics such as budget, pleasure, health, cultural, societal, and environmental impacts. But this System 2 approach is particularly difficult to handle for consumers, as the optimum is very difficult to define and reach, as procrastination and other behavioral limits of System 2 permanently occur, and as the context of packer products sold in self-services is not appropriate.

Change in the value-driver scope of characteristics is the other challenge of the future. Here again, trying to be clear, we may identify two scenarios, one is a remaining delayed personalization, the other is "in depth personalization." The first one focuses on what we may call new "private desires." In addition to the hedonic and wahoo characteristics, these private desires may include social, societal, and environmental characteristics. In this "delayed" scenario, the inclusion of new desires in the process of co-conception will be built using the 3rd IR *ingredients*, including mere niches extensions such as organic ingredients. In other words, new desires expressed with words such as "freshness," "green," "clean," "pure," "healthy," "light," "transparent," and "local" will be accounted for and valued using standard ingredients. This "delayed personalization scenario" contrasts with the other one, defined as "in-depth personalization scenario." Here, the new aspirations – as the obvious environmental crises the planet is facing (Willett et al. 2019) – are seriously taken into account in the platform revolution. Obvious impacts of diets are measured and informed, such as CO_2 impacts, or de-processing, or fair-trade, or animal welfare. Platforms are able to value real impact reduction to the final consumer and able to offer new products designed with new ingredients, or with short value chains skipping the ingredients stage. Will platforms have the power to turn toward the upstream manufacturers and agriculture, and will dispose enough information and marketing strategy to design and deliver new products that are (privately) valued as *really* durable?

Shopping, Selling, and Delivery Mechanism During the 4th IR: Virtual Smart Platforms and New Urban Logistics

With virtual platforms and urban logistic, the final market *purpose* will be renewed. It is now a dynamic double matching process where discovering desires is as important as offering experiences and solutions to meet and value these desires. In other words, the final purpose of the market is now to match desires and products that do not exist yet before the matching mechanism. The *process* for doing this, the shopping, selling, and delivering mechanisms will have to deal with both long term System 2 relationships, and spot spontaneous System 1 market relationships. Long-term incentive contracts on the one side, and nomadic pushed offers on the other will be at the base of such new mechanisms. Transactions costs, or market frictions, will be dramatically reduced. The 3rd IR matching problems – find segmented products on each shelve, and design one owns regime – are solved thanks to information and behavior captors and to AI. Note that trust here is a condition sine quo non, as it is for using a GPS when driving. The delivery process may also be transformed, with home delivery through "uberized" or unmanned vehicles with continuous optimized routes. (Typical is the figure of the milkman who daily delivered any customer in many countries, where lack of fridge meant quick spoiling, and pasteurized milk was not available or fresh milk preferred. The milkman came with the returnable bottles concept. Both returnable bottles and milkman disappeared with the 3rd IR, supermarkets, packaged long life milk, transformed dairy products and refrigerators home equipment (Gantz 2015). Home milk delivery still exist in many less developed counties. It may come back to life, in a totally revisited way, with 4.0 IR.) Two ways information between the food system and the consumers will be thickened and socialized through social networks. Information will then be "vertical," between the product supply and the demand for products, but will also be "horizontal," among businesses but especially among consumers, grouped in communities. Here again trust will be necessary, and the capability of platforms (and regulation) to govern bad behavior and fakes news will be crucial.

As for existing platforms – such as Uber, Booking.com, or OpenTable – the "patrol of the village" will be essential. Platforms are becoming communities, and as such they establish polices, courts, authorities, penalties, and evictions in order to regulate behaviors inside the community. The typical "lemon problems" will find new solutions, through consumers and suppliers rating systems. As for apps developers wishing to join the Apple platform, access to food and drink platforms may become the most challenging issue in the future. (Apple relationship with apps developers is a shining example (Evans and Schmalensee 2016, p. 143). Apple may reject an app on reasons such as "your content is boring," "your design/layout needs a facelift," "our customers place a high value on simple, refined, creative, well-thought through interfaces." Parallel with food and drink are easy to conceive.)

Finally, antitrust regulation might be necessary if some platforms appear to get too much monopoly power and abuse it, as the value of developing multilateral network information gives a significant competitive advantage to large generalist platforms such as GAFAM and BATX.

Note that the information role of the packaging will vanish, as the product information, more precise, analytical and synthetic will be immediately available online on platforms, which means for the consumer, literally anywhere.

Pricing Products During the 4th IR: Between Incentive Long-Term Subscriptions and "One-Click"

The on-line services offered via platforms will be offered using the most sophisticated pricing mechanisms available, thanks to digital technologies and to product personalization.

The Service "Diet" will be offered for shopping and sale via the platform and delivered via the urban logistics. It is a service consisting that may consist of a continuous flow of multiple basic products, sold by subscription. Then, the pricing is that of a service, even if it is made of an assembly of goods. It incorporates much more than a series of goods ready-to-cook or ready-to-eat: the global coherence of the personalized flow of products, in its diversity and fitness with individual requirements and (explicit and implicit) specifications. It integrates home delivery, advice, seasonality, lifestyle, and so on. The pricing may also incorporate *incentives*, as a subscription is a long-term contract. Here, the analogy is with the pricing principles of wages and salaries. Most employees are not paid with a fixed amount, their revenue depending more or less on performances (Kreps 2018). A typical consumer may commit herself, through a long-term pricing contract with the platform, in what we may call an "effort," an effort desired by the consumer, but difficult for him to realize without day-to-day pressure, because of procrastination (Ariely and Kreisler 2017). For example, such an effort may be a commitment to better nutritional quality, less environmental impact, personal budget restrictions, increasing variety and exploration of exotic products or novel food (such as insects), ethical considerations, and so on. These goals are easily customizable by the platform, but they may also be socialized in communities through chats, games, bets, prizes, and so on.

The detailed future of the 4.0 industry in the food and drink industry is still wide open. For the rest of this chapter, we may though without much risk, put forward and defend the thesis according to which the coming fourth Industrial revolution is the one of *platforms* allowing to co-create customer-value with personalized products through a new capability of business to immerse in consumer real-life experiences (including usage), and measure human behavior at the individual and collective levels.

That will, even if of course, and that's why urban logistics will be so important, food and drink products will not be virtualized, turn most commercial products from goods to services. This new service-value will be captured through new pricing metrics and formula, the middle point of which being *subscriptions*. The object of the platforms will be to allow, with minimum "friction" (i.e., minimum transaction costs) and maximum convenience for the final consumer, the ideal matching between individual desires and individual continuous flow of products. The "End-Ingredients products" of the first industrial revolution where aligned with a society where diets and meals were themselves standardized and with very limited time variety except for seasonality. "End-Meal Products" then emerged with a demand for client-segment differentiation still immersed in a context of routinized and normalized diets. With the coming of the industry 4.0, the environment is radically changing. Segments and variants of End-Product Meals differentiation are multiplying and intertwining. The scope of consumer decision variables, and therefore characteristics to put forward on packages, is dramatically increasing. At the same time, this demand for *variety* faces a parallel demand for *coherence*, in particular for health and well-being reasons, but not only that, these complex and contradictory consumer desires come in a broader context where – even if consumers are getting more and more aware and concerned about their food and drink – they have obviously little time, limited attention, and no real support for potential efforts to deal with an actually balanced and satisfying diet. Smart platforms will definitely help to fill the gap between meals and diets at the personal level.

Drivers and (Potential) Limitations of the 4th IR Model in the Food and Drink Industry (Table 5)

(Cf. Table 3) The coherence of the 4th IR will reside in the *matching capacity of platforms and the efficiency of new urban logistics*. The aim is to create and capture value through Final-Meal personalization using platforms, logistics and subscription; as the previous 3rd IR succeeded in creating and capturing value through Final-Dish differentiation, with the nicely fitting use of three tools informative packages and self-service. The success determinant will then be in the capability of platforms to help for shop, design, sell, produce, and deliver valuable personalized Final-Dishes. The capability of platforms to connect the extended value chain with the final consumer will be decisive.

The main difficulties, classic for platforms (cf. Evans and Schmalensee op. cit.) will be on their capacity to reach their critical mass of participants and to be trustworthy enough to motivate consumers to deliver enough information for artificial intelligence to deliver information to Final-Diet designers sufficient to propose valuable new products.

Will such a 4th IR be sufficiently efficient in the future to become an exclusive one? Probably not. Previous models of the 2nd and 3rd IR may remain for long, as other complementary models may emerge, such as local, regional or community models based on physical person-to-person relationships.

Conclusion

New technologies for the 4th IR are already existing but are still underused. Collecting big data is easier than exploiting it to designing high added value mass-customized products. As a consequence, flexible and agile factories may also be underused. Personalized production and consumption requires a new global new infrastructure which will ask for time and huge investments. The global warming issue is getting more and more urgent, putting pressure on the whole extended value chain, on consumers and on public regulation. Other-regarding and long term preferences are needed but may delay or be replaced by important crises due to unavoidable degrowth. Product personalization requires consumers acceptance, trust and involvement. Routines and habits have to change, as the relationship between natural and artificial intelligence.

Personalization, interconnection, home-delivery, and groupings are the key words of tomorrow's food and drink. A new pricing system is emerging from the dynamics created by *platforms*, the big industrial players that are shaping our future. Under this coming pricing system, food and drink prices might not anymore be based on goods sold on self-service shelves – either ready-to-cook ingredients or ready-to-use meals – but will be sold on sophisticated personalized subscriptions, contracting the global path of customized diet in the long term, or raise sudden envy and deliver instantly to respond. This pricing system will put platforms right in the middle of the stage, between the food and drink extended value chain and the final consumers, reshaping the whole model we are living in today. This future may sound as a utopia, as it is asking for so much information, coordination, logistics, and trust that appear far from the reach of the present food and drink traditional stakeholders. Nonetheless, within the scope of what we may summarize as the potential "Food and drink 4.0," and in the continuation of what happened or is happening in other industries such as entertainment, clothes or health, multisided *platforms* – GAFAM and BATX at the forefront – are ready and well equipped, both technologically and economically, to meet such a challenge.

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Part XV

The Future of Eating/Perspectives on Research

Designing Eating and Drinking Experiences 70

Hendrik N. J. Schifferstein

Contents

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Abstract

Although experiences are personal and subjective, researchers can investigate them by observing people's expressions and behavior. This permits to deliberately design these events and see how changes in the design affect people's experiences. By focusing on experiences rather than products, the effects that products and associated services have in human life and their contribution to the consumer's well-being are emphasized. This chapter discusses the concept of experience and some of the tools that were developed to create particular experiences.

An overview of student design projects shows how these insights and design tools can be used to inspire innovations in the food domain, with topics varying between attempts to improve nutritional lifestyle, enriching the emotional experiences that food products evoke, and connecting people through the meals they prepare and consume. Using the approaches presented here could contribute to new ways of tackling the imminent challenges the world faces in the food domain.

Introduction

Consuming food is more than obtaining the correct amount of daily nourishment: It can also be an enjoyable and sociable experience, at many times efficient and simple, and at occasional times exuberant and festive. The way in which eating moments are shaped largely depends on where one lives: the geographical area and its cultural settings. However, it also depends on momentary individual preferences and local circumstances, such as the available budget, the characteristics of the food itself, and the consumption location.

Because many factors can be identified that contribute to eating and drinking experiences, designers can come up with many ways to shape such experiences. Hence, in the concepts developed by food designers the physical food is not necessarily the centerpiece, but only one out of several elements shaping the intended consumer experience. Food designs typically involve considerations of how the food is presented (e.g., packaging, tableware, information provided), how people interact with the food (e.g., during buying, opening packages, preparation and cooking, ways of eating), the context in which the food is consumed (e.g., the location, a special occasion, the time of day, the presence of people), and in some cases also the way in which the food has been produced and its waste is disposed of. As an example, Fig. 1 shows an overview of factors that affect the dining experience when people eat out, and it is possible to create analogous overviews of influencing factors for other situations.

This chapter discusses and evaluates approaches and methods that structure the process that designers may follow in order to design for specific food and beverage consumption experiences. These targeted experiences in their turn may be instrumental in achieving important life goals that contribute to personal well-being

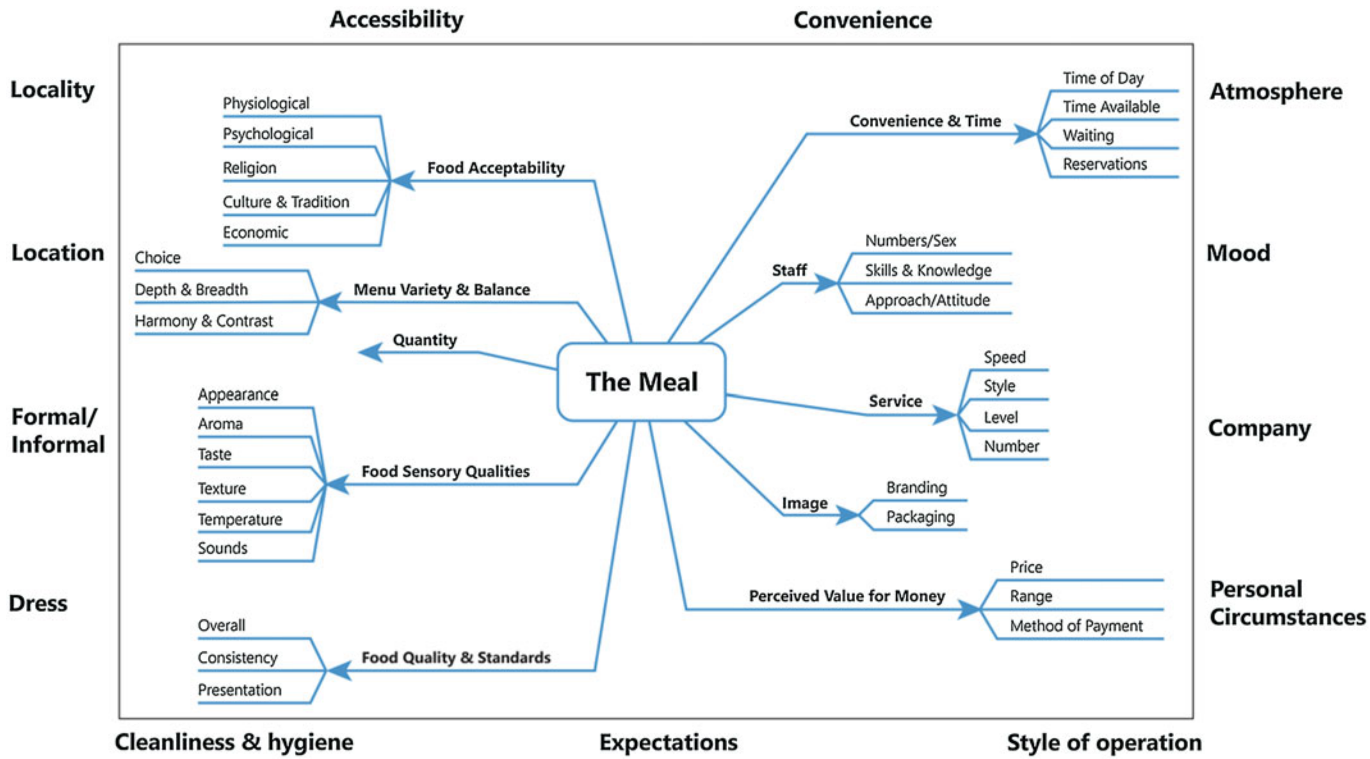

Fig. 1 Aspects of the consumer's meal experience when eating out. (Adapted from Edwards 2000; Redrawn for Schifferstein 2017)

(Desmet and Pohlmeyer 2013). For instance, designers may want to offer a relaxing, pampering experience as a momentary escape from daily reality for a busy office worker. Or they may want to stimulate a sense of belonging for someone who feels homesick after moving to another country. Or they may want to provide support for someone who managed to reduce their daily energy intake in an attempt to fight obesity. In all these cases, the consumption of food is somehow instrumental in achieving or enhancing an effect that influences a person's state of mind.

First the concept of experience is discussed and how this can be used to design for a specific experience. Subsequently, several tools are introduced that may be useful in designing eating and drinking experiences. Then an overview of student design projects in the food domain is provided, with topics varying between attempts to improve nutritional lifestyle, changing emotional experiences that food products evoke, up to ways in which food consumption may become more sustainable. Finally, the main contributions of experience research to the food and beverages domain are summarized.

What Is an Experience?

A product experience has been defined previously as the awareness of the psychological effects elicited by a person's interaction with a product (e.g., Hekkert and Schifferstein 2008). Although phenomenologically experienced as a whole, several major components can be distinguished in product experiences by disclosing several underlying dimensions, such as (e.g., Brakus et al. 2009; Hekkert and Schifferstein 2008; Schifferstein 2010; Vyas and van der Veer 2006):

- A sensory dimension with visual, tactual, olfactory, gustatory, and auditory perceptions
- An aesthetic evaluation of the product in terms of liking, attractiveness, or appreciation
- An affective dimension including emotions, feelings, and moods that are evoked or influenced with the consumer by interacting with the product
- An intellectual dimension containing cognitive associations, thoughts evoked and meanings activated
- A behavioral dimension consisting of actions toward, with, or evoked by a product

Although these dimensions may be distinguished theoretically, in practice they are highly interdependent and tend to occur simultaneously. In addition, besides these qualitatively different aspects, experiences also vary on the intensity dimension, implying that some experiences may be perceived as more or less intense, weaker or stronger, and may vary in the impact they have on someone (Brakus et al. 2009).

Experiences of user-product interactions are known to be inherently dynamic. Typically multiple stages can be distinguished that vary in activities performed and responses evoked. For instance, interactions with food products may involve encountering and selecting the product in a store, transporting it home, storing it, opening the package, preparing the food, serving and eating the food, and disposing of the waste. In all these stages, different sensory modalities may be stimulated, various cognitive associations may be activated, and multiple emotions may be evoked (Schifferstein 2016a; Schifferstein et al. 2013).

Moreover, events that happen in the time before and after food consumption may also change the way it is experienced. For instance, having tried a product at previous occasions may lead consumers to anticipate specific qualities. Information that people obtain through advertising and opinions from friends and family members are likely to affect their expectations. In addition, fantasizing about eating the product can enhance the craving for a product like chocolate (Kemps et al. 2005). And reflecting on the event after a person has stopped eating may still change its memorized experience (Desmet and Hekkert 2007; Law et al. 2009). Hence, what people do or imagine doing, and whether they think about their experience or talk to others can all affect their remembered and future experiences.

An experience does not only result from the interaction with a product, but it also accompanies and guides the interaction, and thus affects the interaction. Interacting with food can be instrumental (e.g., biting, chewing and swallowing) or non-instrumental (e.g., playing with food on the plate, moving food around in the oral cavity), may be rather passive (e.g., letting ice cream melt on your plate or let chocolate melt in your mouth), or can involve remembering or thinking about a product (e.g., anticipating eating cake with your afternoon coffee) (Desmet and Hekkert 2007). In sum, experience and interaction are fully intertwined and in order to explore people's experiences of products, the constituents or building blocks of human-product interactions and the context in which they take place need to be thoroughly understood (Law et al. 2009). For a more elaborate discussion of research on human experiences in the food context, the reader is referred to a recent review by Gómez-Corona and Valentin (2019).

A person's experiences are personal and subjective and cannot be observed directly. However, researchers can obtain information on these subjective experiences from people's actions, behavior, facial and bodily expressions, and their verbal accounts. Hence, it is possible to investigate how people experience a product, an interaction, or a service encounter, which makes it also possible to deliberately design these events and see how changes in the design affect people's experiences. By focusing on experiences rather than products, the effects that products have in people's everyday lives and their contribution to the person's well-being are emphasized.

How to Design for an Experience

Experience-driven design or "design for experience" intends to evoke a particular user experience in a specific usage context. Envisioning what experience to design for and understanding how design can evoke that desired experience requires a thorough understanding of the intended user, the context in which he or she operates, and the role the focal product plays in this situation. Although designers can target specific subjective experiences, the consumer's experience is dependent on that person's internal state (e.g., hunger and thirst, mood, specific needs, motivation, mental and physical resources) that may not be under the designer's control. Hence, designers can optimize their design to evoke a specific effect with the user, but they can never guarantee that all users will indeed experience that effect.

Examples of design briefs in the foods and beverages domain that try to evoke particular experiences may be issued by:

– Food brands that develop special displays and outlets (food service displays, retail outlets, cafes, or restaurants) to communicate their brand values through the experiences consumers have while they buy and consume the food product. Examples include the Nespresso stores, Unilever's Bertolli lunch café, and the Casa Barilla restaurants.
– Brands that want to create thematic campaigns, such as Magnum 5 senses or Magnum 7 deadly sins, that diversify and enhance the experiential qualities of their products in multiple directions.
– Restaurants that try to create a particular atmosphere (e.g., related to a country; lounge, bistro, high end) or enhance their service with additional entertainment (e.g., theme restaurants).

In many cases, the creation of experiences involves several steps and considerations, and may involve multiple stakeholders. The decision to develop specific experiences should be based on a strategic choice, either to communicate specific values of the company or the brand through the created experience, or a strategic decision to offer products or services that have particular expressive and experiential qualities. It requires appropriate techniques to generate and test these experiential concepts.

Designing for user experiences involves at least two challenges. The first challenge is to determine what experience to aim for, and the second is to design something that is expected to evoke that experience. As regards the examples of briefs given in the previous section, in the first case a company may want to communicate that it highly values nature and would like consumers to feel as if they walk in a forest when they use their product. Designers need to determine what colors, shapes, and materials will communicate this value and give that impression? In the last case, the company may already have decided that they would like consumers to experience the countryside of France when they use their product, but for the success of this venture, it is essential to determine which values exactly are incorporated in the image of the French countryside: Freedom? Relaxation? Tradition? Authenticity? Making a deliberate choice for specific aspects will increase coherence, clarity, and focus in the communication.

Desmet et al. (2011) have identified 14 ingredients that characterize many experience-driven design processes on the basis of their involvement in research and design projects. These ingredients should be regarded as options: Which ingredients are used and how they are combined differ between projects, depending on the wishes of the designer and the design challenge at hand. The 14 ingredients have been loosely divided into three categories. As the process is iterative, the three categories do not define a strict order of activities in the design process: The process can start with any of the ingredients, and ingredients from all three categories can be used in an infinite number of combinations.

Understand

The understand category represents activities that help designers understand the current situation and empathize with the intended users. Experience-driven design typically involves extensive analysis of user behavior and underlying motivations. Ideally, the designer would like to get under the user's skin, trying to obtain insight in processes the consumer is hardly aware of, in order to predict future users' responses to the design. A deep understanding of the psychology of the potential user and detailed knowledge of the context in which a product or service is presented is essential to foresee the users' responses to the various design iterations.

These activities can make use of qualitative consumer research methods including projective techniques, such as making collages (Costa et al. 2003), filling in creative booklets (Ozkaramanli et al. 2013), user observations, focus group discussions, and in-depth interviews (Kouprie and Sleeswijk Visser 2009; Sleeswijk Visser et al. 2005). In addition, the analysis of big data sets on consumer search behavior and actual consumption patterns may prove useful to reveal patterns that people are unaware of or are unwilling to report (Fig. 2).

Envision

Based on the insights and understanding obtained in the previous stage, designers and other stakeholders (e.g., marketing strategists, policy makers) can perform activities to envision and define the design intentions. This stage focuses on the effects the designer would like to achieve: envisioning a specific target user experience, the character and qualities of the intended user-product interaction, the character or expression of the end product, or on how they would like users to appraise the meaning of the product.

Create

The third category represents activities that help designers make the transition from design intention to product design. Some of these ingredients focus on the users and their experiences, some on the interaction between user and product, some on the context in which these interactions take place, and some focus mainly on product properties.

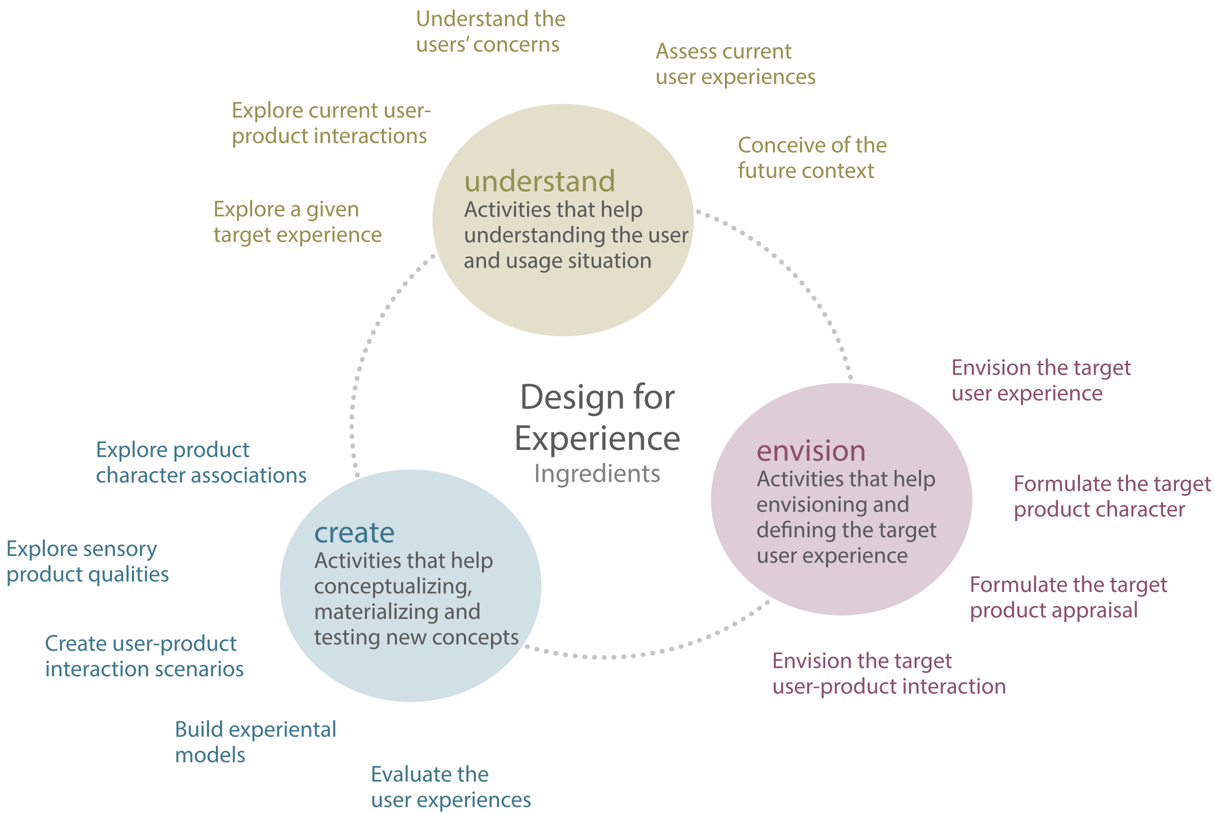

Fig. 2 Ingredients for experience-driven design processes. (Adapted from Desmet et al. 2011; Redrawn for Schifferstein and Sleeswijk Visser 2013)

Materializing an experiential vision is not an easy task. Fokkinga and Desmet (2014) elaborately describe a case study in which they used a conceptual framework based on a "design for emotion" approach that uses negative emotions to enrich product experiences. They developed and tested a prototype that was intended to add stimulation and engagement to the activity of running by providing users with the experience of being chased. Trying to materialize their experiential vision within a specific usage context provided many challenges and new insights that are broadly relevant when using an experience-driven design approach. In their paper they describe a number of potential pitfalls one may encounter when design interventions are based on theoretical reasoning and conceptual thinking. For instance:

- The design vision needs to be developed with an eye for subtle, nuanced differences in the intended experience. For example, people who feel anxious, worried, nervous, or confused all experience fear, but the differences between these emotions are crucial in understanding the associated feelings and behaviors that people experience and the events that can enhance or attenuate them.
- Experiential effects may be elicited through multiple psychological mechanisms. Some stimuli can directly induce a particular emotion, while others evoke memories or associations that trigger an emotion. Some emotions may only be experienced in a social context (e.g., shame). Hence, the peculiarities of the activating mechanism will affect the exact experience users will have.
- Creating experiences involves not only the static elements of the design (e.g., shape, material) but also dynamic aspects of the interaction. Hence, the creation of experience scenarios can help to capture essential elements of the design. The technical and practical limitations of the application within a certain context are likely to affect the character of the final design.

In order to evaluate the outcomes of the creative processes and to fine-tune the details of the final design, potential users may be involved during the evaluation stage with the use of quantitative methods (Desmet and Schifferstein 2012). After creating experiential prototypes, potential end users may be asked to evaluate the proposed concepts to determine whether the product indeed is successful in fulfilling its primary functions and evokes the target experience. This type of research should go beyond simple liking judgments, into more specific aspects of its sensory characteristics (e.g., how rough, sticky, soft the product is) and the cognitive associations (e.g., whether the product is modern, natural, authentic), emotional associations (e.g., if it is surprising, relaxing, exciting), and action tendencies it evokes. This type of feedback can help to determine whether all the specified design goals are met and can provide the food designer with input on the effects of their manipulations on consumer impact.

Some authors suggest including naïve potential users in the creative process in so-called cocreation sessions (e.g., Prahalad and Ramaswamy 2004). However, there is also a risk involved when users are involved early in the creative process, because it may decrease the experiential qualities of design solutions (Gemser et al. 2011). Hence, it may be better to leave the creation of concepts primarily to the creativity and skills of the design team, and to involve end users only in the last stages of testing, when their responses can make sure that the final product will be appreciated by the target customers.

Design Tools

Several tools were developed that may support the creative processes of food experiences. Some of these tools focus specifically on the domain of eating and drinking (Thoughts for Food, Food Design Cards), while others support the creation of consumer experiences (Emotion typologies, the Experience Map). Some are particularly useful in the first stages of a design process by stimulating creativity (Thoughts for Food) or pinpointing a particular design goal (Emotion typologies), while others help to create overview and may be used during the entire design process (Food Design Cards, Experience Map). Hence, together they support multiple stages in the creation of food experiences and may be of use to newcomers in the field and to those who seek to expand their horizons.

Thoughts for Food

Zampollo and Peacock (2016) developed a card set that is specifically aimed at stimulating creative thinking about food products, food services, and food systems. It is a design tool for the idea generation phase that facilitates reflection on the eating experience. Each card embodies one characteristic of the ideal eating situation and the set of 20 cards together aims to sum up everything that people love and find meaningful about eating and how eating situations should ultimately be. Besides seven cards addressing general personal needs and desires, five cards focus on food, four on eating companions, two on other people who are eating, and two on the environment. Examples of themes on the cards are sharing, immersion, being close to nature, observing curiosity, and appreciation of food. This card set is aimed primarily at stimulating creativity and obtaining inspiration in order to generate new ideas in the early stages of product development.

Food Design Cards

Lee et al. (in press) developed and tested a card set reflecting the richness of the food design field. Their intention is to use the cards to inspire, enrich, and facilitate design processes in the food domain. This card set is particularly helpful in getting an overview of the many different aspects that are relevant for a food design project.

The topics of the Food Design Cards are clustered into seven main categories: agriculture, industrial processing, distribution and marketing, kitchen management, eater, consumption situation, and policy and legislation. Each category consists of five topic cards and one overview card. The front sides of the topic cards introduce

Fig. 3 Example of a Food Design Card (Lee et al. in press)

the subject through a visual and a question. The back sides describe six to eight examples related to the topic that can be used for refining and critically evaluating ideas (Fig. 3).

The card set is accompanied by instructions for six exercises that facilitate the start of the design process. In the beginning of the design process the front sides of the Food Design Cards can be used as inspiration for new ideas or to gain overview of the food design topic at hand. Along the process, the cards can enhance brainstorming, facilitate discussions, create scenarios, and refine ideas. In later stages, the variety of topics can be used to check whether all important design aspects are covered. The cards remind designers to consider a multitude of aspects that need deliberation, can enrich their proposition, can enhance design details that yield competitive advantage in a saturated market, and reflect evaluation from multiple stakeholder viewpoints.

Emotion Typologies

Part of understanding the users' experiences involves empathizing with the user and diving into the nuances of their emotions. Designing for the wrong emotion or evoking an emotion in the wrong way is detrimental for the quality of the design. Therefore, Desmet and Fokkinga developed emotion typologies that facilitate determining the best emotion term the designer should target and its underlying concerns and behaviors. Desmet (2012) describes a typology for positive emotions, which has also been transformed into a card set (Yoon et al. 2016). For the negative emotions, they developed an online overview (see www.emotiontypology.com) that serves as a tool that provides both analytical understanding of a large number of emotions and also intuitive familiarity through detailed texts, movie clips, and cartoons.

Experience Map

By focusing on user experiences rather than on the formal qualities of the product during the creative process, designers are confronted with multiple challenges in the materialization of their design ideas. They have to find ways to transform an abstract vision defined as an experiential, subjective effect into a concrete offering. In order to elicit the intended experience, designers need to navigate through several choices, while shaping and refining the product qualities. To support this process, Camere et al. (2018) proposed a tool, the Experience Map, guiding designers in the progressive transformation of an experiential vision into tangible formal qualities, thereby explicitly considering all the opportunities provided by the human sensory modalities. The Experience Map builds on and connects the design principles of two frameworks: Vision in Product Design (Hekkert and Dijk 2011) and Multi Sensory Design (Schifferstein 2011; Sonneveld et al. 2008).

The Experience Map is organized in five steps arranged on a radial layout. The stepwise process assists designers in progressively transforming their experiential vision into a pattern of sensory qualities. In this process, they move in five steps from the most abstract level at the center of the tool toward the external layers of the map that provide sensory touchpoints. The five steps include:

1. Statement of Product Vision. This statement should provide straightforward and detailed information on the quality of the target experience, describing the value to aspire. The emotion typologies mentioned above may be helpful in this step.
2. Conceptual Exploration. This step requires designers to explore the intended experience by looking for visual sources of inspiration that relate to it. This step corresponds to the first interpretation of the product vision, focusing on how that specific experience can be rendered in a product, still in an abstract conceptual or metaphorical sense.
3. Selection of Expression. The third level of the tool addresses the definition of qualities that together form the expression of the product character. The designers select keywords that describe the product character, reflecting on what the product will express through its properties. Furthermore, this step stimulates designers to identify which sensory modalities, like vision or touch, can best express these aspects of the product character.
4. Sensory Exploration. This step asks designers to explore the experiential vision in a more tangible way, imagining how the future product must look or feel in its physical details and its dynamic qualities. Designers collect a new set of visual

sources of inspiration, which should be more concrete than the ones selected in the conceptual exploration phase. The upper part of the map (from visual to auditory) addresses the characterization of the static appearance of the product, whereas the bottom part supports the dynamic characterization of the concept.

5. Sensory Analysis. In the last step, designers are provided with a list of sensory qualities stimulating them to decide on the details of their concepts. They analyze how much any suggested quality is appropriate to express their experiential vision. With this last step, the Experience Map guides designers through the possibilities coming from the characterization of the product in all sensory domains.

The Experience Map provides a basic structure to organize creative thoughts and progressively decrease the level of abstraction. It stimulates greater confidence and awareness of design decisions, while allowing for the exploration of several design directions in parallel. These benefits, together with the visually stimulating layout, make the Experience Map an effective tool to support experience-driven design practice, especially in the early phases of the creative process (Fig. 4).

Design Projects

To illustrate what a design approach can bring to the field of eating and drinking experiences, a number of student graduation projects are discussed below as case studies that try to tackle specific challenges in the food context by designing interventions that may contribute to a long-lasting solution. Because challenges occur within a certain context, the solutions are typically developed for a certain situation and with a target group of users in the designer's mind. Hence, these projects tend to show examples of how a certain situation could be tackled. They do not present final or optimized solutions, and these solutions may not be directly relevant for other situations and user groups. In many projects the final designs have only been evaluated by a handful of potential users and they are by no means ready to be introduced on the market. This would require more extensive testing with iterative improvements of the design and also an evaluation of its economic feasibility and its profitability for any commercial parties involved.

In contrast to researchers, who often try to separate or control factors in order to study them, the strength of designers is to approach challenges holistically: They link abstract insights and ideas to people's everyday lives, and try to take the whole complexity of this everyday context into account, while having an eye for all the accompanying products, stakeholders, processes, or nuances that may be relevant. In this process, designers bring together and integrate the knowledge from multiple disciplines (see Schifferstein 2016b). The main value of these projects is to show possibilities, to highlight new approaches to existing everyday challenges, and to inspire designers, researchers, and policy makers to think in new directions.

Fig. 4 Example of an Experience Map filled out for the Pulse laundry machine developed for Whirlpool (Camere et al. 2018)

Enhancing Food Texture

(Tsai-Wen (Heidi) Mao, supervised by Rick Schifferstein and Annemiek van Boeijen)

Satiation is the physiological signal that makes people terminate eating, but the sensory rewards that foods provide often override this signal (Rolls 2012). Offering food with textures that attract attention or require people to use effort in mastication make people more aware of what they eat. They are likely to increase oral exposure time and feelings of satiation (e.g., de Graaf 2012; Hogenkamp and Schiöth 2013) and could, therefore, provide an effective means to tackle obesity.

Tsai-Wen (Heidi) Mao (2017) wanted to enable designers to augment the texture of food products. Desk research helped to identify several factors that are likely to make people more conscious of their eating experience while snacking. These include the presence of perceivable or surprising changes in the mouth, the degree of filling of the mouth, and the efforts required for mastication of the food. Furthermore, people may become conscious of the quantity they consume due to the sounds they hear during chewing, the degree of manipulation the food requires in the mouth, or when they observe that the food stays in the mouth for quite a long time.

In terms of food texture, Mao chose hardness, fracturability, chewiness, viscosity, elasticity, adhesiveness, and moistness as characteristics that would be the most relevant for people's texture experiences as well as have impact on oral exposure time. To obtain insight in how to create specific intended eating experiences, she created 83 texture prototypes of pork meat, carrot, and chocolate by applying existing cooking techniques, adding ingredients, and incorporating some of her own creative ideas. These prototyping processes were documented through written explanations, pictures, and videos in an online web blog: https://designerstoolbox.tumblr.com/. After testing some of her prototypes to determine the relationships between texture characteristics and the factors determining the degree of conscious snacking, she used the outcomes of her research to develop an interactive webpage that provides intuitive directions on how food designers can create a specific mouthfeel or can design for conscious and satiating snacking experiences through texture manipulations (Fig. 5).

Food Design for Bliss

(Carola Breuer, supervised by Rick Schifferstein and Anna Pohlmeyer)

People nowadays are spending less time consuming their food than any generation before them, and eating has evolved into an activity that many people perform without much awareness (Spence 2017). This estrangement may cause a decay of the amount of knowledge about food, as well as a decrease in appreciation of the meal. In contrast, what makes a meal memorable to people covers not only the sensory and hedonic experiences elicited by the food but also the company, the location, and the particular atmospherics (e.g., Jacobsen 2008; Spence and Piqueras-Fiszman 2014).

Carola Breuer wanted to make eating experiences more blissful (Breuer 2018). Seligman (2011) distinguishes between five elements that can contribute to human flourishing: positive emotions, engagement, positive relationships, meaning, and accomplishment. A number of activities and thinking strategies (e.g., expressing gratitude, acts of kindness, savoring, optimism, committing to one's goals) have been shown to provide a lasting increase in happiness (Lyubomirsky 2007; Seligman 2011). Design can play a role in facilitating and supporting these elements that contribute to human flourishing and well-being (Pohlmeyer 2012). In this project,

Fig. 5 Carrot samples with a variety of textures (Mao 2017)

the strategy of savoring, which can be best described as an active process of enjoyment (Bryant and Veroff 2007), was chosen as the main strategy to create blissful eating experiences.

Three concepts were developed to assist people in savoring their home eating experience: the mindful spoon, the sharing plate, and the travelling tin. The mindful spoon targets people eating alone. It is a spoon-shaped object, which is held in a special way to draw attention to the sensory characteristics of food, in order to increase the joy of eating. The integrated lens magnifies food and permits to see details that are otherwise only known from macro photography. The concept helps the eater to take a closer look at what exactly is on the plate. This can support the appreciation of the food's quality and can stimulate people to reestablish a positive relationship with food (Fig. 6).

The sharing plate focuses on couples eating together. It is a uniquely shaped plate that inspires people to serve their food in a creative way and it promotes personal contact by eating food from the same plate. When using the plate, a couple sits on two chairs facing each other and balances the plate on their legs. They can arrange the main ingredients on the elevated central area and put extras like sauces or salad in the deep neighboring bowls. The sloped sides permit to put down cutlery. Because the plate rests on the eaters' legs, it connects the couple in a physical way and

Fig. 6 Using the mindful spoon to explore the characteristics of your food (Breuer 2018)

Fig. 7 The sharing plate enhances the experience of sharing a meal together (Breuer 2018)

requires collaboration. This encourages teamwork and conversations that support the relationship in everyday life (Fig. 7).

The travelling tin is intended for sharing food, exchanging information about each other's cultures, and building memories with your friends. It is a box that can be filled with homemade food and passed on to a person with a different cultural background. The origin of the food can be indicated on the map displayed on the lid. Additionally, information about the food and its recipe can be obtained online through a QR code. The journey of the box over time is evident from the marks on

Fig. 8 Exchanging ethnic food experiences by sharing a home-cooked meal using the travelling tin (Breuer 2018)

the lid and can be followed online or on social media. This product encourages random acts of kindness and thereby enhances connections between people with different cultural backgrounds (Fig. 8).

Food as Poetry

(Randy Kadarman, supervised by Jouke Verlinden and Rick Schifferstein)

Through modern means of communication people can stay connected with others who live far away. This makes it relatively easy to stay in touch and even maintain a relationship. However, these communication media are also limited: They can transmit words, images, and sounds, but are poor in communicating through touch, taste, and smell, senses that are important for experiencing enjoyment, intimacy, and for developing attachment (e.g., Blomqvist et al. 2004; McBurney et al. 2006; White 2004).

Randy Kadarman intended to enhance the connection among people over long distances through food poems (Kadarman 2017). His vision on food poetry seeks to share stories through food by addressing the senses and by using ingredients that relate to that story. It starts with the writer, who recalls a memory or creates a story

Fig. 9 A food poem unwrapped by its receiver (Kadarman 2017)

they would like to transfer. This story will not just be shared through words, but more intuitively, through a multisensory food experience. The writer starts out by collecting all relevant material related to the story, similar to making a mind map. He then needs to select three key elements of the story and determine the physical details that correspond to these. He selects food ingredients and determines the shapes that best represent them. In addition, each element is transformed into a line of a haiku, a Japanese verse. This information is then sent in a digital form to a receiver, who can be at any location around the world (Fig. 9).

When the receiver receives the message, it is sent to a 3D food printer, where the three haiku elements are printed and placed inside a specially designed package that enhances the subjective experience. The receiver can already notice the smells, colors, and silhouettes through the box. When they open the box, they can see the collection of bites, and they can start smelling and tasting them: The sensory impressions start to tell a story. Finishing one of the three pieces also reveals part of the written haiku that is displayed on the bottom of the box. The subtle and implicit way in which a food haiku communicates strong feelings is a perfect fit for the Japanese culture, where one is expected to stay humble and composed, implying that one is not supposed to express intense feelings.

Tackling Comfort Food

(Leonie Houwen, supervised by Pieter Desmet and Rick Schifferstein)

Many people tend to consume specific foods when they are in negative moods, such as when they feel sad, bored, irritated, or angry, and these foods are consumed in an attempt to find comfort. However, the majority of these so-called comfort foods (e.g., chocolate, ice cream, crisps, or pizza) typically contain large amounts of relatively unhealthy components, such as sugar, fat, or salt (e.g., Kandiah et al. 2006).

Leonie Houwen wanted to change the interactions people have with food products when they are in particular moods, in a way that they would feel supported, but that the interaction would not have a potentially detrimental effect on their physical health status (Houwen 2017). Her interviews demonstrated that people had different food preferences and eating habits in different moods. Even within a single mood individuals could act differently and use food in different ways to regulate their mood.

This variety of strategies was transformed into concepts that addressed three food roles for two different moods: sad/gloomy and tense/nervous. For each of the six roles, a context scenario was created that served as a specific design context in the home environment. For sad/gloomy, the scenarios describe the role of food as a treat, medicine, or headache. For tense/nervous, the food serves as a break, fuel, or necessity. Both moods contain one scenario that tries to seek distraction (treat, break), one that tries to restore balance (medicine, fuel), and one where people do not really deal with the mood, but tend to surrender to it (headache, necessity).

Fig. 10 The six scenarios addressing sad/gloomy and tense/nervous moods (Houwen 2017)

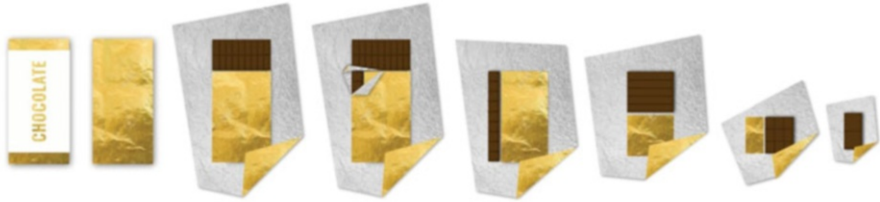

Fig. 11 The Chocolate Matryoshka provides the opportunity to treat oneself to a piece of chocolate, without having to feel guilty that you finished it all (Houwen 2017)

One of the scenarios is given here that describes food as a treat: “When I have an off-day, I often have an instant craving for something sweet. During my daily grocery shopping I definitely make a stop at the chocolate shelf and consider the variety of options. After some deliberation I take one bar, together with the other groceries, to the check out. Once at home, the first thing I take from the shopping bag is the chocolate bar. I take a bite right away while I store the rest of the groceries. When done, I make myself a cup of tea and move myself together with the chocolate and a magazine to the table and take a comfortable position. While reading, I continue breaking off pieces of chocolate, until the bar is almost finished. Then I realize I finished almost all of it on my own and put the rest back in the wrapper and put it away” (Fig. 10).

The goal when designing for these moods is to support the chosen mood regulation strategy, without criticizing people’s behavior or forcing them into doing something they do not want to do. Instead, Leonie Houwen would like people to embrace the chosen strategy and its qualities, which intends to provide comfort, even if it works only on the short term. In addition, the designer would like to strengthen its effect by eliminating negative side effects or by making the chosen strategy as effective as possible, without steering too much. Any concept should respect the current situation and the chosen strategy, without judging or punishing people for the way they feel or the way they act. In this way, the concepts are somewhat poetic interpretations of the research insights.

Eventually, Leonie created six product concepts that help people reflect on their own eating behavior when they are in a certain mood. These designs were intended to open up discussion about their experiences and to make these experiences more tangible. One of the concepts is shown here: the Chocolate Matruschka that matches with the “Food as a Treat” role: “A chocolate bar that you can keep unwrapping. Every part is a bar on its own. When you decide to put back a part of it, next time you will always find a complete bar in a wrapper, and not some sad, tiny leftovers that you are tempting to finish. If you decide to open a new bar, it gives you the same joy again, like a small celebration. You unwrap and start eating a new bar, not like you already finished half of it. It is a chocolate bar that makes you feel good, in any case” (Fig. 11).

Fig. 12 Toddler exploring the Kookid (Picture: Lotte Jacobse)

Connecting Children and Parents During Cooking

(Lotte Jacobse, supervised by Anna Pohlmeyer and Stella Boess)

Before and during mealtime young parents face multiple challenges, such as cooking dinner while keeping an eye on the child, dealing with children who are tired and hungry, and making sure the child eats enough nutritious food. The toddlers, however, typically like to make a mess of everything while their parents are cooking. They enjoy climbing around on unsafe objects, and may try to capture their parents' attention by interrupting them. However, the parents who experience time pressure may be reluctant to give attention to their children during cooking. Then when the situation switches from preparation to eating, the toddler may refuse to eat and challenge their parent by playing with their food, throwing vegetables, or covering their mouth with their hands. The following struggle between parent and child is satisfying for neither of them and parents may resort to tricks (e.g., rewarding or punishing) to persuade the child to cooperate.

Involving children during the cooking activities might be an option to improve this situation. However, many cooking tools contain sharp edges and may be dangerous in the hands of small children. Therefore, Lotte Jacobse developed the Kookid: a number of simple and safe cooking tools for toddlers. The product elements stimulate the child's explorative use and play while at the same time facilitating easy cooking actions like cutting, mashing, and cracking. In this way, young infants can contribute to dinner preparation, without the danger of being harmed by any sharp blades or edges. In addition, it allows parents to prepare a healthy meal, while enjoying the child's presence (Jacobse et al. 2016) (Fig. 12).

Overcoming Barriers: Eating Insects

(Roos Durieux, supervised by Rick Schifferstein and Annemiek van Boeijen)

With the growing world population and the increase in income in developing countries, the demand for animal products is expected to increase. As meat production is unsustainable in the long term, there is a need to find new protein

Fig. 13 Insect foods sold at a local Asian food market (Durieux 2017)

sources as meat alternatives (Verkerk et al. 2007). This sustainable alternative could be insects, because the conversion from plant to insect protein is highly efficient compared to livestock, while needing less land and producing less CO_2 (DeFoliart 1999; van Huis et al. 2013). However, many people in Western countries experience feelings of disgust, aversion, or distaste toward insects in general and as food in particular, since they are not familiar with such ingredients (Deroy et al. 2015). In addition, in countries where eating insects is more common, insects are often seen as food for poor people and the more affluent people will be reluctant to consume them (Durieux 2017). The fact that people experience these negative emotions hinders a greater acceptance of insects as an edible product.

Roos Durieux aimed to develop an intervention that would increase acceptance of insects as food both in Western and Eastern countries. She started with a multicultural exploration in the Netherlands, Thailand, and Cambodia (Fig. 13). Her final design tries to build bridges between the different contexts and influences all three settings in different ways (Durieux 2017). In the Netherlands, the intervention targets people who find healthiness and sustainability important, who would typically travel to Eastern countries and have seen insects presented as foods in local markets and restaurants. During their travels, they encountered insect products in restaurants for foreigners that are typically also run by foreigners. In this context, insects are seen as local curiosities and insects can become a delicacy, a premium snack that expresses important values like togetherness, altruism, and care for the environment. This encounter with colorful and intriguing insect foods will help to develop a positive attitude toward cooking with and eating insects. This opens up the possibility for trying insect foods when they get back home as well.

The final design consists of three different products (a cricket breeding bowl, insects as ingredients, a cricket tapas package) and an information flyer. Together these products cover various stages of discovering insect foods. No matter which type of product is encountered first, they each provide an entry into the process of becoming acquainted with insect foods and may trigger people to try out the other products as well. The products are all interconnected by a consistent visual style that connects to traditional Cambodian images and fabric patterns.

- The cricket breeding bowl fits the restaurants and cafés in Asia that are owned by foreigners. It lets customers experience the positive sides of cricket breeding: that they are clean, fun, beautiful, and create interesting and tasteful dishes. In addition, the breeding bowl can be sold in specialty stores for gardening and for biological and sustainable food products in Western countries. It contains an instruction on how crickets can be bred and harvested at home.
- Crickets as ingredients are presented in dried form in a jar that can be shown in the shelves of Western supermarkets among dried ingredients. It encourages people to cook with dried insects.
- The cricket tapas exist of four different types of snacks inspired by Cambodian snacks (e.g., samosas). They offer an opportunity for Western consumers to experience the sensory properties of various insect foods and to become familiar with Cambodian flavors. The tapas are offered as snacks in the fresh food section of Western supermarkets among sushi and salads.
- The flyer explains the story of crickets and their role in food habits in Asia. In addition, it gives recipes and links to insect cookbooks. It presents the three different products described above and links them together. Connecting the breeding, cooking, and eating of insects allows consumers to become acquainted with all the fascinating aspects of interacting with insects as valuable and sustainable sources of food.

Conclusion

Designers are trained to be creative and come up with solutions for ill-defined problems. Many challenges the world faces in the fields of food supply, food technology, and eating behavior consist of such intricate, multifaceted problems and may benefit from the skills designers have developed during their education, including associative, divergent thinking, process and product visualization, prototype building, and project management, to name a few (Schifferstein 2016b). In addition, the focus on experiential aspects during the design process ensures that not only hardwired, functional aspects are considered, but also the aspects that consumers perceive individually and subjectively. Several tools were discussed that can support designers when working in the realms of food and subjective experience.

The graduation projects show a variety of approaches that tackle some of the important challenges in the field of food and eating that the world is currently facing. For instance, concrete questions were tackled related to healthy eating (Heidi Mao) and the sustainability of the food supply (Roos Durieux). Other designers tried to increase people's quality of life by providing them with great experiences by enhancing the perceived quality of food, connecting them with other people, and creating or savoring memories (Carola Breuer, Randy Kadarman, Lotte Jacobse) or by supporting them in times of distress (Leonie Houwen). Hence, the designers' projects can inspire new ways to tackle evident world challenges and contribute to human well-being. These design approaches and example projects may set off a creative spark in the field of food and eating and thus contribute to new ways of tackling the imminent challenges the world faces.

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Why We Know So Little About the Psychology of Eating in Humans

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Paul Rozin

Contents

Abstract

Considering the major importance of human food and eating in human life, it is surprising how little we know about the psychology of it. The area of human eating is divided into understanding *how much* humans eat and *what* humans eat. After massive efforts and expenses, by excellent researchers, we have been very unsuccessful at treating obesity, the major "how much" disorder. We have barely attempted to understand or treat the very common phenomenon of picky eating, the major disorder associated with what we eat. In accord with Herman et al. (Social influences on eating. Springer, Cham, 2019), it is argued that for *how much*, we have in large part been looking in the wrong place. Multiple, situational (institutional), social, and cultural factors are the principal determinants of *how much* humans eat. Major research efforts on animal eating, motivated by a

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homeostatic model, have taught us much about animal food intake regulation and informed us about the physiology and psychology of a similar system in humans. But that system accounts for a small minority of the variance in human food intake. To understand *what* we eat, there is no homeostatic model, and animal data are understood to be minimally relevant. The roles of context and social-cultural-cognitive factors are much more obvious for *what* humans eat than for *how much* they eat. Probably, for these reasons, there has been little motivation in psychology to work on food choice. For future work on both *how much* and *what* we eat, we should value observation more, focus more on human and less on animal research, less on experiment and more on multiple variables operating together, and less on laboratory settings and more on the real world. Psychology is good at experiments, at isolating causal factors, and at constructing scales to measure beliefs and attitudes. These important skills can be combined with the orientations of sociology and anthropology to yield optimal progress.

Person A is looking for something at night, under a street light, and tells Person B that he is looking for his keys. Person B says: "Where do you think you lost them?" Person A points to a dark area about 30 feet away. Person B says: "Then why are you looking here?" Person A says: "Because there is light here."

Introduction

The author is sometimes asked by journalists or distressed individuals about how to deal with a problem of perceived overweight or obesity. Although about one-third of Americans are obese, the only reliable treatment for this, applied almost exclusively to cases of more extreme obesity, is very intrusive bariatric surgery. The author feels that a justifiable response to a plea for help with moderate levels of obesity is to say, "Live with it! You don't ask for help with your height. It's really hard to lose weight (or gain height) and maintain the loss. Find another way to improve your life." In many circumstances, in the absence of extreme obesity, it may be best to think of weight like height and direct one's concerns and efforts elsewhere.

Many or perhaps most adults maintain their weight within a narrow range over periods of months or years without being on a diet or monitoring their intake (e.g., Davison and Birch 2004). This occurs in spite of a wide range of dining experiences over a day or week, including different types of meals, meals at home or away from home, special eating occasions, or rushed meals. We don't know how this "weight regulation" is accomplished, in spite of major advances in the study of metabolism and the neural/neurochemical brain systems involved in eating. We know of many factors – physiological, psychological, and cultural – that contribute to food intake and weight, but we do not know how they are integrated. Not surprisingly, given our lack of understanding of the complex control of food intake, we fall short in the area of treatment.

Our lack of understanding extends to the other side of eating, *how much* is eaten, as opposed to *what* is eaten. The author is often asked, by parents, journalists, or others, about what to do about a young child who is very picky about food and often only eats a small number of foods. The author has to shrug his shoulders, admit that this is very common, and say that there is no clear way to improve this situation. In most cases, the few selected foods seem to be adequate nutritionally, perhaps with the addition of a micronutrient pill, so the best strategy may be to wait it out, displaying a generally positive attitude to a wide range of foods. This professional lack of understanding is embarrassing and very unfortunate. Picky eating is a very common problem in the United States, with a prevalence estimated at between 15% and 30% (Taylor et al. 2015). Picky eating in children is often a cause of tension between children and their parents. In its more extreme forms, it is an important part of a new DSM 5 clinical entity called ARFID (avoidant restrictive food intake disorder) (American Psychiatric Association 2013). Our lack of understanding of picky eating, which is a food choice disorder, reflects our minimal understanding of the complex factors that cause human food choice and how these factors interact in the real world. This chapter is an attempt to explain why we know so little about this fundamental area.

So with all the advances in the related sciences, we are way behind in understanding human food intake and food choice. There is a "third" aspect of eating, *how we eat*, and we know the least about it (Bellisle et al. 2000). Much of eating is accomplished in social situations, at home or away from home. *How we eat* represents a major part of human life; we do not eat like animals. We adults usually sit around a table, use silverware, eat rather daintily without dropping food on the floor or table, and converse with others facing us (if not staring at a cell phone or a television), spewing out language from the same hole (mouth) that we are stuffing food into. It is a remarkable and unstudied feature of most adults that we can hold a conversation at a meal with people who are looking at our mouths, without allowing them to see the disgusting mass of masticated food behind our lips. Eating by humans is a remarkable demonstration of our being civilized as opposed to animals, as brilliantly described across European history by Leon Kass in *The Hungry Soul* (1994). "We eat as if we don't have to, we exploit and animal necessity as a ballerina exploits gravity" (Kass 1994, p. 158). Learning how to eat is a major aspect of socialization. No discipline knows much about it, but ethnographers are most likely to take note of it. How do we learn the rules of eating etiquette, and how do we learn specific skills, like using a fork and knife or eating grapefruit? This important matter will not be discussed further in this chapter. Basically, we know very little about it because there are very few studies on it. The chapter will discuss *what* we eat (food choice) and *how much* we eat (food intake), with a focus on the author's discipline, psychology, which has a central role to play in explaining this.

Why don't we know more about what we eat and how much we eat?

It's Just Not an Important Area: Nobody Cares, Nor Should They

There are no certain criteria for establishing that a particular area or approach is important or not. However, there is some relevant evidence for the claim that the way humans relate to food should be one of the most important areas for study in psychology and other behavioral science (see review in Rozin and Todd 2016).

(a) Of the basic biological functions (eating, sex, protection, excretion, etc.), eating is the most pressing and most central for survival. Breathing is actually more pressing and more "frequent" but is often properly dismissed in behavioral science as very rudimentary, simple, and easy to understand.
(b) Food choice is probably the most important force in the biological evolution of animals.
(c) The food system is the only biological system that has a dedicated basic emotion: disgust. Disgust, meaning literally bad taste, almost certainly originated as a communication associated with oral rejection of potentially dangerous foods.
(d) Food milestones are among the very most important in human evolution. Cooking and agriculture/domestication are obvious examples.
(e) In the developing world (roughly 80% of the humans on Earth), food accounts for more than any other category of expenses.
(f) Food accounts for a major part of expenditures in the developed world. In the United States, for 2018, total food expenditures were estimated to be greater than $1.5 trillion (www.ers.usda.gov › ag-and-food-statistics-charting-the-essentials). This compares, for example, to the Federal Defense budget for 2018, of $693 billion (for comparison, the US Department of Agriculture budget for 2018 was $140 billion).
(g) Food is by far the most elaborated of the biological systems. Eating at a table and with silverware is very distant from the way animals eat (Kass 1994).
(h) Food occupies more time in human life (shopping, preparation, consumption, and cleaning after meals) than any other activities except sleep and work. And much of work is devoted to generating food expenditures.
(i) Malnutrition and obesity are both major health problems in the world today.
(j) Food habits are one of the major areas of study in ethnographies in anthropology and species descriptions in zoology.
(k) Food provides a major way of organizing social activities.
(l) Food is a major source of pleasure. In a culinary context, food can function as a major source of aesthetic pleasure.
(m) Food is a major source of meaning in human life, via its connections to the social world, identity, and religion (Kass 1994; Grunert and Grunert 1995; Arbit et al. 2017). It is a major source of metaphors (e.g., "Let's get to the meat of the issue."). It should be obvious that food and eating are centrally important areas for human beings. But what about food in psychology, the field that could reasonably be considered at the center of concerns about food intake and food choice?

Food and Eating in Psychology: Wrong Focus for Intake and Minimal Research on Choice

Psychology, as a discipline, has a very selective interest in food and eating. As a field, psychology has been much more interested in process (e.g., memory, perception) than in the domains of life (eating, protection/clothing, leisure activities, with the odd exceptions of sleep and sex) (Rozin 2006). Post Freud, modeling itself on its conception of the natural sciences, psychology has consistently focused on measurement, objectivity, and experiment. Observation is of relatively low repute (Rozin 2001). These features characterize what might reasonably be considered the two major movements in psychology over the last 80 years: behaviorism and cognitive science. Recent introductory psychology texts are a reasonable representation of the interests and accomplishments of modern academic psychology. To assess the importance of food and eating in the field, and the relative importance of intake and choice, the author examined a convenience sample of three major introductory psychology textbooks published over the last 10 years (Gazzaniga 2018; Myers and De Wall 2018; Schacter et al. 2011). The author examined the indices of these large books and simply added up the number of pages cited for each of a set of food intake or food choice terms for each text and then calculated the mean for the three texts. For "*how much*" items, the mean number of pages for a set of keywords (food intake, eat/ing [other than eating disorders], drink/ing, hunger, and thirst) was seven (of course, this is an overestimate, since, e.g., "hunger" and "food intake" may refer to some of the same pages.) Considering disorders of intake (eating disorders, anorexia, bulimia, and obesity), the mean number of pages is 16. For *what* is eaten, there is a mean of two pages cited for a set of critical keywords (food choice, food preferences, food selection, and disgust). For disorders of selection (picky [eating] and ARFID), the mean is 0. Thus for all aspects of eating, there are 25 page citations (much less than 25 actual pages) out of a mean of 653 text pages for the three texts. Each book has a section on food motivation that occupies five or six pages (in some texts, eating disorders are considered in a separate section). Is 25/653 (4%) or 6/653 (0.9%) pages an adequate representation for an area of the importance described above? The number of pages is 1 or 2 for *what* we eat. Similarly, do citations of 23 for *how much* and *2* for what we eat represent the relative importance of these two areas?

Taking the present book, *Handbook of Eating and Drinking*, as representing the major aspects of the relevant psychology from experts in the field, of the 33 authors of chapters in this book who were in psychology or in a related discipline that might comment on a psychological issue, only 4 or 5 were cited at all in the 3 texts (the texts list between 2000 and 5500 references). Altogether, the 33 relevant authors were cited, as first authors, in 3, 9, or 10 references of the thousands of references for the 3 books.

As another indication, so far as the author knows, there is not a single person on the full-time faculty of any of the "top" 20 US psychology departments (US News evaluations 2018) whose principal area of research is or is closely related to human food selection.

It is fair to say that we probably know more about the psychology of food intake than of food choice, which is reflected in the pages devoted to each. We can say that one reason we don't know too much about the psychology of eating is that it receives little attention from psychology. *What* we eat is ignored much more than *how much* we eat. What leads to more attention to intake is its linkage to obesity and the fact that there is an appealing natural science framework, homeostasis, to organize the study of intake. As discussed later, the homeostatic framework may also have hindered a full understanding of human food intake.

Jobs and Careers

In psychology, there is a lack of interest in food and eating, especially in food choice. A consequence of this is that psychology majors are minimally exposed to these issues. *How much* we eat is saved, to some degree, by its link to obesity. Picky eating is not associated with major health risks, nor stigma, nor unattractiveness. Its effects are, in substantial part, indirect, acting largely through increased family tensions early in life and sometimes peer tensions in later childhood, as well as problems socializing when food is present. Graduate programs do not emphasize eating, outside of obesity. The introductory texts represent the interests of psychology and perpetuate them. There are few academic positions oriented toward people who study eating outside of obesity and almost none in the area of food choice.

There is, of course, a second source of careers for those interested in food choice. That is, the food industry, and large institutions that feed many employees (or students), such as the US military. The food industry has invested in one area in psychology, the measurement of sensory profiles of foods. This is one substantial aspect of food choice, but there are many others, such as beliefs and attitudes about foods, social factors, and sociopolitical and cultural issues. There is very little food industry employment in these areas. Probably, part of the reason for this is a suspicion about psychology and the social sciences by the food scientists who are the primary influence in research directions for the food industry. The industry seems, on the whole, to believe that the product should be the focus of research, rather than the consumer. Sensory measurements are often more quantitative and are, of course, product focused. Slighting the study of attitudes and contexts may be a mistake. Some of the reduction in meat consumption in the developed world has more to do with lay beliefs about meat and health, growing compassion for food animals, and the new concerns about sustainability. The author's experience with failures to get funding from the meat industry to study these things supports my position.

There may be a growing interest from large employers in improving the food they serve their employees, from both health and moral perspectives, and this may prompt more company research on food choice. There is one major institution that has a long history of research on food choice, on the account of serving hundreds of millions of meals per year. That is, the US Army and its Natick research laboratories. The editor of this volume, Herbert Meiselman, has been a leader at the Natick laboratories.

Research Support

There is an obvious positive feedback link between fields of interest to psychology (and medicine), training of people to work in these fields, and support for research in those same fields. Federal research grants are peer reviewed, and the more peers in an area, the more likely a grant will be reviewed entirely by researchers committed to support in that area. Most of the food intake grants and articles I have seen begin with a paragraph or more on the importance of reducing obesity, and one is unlikely to get a review taking issue with this premise. A research proposal on picky eating will not encounter such a friendly reception.

In the author's own experience over the last 40 years, this was illustrated best by the research and support of one of the best researchers in the field, the late Leann Birch. Early in her career, she did some of the most important research on the determinants of food choice in children. She shifted to doing excellent work on food intake in children, often in relation to obesity, because it was much easier to get grant funding.

To support this claim, the author examined the active grants, as of October, 2019, from the National Institutes of Health and the National Science Foundation. I looked at the grant titles, as to whether they contained critical words for food intake versus food choice. The combined number from NSF and NIH that included *how much* words in the title (food intake, hunger) was 33, whereas the number that mentioned "what" words (food choice, food preferences, food selection, liking or hedonic) was 12. The number of grants mentioning "obesity" was 702, with 0 for picky or ARFID. There are two important qualifiers here. Many of the obesity grants have nothing to do with behavior, and there are other federal sources of funding for food research, notably, the USDA. These might show a different ratio.

There is evidence for a major difference favoring *how much* is eaten as opposed to *what* is eaten within psychology and probably in medicine as well and the same direction of difference for research positions and grant support.

Why there is surprisingly little known about food intake and choice?

It Is Hard to Do Research on Food Intake and Harder Yet on Food Choice

Studying Food Intake

Initially, one might think that work on food intake would be easy. It is hard to imagine a simpler set of dependent variables: amount eaten and weight, with an obvious relation between the two. Recording intake is easy to do in the laboratory and can be done with some difficulty in real-world situations. Options include photographing or videotaping a meal, food diaries, dietary recall, or food sales in a community or nation. For body weight and height, measurement is easy and inexpensive (except for the fact that many women do not want to be weighed). Independent variables are plentiful, with good ways to get a variety of blood measures and now measures of brain activity and levels of neurotransmitters. Just as people think it will be easy to lose weight, investigators, at first, would think understanding why people eat a certain amount is an easy problem to solve. We have a homeostasis model and so many relevant physiological measures.

There are some problems with the many physiological measures that have been identified as exciting or inhibiting food intake. First, the food intake control system is very multidetermined. Second, there is a lot of redundancy, as one would expect in a vital system; these two features make experiments, the method of choice in the psychological and physiological study of motivation, hard to do: for example, with a multidetermined system with redundancy and eight independent physiological (or psychological) variables to study (e.g., stomach fill, blood glucose, blood leptin, blood ghrelin), there are 28 two-variable combinations of these and over 200 combinations of these variables, considering all possibilities of groups of 1–8 of them to exhaust the possibilities. These numbers don't even begin to deal with selection of levels of each variable.

Experiments are problematic. But there is a much bigger problem. The normal physiological candidates are sometimes assembled into an integrative model with another little box of variables, sometimes labeled "other" or "social" or "cognitive." These "other" variables are often harder to measure and are very probably the *major* determinants of human food intake (see Herman et al. (2019) for a clear statement of this point). And the more important social-cultural-cognitive variables are, the less value there is for animal studies as models of human intake. So the preferred natural science approach of isolating causal variables experimentally, with animal models, is impractical. Furthermore, the laboratory model, which has worked rather well for animals for food intake and other outputs, is so impoverished for humans that it can primarily be used to suggest potential specific influences, as opposed to developing a fully integrated model.

Let us consider some concrete examples of variables controlling food intake.

The first comes from environmental influences on amount eaten in *rats* under highly controlled conditions. In one study, one group of rats was offered food, ad lib, in a small chamber (roughly the size of a typical lab cage) and ate a mean of 9.3 meals a day. Another group of rats with the same housing had a small nook installed, which caused them to sleep for longer periods. These rats averaged 6.8 meals a day (Nicolaidis et al. 1979). So what levels of physiological measures triggered eating depending substantially on the alternative behaviors rats had? Though not normally offered to rats, the opportunity to sleep well had a major effect on eating pattern, though total food intake was unchanged.

A second example illustrates the importance of social norms and memory for eating. Two totally amnesic adults, who did not remember that they had just eaten, were offered three identical consecutive full lunches, with 0–30 min between meals. Each amnesic experienced this three meal sequence on three occasions (Rozin et al. 1998). On all six occasions, the second serving was consumed in at least the same amount as the first. In five of six occasions, the third meal was partially consumed. Two control subjects with intact memories, each run through the same procedure twice, rejected the second meal each time. This study shows two things: one factor that causes rejection of food is memory for what has recently been eaten. A second factor is that consumption begins if one is served palatable food in an appropriate situation.

A third example also illustrates the importance of social norms, in terms of portion size. In a real-world setting, American adults were offered a bowl of snacks in the lobby of their apartment house every day. In an experiment, the contents of the bowls were varied on a daily basis. The contents of the bowls were weighed every day (Geier et al. 2006). In one set of comparisons, the tootsie roll units differed by four times in weight from day to day. In another set, using large pretzels, the weights (size) differed by a factor of two. In a third case, a large bowl of M&Ms was presented, and the serving instrument was either a tablespoon or one-quarter of a cup (four times one tablespoon). For each of the three snacks, people ate more than 50% more by weight when the larger size was available, even though there was no limit to the number of snacks they could consume. There was a strong norm for consuming “one” of the offered foods (“unit bias”).

A fourth example deals with culturally prescribed regular meal times. A homeostatic energy regulation model of eating (applied with some success for ad lib feeding rats) suggests that, after a large meal, there will be a longer time interval to the next meal than after a small meal. However, in France (to a greater extent than in the United States), the three meals occur at very predictable times, with little variation (Fischler and Kahneman, unpublished data). Thus, this type of energy regulation is not possible due to culturally proscribed meal time constraints.

A fifth example has to do with the actual presence of others at a meal (the usual case). There is a substantial number of studies in which food intake of a participant is measured, in the laboratory, while he or she eats with a confederate who consumes, on different days, or in different experimental conditions, a large or small amount of food. Reliably, the participant eats more in the presence of a person eating more (reviewed in Herman et al. 2019). So the amount eaten by another person influences the food intake of a person.

The next example, in the cognitive/social domain, shows that how an eating episode is framed affects the degree of satiety. Pliner and Zec (2007) arranged for Canadian students to consume identical sets of foods, in one condition represented as a meal (table setting, course order, utensils) and in the other presented as a snack (eaten while standing, no course order, without utensils). At a later eating opportunity, participants ate more if they had previously consumed a snack. The perception of having previously eaten a meal as opposed to a snack reduced intake.

A seventh example pits a biological variable against a psychological variable. Wooley (1972) provided student participants with one of four preloads: high calorie (600) or low calorie (200) crossed with the appearance of high calorie (with thickeners) or appearance of low calorie (without thickeners). In a subsequent test of ad lib food intake, perceived calorie load predicted intake, and actual calorie intake did not. Cognition trumps calories.

Finally, as a simple illustration, think how much you would eat for lunch if you were going out for a really tasty dinner in the evening, as opposed to a normal evening dinner. Here it is your expectation of future eating, a cognitive effect, that is influencing your current intake.

Ultimately, we have to understand how multiple signals are integrated, in the real world. First we have to know what the signals are, and we don’t know many of the nonphysiological signals (and probably some of the physiological signals, too). Most of the signals can be identified in the laboratory under controlled conditions, but context, social norms, and cultural values are so important that even isolating signals can be challenging. Of course, all of these signals and contexts and their integration are expressed in the brain, but it is questionable whether neural studies with current tools will explain this process.

Natural science, with laboratory controls, animal models, and experiments, is considered to be excellent and "better" science than social science. It is where the light is. But for human food intake, most of what is driving the effect is not under the light (Herman et al. 2019). The focus of research on food intake may have been misplaced. It should include humans, in real-world settings, balanced against more analytic studies. As Herman et al. state, in their "theory of normal human food intake": "When tasty, attractive food is available, people will be inclined to eat a lot, but at some point they may be inhibited by social norms that forbid or proscribe excessive eating; they want to eat appropriately." There is no doubt that the energy intake regulating system that has been well described in the rat is also present in humans. It is just masked or overwhelmed much of the time, at least at shorter time intervals, such as individual meals.

In the developed world, people don't usually start eating because they are hungry, rather, it is because of the presence of palatable food, at an appropriate time and place. They do not stop eating because of satiety, but rather because they have consumed an appropriate amount. However, it is important to recognize what was pointed out at the beginning of this chapter. Many people maintain their weights well over months or even years without counting calories. This could be accomplished by either subtle or overt monitoring of intake and/or weight and/or by subtle effects of physiological signals, averaged over days or weeks.

Let us consider some of the factors/signals that we know or think contribute to food intake in a meal or over longer periods. There are metabolism-related/physiological or volume signals coming from the mouth, stomach, small intestine, large intestine, liver, pancreas, blood, and fat storage depots. There are cognitive social/cultural factors: norms for what is an appropriate meal size (for different meals), ideas about what makes a good impression (depending in part on the type of people who are present), memory for what has been eaten, perceived number of calories consumed, anticipation of future eating events, behavior of other eaters who are present, and types of food available. There are also personal (individual difference) factors such as self-discipline, self-confidence, personal weight/figure ideals, and general views about the link between BMI and health.

The critical term for many of the variables, as suggested by Herman et al. (2019), is "appropriateness". In any situation or culture, what is an appropriate amount to eat is a function of many variables, some represented in the situation and some in the cultural norms in the mind of the eater.

Studying Food Choice

The situation with food choice is quite different. There is much less research in psychology. This is partly because the determinants of food choice are obviously substantially cognitive, social, and cultural. It is fair to say that if you want to know as much about what different foods a person eats, the most informative question is "What is your culture?" There is not a relevant homeostatic model for food choice, and though, of course, there is a neural basis for food choice, it is unlikely Italians have a lasagna center in their brains.

Humans are quintessential omnivores and, as a result, must rely almost entirely on learning to determine what is edible and nutritive and what is not. Humans (and rats) do have a few biological predispositions, including an ability to learn to connect oral experiences with gastrointestinal events that occur even hours later, a particular ambivalence about trying new foods, innate oral preferences for sweet tastes and fatty textures, and aversions for bitter tastes and oral irritation (see Rozin and Todd 2016 for a review). The innate sweet and fat preferences have had a major effect on the culinary evolution of humans, culminating in strong desires for, among other things, chocolate, ice cream, and both sugared and diet sodas. There are some innately based differences in taste sensitivity, but it is very striking that at least for Americans, there is a surprising low correlation (averaging 0.15) between the specific food preferences of parents and those of their adult children (Rozin 1991). The parents share genes with their children but also control most of the early food environment. Cultural learning and peer influence may be more potent influences.

The two major determinants of what people eat are availability (largely mediated by culture and geography) and cost. (Cost also affects how much is eaten, especially in the developing world.) Study of these factors fall primarily in the domains of cultural anthropology and economics, respectively. In the developed world, there is an abundance of food available for most people. The supermarket has an enormous variety of food, and most of it is within the budget of at least middle-class people.

It is a challenge to list and organize the variables that affect food choice, over and above availability and cost. Meiselman (1996) notes that they can be divided into the food, the person, and the environment, each of which has many components. A major model for discovering and organizing the major social-cultural-cognitive determinants of food choice was developed by the interdisciplinary Cornell Food Choice Research Group, under the leadership of Jeffery Sobal (Sobal and Bisogni 2009). This scheme is based on interviews with American adults and is displayed in Fig. 1. The many terms in the figure are explained in Sobal and Bisogni (2009). The model describes not only the current determinants but the developmental and cultural determinants. As the authors note, "Overall, all food choice decisions are embedded within personal time and historical time." (Sobal and Bisogni 2009, p. S41). The wide range of factors that have to be taken into account to fully account for a food decision is well illustrated by this approach. Food choice is deeply social, as is the usual experience of eating, commensality (Fischler 2011). The multiplicity

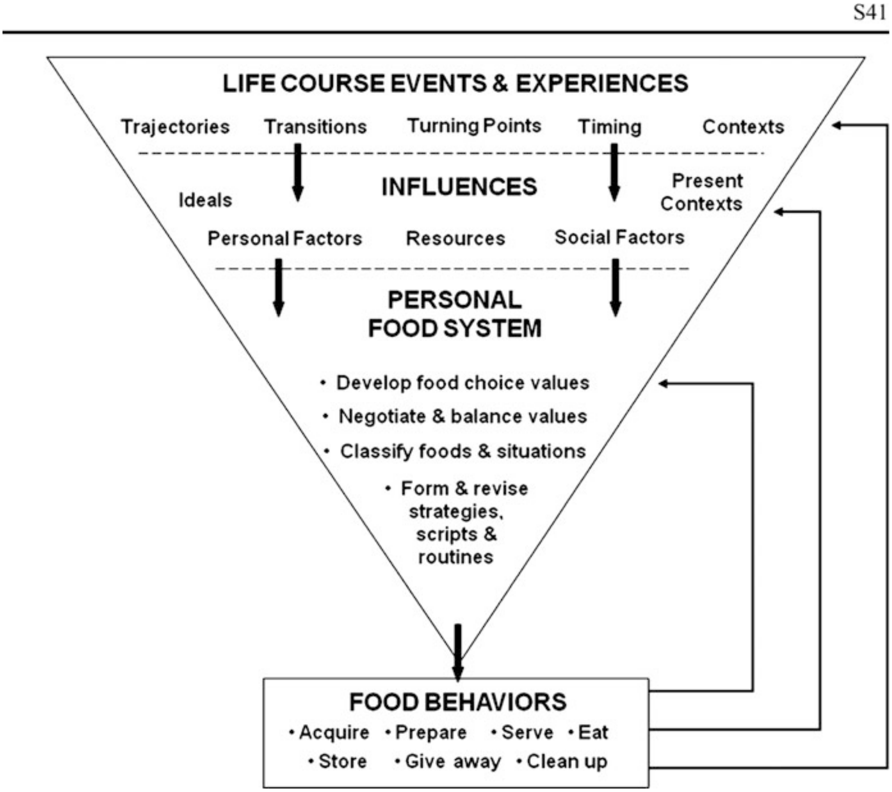

Fig. 1 Scheme of social-cultural-cognitive variables that influence food choice (Sobal and Bisogni 2009)

of factors involved in food choice is illustrated by The Eating Motivation Survey (TEMS), which identifies 15 motives for eating (Renner et al. 2012), and The Meaning of Food in Life Scale, which identifies five non-nutritive meanings (Arbit et al. 2017; see ▶ Chap. 57, "Measuring Meaning of Food in Life" by Grunert in this volume).

Cost and availability aside, the major documented factors controlling food choice, from a psychological perspective, are liking, convenience, and perceived healthiness. Of course, almost all the findings come from the developed world, with few economically deprived participants. And only about 20% of the world population lives in the developed world, although this number is growing. For many people in the developing world, there is minimal choice at a given meal, with cultural and economic factors dominating.

Given the laboratory setting in which most studies are conducted, availability and cost are neutralized. Dependent variables are either amount consumed or rated liking. Rated liking is a subjective measure and hence generates some suspicion from psychologists and a great deal more from food scientists. The results of these studies are often subject to alternative interpretations, because of the artificiality of the physical and social setting, the participants' awareness that they are in a study, the particular instantiations of the foods in question, and the infrequent use of whole meals.

Let us consider, for example, a study of asparagus preference or liking based on intake of asparagus present in an offering of a range of foods. Asparagus intake will depend on time of day (relatively lower at breakfast), who else is eating and how much asparagus those persons are eating, the choice set (is it tomatoes and broccoli or ice cream and tuna salad), and the form of asparagus that is presented. It could be cold or hot, presented with a variety of dips or sauces, or not. Suppose the participant loves asparagus, but only hot with melted butter. Your asparagus might be cold without sauce. In this or many other "wrong" presentations, the participant may eat very little asparagus. But if you ask this person how much she likes asparagus, it may get a very high score, because this question is usually interpreted as "how much do you like asparagus when it is presented in the way you like it best?" And that's what you want to know. The person is not thinking of asparagus with melted chocolate or cream sauce or cold asparagus with mustard. In response to the liking question, the subject is doing just what you want her to do; you couldn't have prepared the asparagus and other choices in the favorite form for each subject. In many respects, the more subjective question about liking is more informative than an objective intake question.

A major reason we don't know much about food choice is that little work has been done (unlike the case for how much is eaten). Animal work is almost irrelevant, and there are many variables to consider. The experimental lab setting can give some ideas about relevant variables, but it is difficult to produce real eating situations in the laboratory. However, there are a few cases of constructed "experimental" restaurants or getting an actual restaurant to allow certain types of variations across days. It may be that in some cases, ratings and intake can be collected in ongoing simulated eating situations, as with video presentations. With modern technology, it is possible to get measurements including ratings in real-world eating situations. More possibilities are becoming available with big data and experience sampling. Though we cannot yet look where there is a lot of light, there is much more light than there used to be.

Understanding Liking

This section illustrates some of the points raised above for an area the author has worked on: acquisition for liking for foods. We know very little about how people get to like foods. This problem falls squarely in psychology and now, in the relatively new discipline of marketing. Psychologists have not been very interested in the acquisition of liking, not just for foods but for music, cars, clothing, camping, and a wide range of products and activities. (There is a related area of intrinsic versus extrinsic preferences that has received considerable attention in psychology.)

Liking is not the same as preference. Liking is a major cause of preference, but there are other factors, including convenience, perceived healthiness, and a wide range of social and cultural influences that determine preference. For example, a dieting person might prefer (choose) cottage cheese to ice cream, but like ice cream more. Liking will be considered here as a trait-like characteristic, which is to say, generally stable over months or years. There are three types of experience that have been demonstrated to influence liking.

1. *Mere exposure* to a food (or other entity) in a neutral environment *usually* increases liking for it, but we don't know the conditions under which mere exposure fails (Zajonc 1968; Pliner 1982). Mere exposure in the real world is largely the result of social and cultural forces, acting through the environment.
2. *Evaluative conditioning* has been demonstrated to, under some conditions, increase or decrease liking. Evaluative conditioning is a form of Pavlovian conditioning, in which the conditioned stimulus is a target food and the unconditioned stimulus is a particular set of positive or negative events. The most dramatic case is conditioned taste aversion: a single pairing of a food (it could be initially liked) with nausea within a few hours usually leads to a marked decrease in liking for the food. On the positive side, positive preferences have been established with humans in the laboratory, but the effect may be small and rather fragile (Zellner et al. 1983). One form of conditioning uses observed positive or negative expressions of another person who consumes the target CS food or beverage (Baeyens et al. 1996). It would seem that evaluative conditioning of liking is rather common in the real world (with sweetness often the unconditioned stimulus, as with sweetened coffee), but harder to demonstrate in the laboratory.
3. *Social factors*. The third category is social, which stands for a wide range of potential social influences, including observed liking of admired others and motivations to be similar to admired others. Social influence is frequently used in advertising. Influential social factors are plentiful, but we don't know how and when they operate in any detail. Social factors may be the most important causes of acquired likings and aversions (see ▶ Chap. 14, "Social Influences on Eating" by Higgs, this Handbook).

There are two particular aspects of acquired liking that stand out over and above the three suggested mechanisms. One, related to the intrinsic-extrinsic literature in psychology, is that although explicit reward for consuming a food can produce an increase in intake while the reward is active, when the reward ceases (even though exposure has been accomplished), the intake usually drops back to or below prior levels, and there is no sign of increased liking. Leann Birch and her colleagues performed the classic demonstration of this effect for foods in children (Birch et al. 1982). A related finding in adults is that they rarely develop likings for the taste of oral medicines, which may (as in the case of antacids) have rapid positive effects (Pliner et al. 1985). It may be that in many situations, rewarding ingestion of a substance may cause a person to attribute the ingestion to the expected positive post-ingestional or other instrumental effects, and that may block acquisition of liking.

A second phenomenon of interest is the frequent acquisition of liking for foods that are either innately aversive (e.g., irritating chili pepper, bitter coffee, or ice cold soda) or have a previously learned aversiveness such as disgusting foods (e.g., smelly cheese in Europe and North America or fermented fish sauce in Southeast Asia). These phenomena can be called "hedonic" reversals. All evidence indicates that these phenomena do not occur at the sensory level, but rather involve "reinterpretations" of the same sensory inputs when they arrive in the brain. Chili-pepper-likers like the burn. A biological account of such events could involve conditioned opponent processes, which would posit, for say oral irritation, a conditioned response to oppose the negative experience with a positively generated internal experience, where this experience eventually overwhelms the original negative experience. Endogenous opiates would be an obvious physiological mechanism. Currently, there is little evidence for this mechanism, and there is one finding that provides evidence against this type of account as the only mechanism of pain-related hedonic reversals. Conditioned opponents should work for mammals other than humans, but while hedonic reversals are abundant in humans, there is minimal evidence for any in animals. In fact, rural Mexican dogs and pigs, who consume spicy Mexican food in the garbage daily do not develop a liking for chili pepper (reviewed in Rozin et al. 2019). An alternative, uniquely human account of hedonic reversals, appropriately much more cognitive than the conditioned opiate account, is what we call "benign masochism." This account begins with the observation that hedonic reversals are extremely common in humans (and virtually absent in animals). Many humans like irritant foods, bitter foods, very cold foods, fear (as in a roller coaster, horror movies), pain (as in massage, entering a hot bath, or muscle pain at the end of extended physical exertion), disgusting experiences (as in disgusting movies or jokes), and sad movies, novels, paintings, and music. In all of these cases, negative inputs that would ordinarily signal danger or problems become pleasant. Benign masochism suggests that negative experiences that we know are not really threatening become pleasant because we recognize that fact; it is a matter of pleasure at appreciating mind over matter (Rozin et al. 2013).

Given the minimal amount of research on acquired liking, it is likely that we will discover other interesting anomalies in addition to the paradoxical effects of reward and hedonic reversals.

Conclusions and the Future

There is much work to be done for us to understand both *how much* humans eat and *what* humans eat. If we had a high level of understanding, we should be good at treating the corresponding disorders. In spite of a massive amount of research by qualified researchers, with the exception of bariatric surgery for extremely obese people, obesity is almost untreatable. Treatment of eating disorders is in better shape, but still far from what it could be. Treatment of the principal disorder of food choice, picky eating, has been minimally investigated and cannot be built on a deep understanding of food choice, since that does not exist.

For both *how much* and *what* is eaten, there has been little attention to facing the complexity of human eating in the real world. Animal studies have limited value, and laboratory, experimental studies are helpful in isolating important variables but should not be the main focus of research. It is good to have laboratory models, but they must capture the essential nature of the phenomenon under study.

There is a big difference between food intake and food choice. Powered by the important homeostatic model and the urgency of finding treatments for obesity, along with major advances in understanding and measurement of neural and neurochemical activity related to eating, there is an impressive body of research on the physiological contributors to the control of food intake. Much of this work has been in the experimental, laboratory frame with animals, and it has made real progress in understanding the metabolic and neurophysiological control of food intake in animals. There is little doubt that a regulatory system like the one that operates in rats is also present in humans. The problem is that while this system accounts for much of the variation in how much laboratory rats eat, it accounts for little of the variation in human intake. From the perspective of psychology, there has been a reluctance to tackle the many social-cultural-cognitive variables that have to be incorporated in a model. There have been sufficient experimental studies with humans on social-cultural-cognitive variables in the laboratory to strongly indicate how important these are for fully explaining human intake (reviewed in Herman et al. 2019). Similarly, there is extensive evidence for the importance of environmental variables (reviewed in Wansink 2004, see ► Chaps. 51, "Contextual Considerations in Experimental Food Research and Policy" by Saulais and ► 13, "Atmospheric Effects on Eating and Drinking: A Review" by Spence, this Handbook).

We have to realize that though it is valuable to identify another influence on food intake, given the many factors and the redundancy in the system, our ultimate goal will be a complex multivariate model, with cognitive and social-cultural variables accounting for most of the variance. The homeostatic model that has dominated in the psychology of food intake might have more success in traditional cultures, where there is still a substantial amount of malnutrition, and hunger may be more important. At this time, there is more malnutrition than obesity in the world, but obesity will probably exceed malnutrition in the next decade or two. Unlike obesity, which has fascinated psychologists, there has been little attention to the causes of malnutrition (as opposed to its effects). I think psychologists correctly understand that malnourishment is not so much a psychological problem, as it is a political and economic problem.

The situation with *what* we eat is different. We know even less than we do about *how much* we eat, partly because there has been less looking under the light, because it is obvious that we won't find much there. There has been much less research and much less funding of research. There is no unifying metric like calories. Food choice is obviously a multidisciplinary problem, and although almost everyone supports multidisciplinary work in principle, partly because of the division of the academic world into disciplines, this support relatively rarely evolves into actual academic positions. Somewhat surprisingly, the causes of liking, often the major predictor of choice, have not been a major concern for psychologists.

The hundreds of world cultures have each developed solutions to the basic problems of living. We can learn from other cultures, which are something like less controlled experiments. An example is research by the author with Claude Fischler (a French sociologist) and a number of students to try to answer the question: How is it that the French have an obesity rate approximately half of the American rate while consuming a diet that is higher in fat than ours? A series of studies (summarized in Fischler and Masson 2008; Rozin et al. 2019), looking at both attitudes and behaviors, indicates that in contrast to Americans, the French treat food as something to enjoy, rather than as a vehicle for producing effects on the body, they have deep respect for their food and their meals, they spend more time eating, they snack less, eating is more social, they savor their food more, *and they eat less.* Their food traditions value quality more than quantity. Some of these deep attitudes to food may be difficult to transfer to the United States. But there is one French feature that is rather easy to transfer, and that is smaller portion sizes. That is already happening with smaller soda can sizes from major American soda producers. The "unit bias" discussed earlier suggests that the smaller portions will be accepted as sufficient food intake.

There are notable changes in the world now, which should project into the future and may augur well for research on food choice:

1. Because of the epidemiological revolution, which is gradually penetrating the whole world, the relation of eating to long-term health and well-being has become more important. There is medical and epidemiological evidence that diet has an effect on longevity, and this may map into greater concern about the causes of food choice. Discussions of "healthy eating" are common in the developed world.
2. The research community in psychology has become notably more worldly. In behavioral food research, two major journals are *Appetite* and *Food Quality and Preference*. Examining their full editorial staff as of 2019, the continent accounting for most individuals is Europe. Both have representations of individuals from developed countries in Asia, and *Food Quality and Preference* has 8% from Latin America. Participants or respondents from the developing world (about 80% of humans) are not well represented, but that will happen as more research universities are established in those countries.
3. A new, major moral concern has become important for people, at least in the growing developed world. That is *sustainability*. Food choice may have found its "obesity." Sustainability as a major world "health" issue may be here for a long time. Taking care of our environment may turn out to be even more important than controlling obesity, and it has a moral quality that obesity does not. Food choice, in particular decreasing meat consumption and food waste, will probably become central concerns of psychology.

As psychologists take on these new responsibilities, they have to realize that though they can do better science where the light is, they might have to compromise in service of reality in order to tackle some of the most critical variables and look where there isn't much light. There is some trade-off between scientific rigor and control, where the light is, and working with variables that are of major importance in food consumption and choice. Psychologists should collaborate with other disciplines, such as anthropology. Psychology stands out among the social sciences in the refinement of experimental science, hypothesis testing, and development of valid measurement scales. These skills could complement those in other social sciences, to produce major advances.

Besides the rise of concerns for sustainability, which raises hopes for more research and more funding for research on food, in general, there is one other set of events that is encouraging for food research. With globalization, the world, and in particular the food world, is becoming less traditional and more modern, so our past focus on Americans may have more generality than it did in the past. This, of course, may be good for research, but it is bad for those of us who love travel and food.

The concern for a broad multidisciplinary scope for food research is well represented in the current volume and also in another book edited by Meiselman (2000), entitled *Dimensions of the Meal: The Science, Culture, Business, and Art of Eating* (see also Meiselman 2009). This concern also motivated a group of us at the University of Konstanz and the University of Pennsylvania to begin a ten-country project to explore the transition from traditional to modern diets, the motivations for eating, and the meanings of food. The project has at least one collaborator from each of the ten countries, covering the disciplines of anthropology, nutrition, psychology and sociology. The countries are from both the developed and developing world: Japan, China, India, Ghana, Turkey, Germany, France, Brazil, Mexico, and the United States. Support has been obtained from the German Science Foundation. We are already collecting data, and 16 authors now have their first publication. It is a theoretical paper which analyzes each of two dimensions of eating, *what is eaten* and *how it is eaten*, into six subdimensions, as a guide for our own research and that of others (Sproesser et al. 2020). It is a start. If there is one word that should be kept in mind for our future work on food and eating, coming from Gestalt psychology, it is *context* (Meiselman 1996, 2019; Rozin and Tuorila 1993). Stripping it away in the service of greater control is often a risky strategy.

There is a last piece of good news for the future.

The less we know, the more we have to learn!

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Commercial Product Design: Psychophysics, Systematics, and Emerging Opportunities

72

Howard R. Moskowitz

Contents

Abstract

Over the earlier decades of the last century, researchers began to explore the use of people as "measuring instruments." For food, this systematized effort began in earnest with ratings of liking of different products, with such ratings being analyzed for differences (Peryam and Pilgrim 1957). Measurement by itself, no matter how well executed, was not sufficient. It would take a change of world view, from measure of single items or happenstance discovery of relation to the world of systematics, DOE, design of experiments.

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Introduction: Systematics

Over the earlier decades of the last century, researchers began to explore the use of people as "measuring instruments." For food, this systematized effort began in earnest with ratings of liking of different products, with such ratings being analyzed for differences (Peryam and Pilgrim 1957). Measurement by itself, no matter how well executed, was not sufficient. It would take a change of world view, from measure of single items or happenstance discovery of relation to the world of systematics, DOE, design of experiments.

The new psychophysics has had a direct impact on the world of product design and perhaps one that was anticipated. More enterprising researchers realized, however, that they had a tool by which to understand how ingredients drove responses, whether the response be the perceived sensory intensity of the food or beverage (e.g., the sweetness of cola) or the degree of liking. Psychophysicists, specializing in the study of the relations between sensory magnitude and physical intensity, soon began to contribute to this effort, especially with simple systems, such as colas and some foods (Moskowitz et al. 1979.) What is important to keep in mind is that these curves provided foundational knowledge. It was quickly discovered that the same percent change in ingredients could very well produce radically different perceived changes. Doubling the concentration of a flavor ingredient, for example, was seen to be less effective than doubling the concentration of sugar for the same food. We will elaborate this type of thinking below, when we deal with stimulus-response analysis and response surface designs.

Stimulus-Response Analysis

Product design becomes far more powerful when we move from testing one product or several unrelated products to a set of prototypes that are systematically varied. The original thinking comes from both statisticians who promoted the idea of DOE (design of experiments) and from psychophysicists who promoted the idea of uncovering lawful relations between physical stimuli and subjective responses.

Beyond the design of experiments, the creation of the systematically varied prototypes, lies an entire body of statistics known as regression analysis or curve fitting. With regression analysis one discovers how a physical ingredient or set of ingredients drives a response, the most important response being overall liking. Furthermore, with nonlinear regression analysis, it becomes easier to uncover optimal or most highly liked product formulations within the range of prototypes tested but a formulation that is not necessarily one of the prototypes created (Box et al. 2005; Cochran 1950).

The author's experience is that a reasonably simple polynomial fits the data regression modeling typically creates either a linear plot, described by the equation, and shown schematically in Fig. 1 (left panels), or described by a quadratic equation, and shown in Fig. 1 (right panels). The plot can either reflect a one-ingredient system (panel A, panel B) or a two-or-more ingredient system (panel C, panel D). We

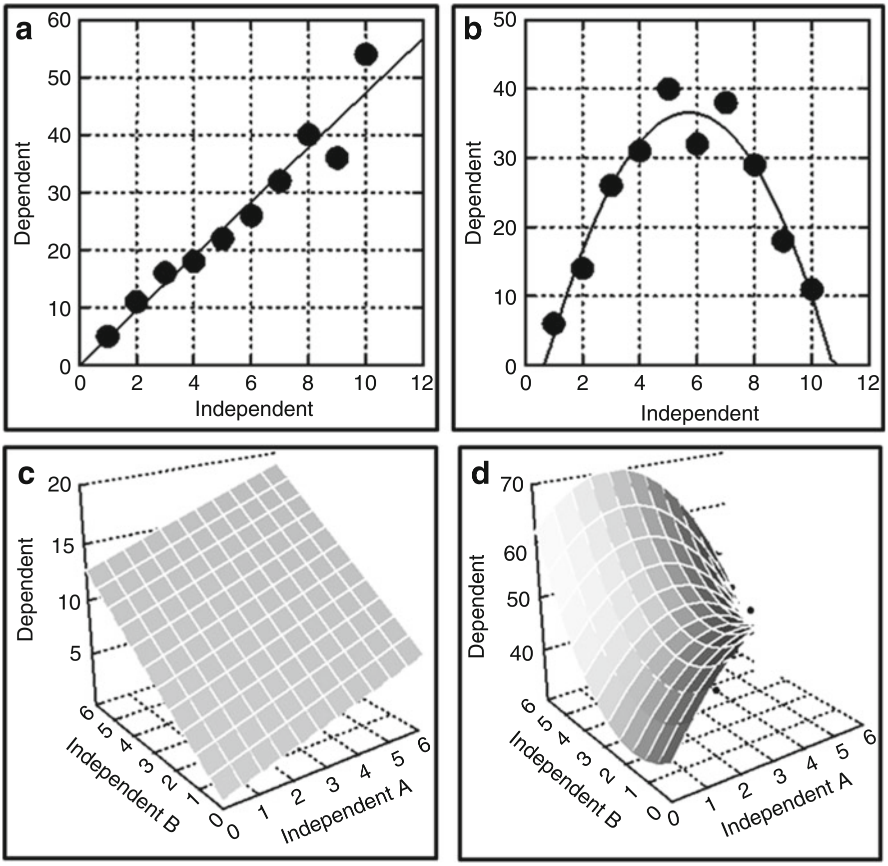


Fig. 1 Scatterplots showing the relation between a dependent variable (ordinate) and either one independent variable (panels **a** and **b**) or two independent variables (panels **c** and **d**). Source: Unpublished data from author

present a visual only of the two-ingredient system, but the mathematical modeling can accommodate many more independent variables, even when we cannot easily visualize the model. The plots represent the type of relations one might observe when the dependent variable (ordinate) continues to increase linearly with increases in the independent variable (panel A, panel C) or when the dependent maximizes at some intermediate point of one or both independent variables (panel B, panel D.)

Regression modeling plays an important role in product design for at least two reasons:

1. Regression provides insights into what might be important, thus giving direction for product design. The developer creates a quantitative structure to discover what operationally varied factor might be important, rapidly providing insights that could not be obtained were the effort to be focused on one product.

2. The second, perhaps more important, is that regression analysis forces the necessary shift from focusing on one product to focusing on many products. One soon realizes the futility of efforts to understand the drivers of liking by relating the rating of liking for one product to the rating of sensory attributes for the same product, using as inputs both the sensory and the liking ratings assigned to a single product by many respondents. The reliance on one product alone produces a fallacious approach which confuses the "noise- or variability-based" information one learns from the variation in responses to one product with the "signal-based" information from the variation in responses to many products. As the intellectual development of the field proceeded, this change in focus, from the study of variability to the study of patterns, would inevitably lead to more powerful tools.

The question often arises as to the reason for the late adoption of experimental design and modeling in the world of food development. Almost 50 years ago, the author had the opportunity to meet and chat with two leaders in experimental design, Mr. Al May of Pillsbury Inc., and Dr. Robert Carbonell of Standard Brands, Inc. (later a division of Nabisco, Inc.). The discussions of both of those meetings, one in Minneapolis with Al May, the other in New Jersey with Bob Carbonell, focused on this topic. Both suggested quite separately that the field of product design was simply not ready. Both were strong proponents of design and could show success, but the "Zeitgeist" was strongly influenced by the spirit of expert panels and descriptive analysis. It would take a generational shift, pushed by quite young researchers in their first real jobs, these being Dr. Herbert Meiselman (editor of this volume) and Dr. Howard Moskowitz (author of this chapter). Both researchers would pull the world of evaluation out from the cloister of expert panel to the world of consumers, whether these be soldiers (studied by Meiselman) or civilians (studied by Moskowitz, first for the US Army, and later for the food industry).

1970s–2000: Large-Scale Response Surface Modeling and Subsequent Business Success

As we proceed with the history, we come to new developments, best called "systematics." Product development would evolve to a systematic exploration of alternative prototypes. The logic of the approach might be obvious, since it has produced in its wake many corporate successes, the approach new to managers at the time of the efforts, 1970s–2000s. There were four main obstacles, cultural barriers that would have to be overcome. It's relevant to note these barriers because they apply to many approaches which may disrupt conventionally accepted methods, even though these new approaches produced better results:

1. *Effort deflected from the standard procedures*: To produce the prototypes often required plant runs, taking away valuable plant time from producing products.

2. *Resistance to experimentation because some prototypes are clearly not optimal*: Product developers were accustomed to presenting one or two prototypes to be tested. The notion of testing "nonoptimal products" was simply not reasonable.
3. *Fear of technically sophisticated methods*: Many researchers were not familiar with thinking and statistics of systematic experimentation.
4. *Expansion of responsibilities requires breaking down conventional corporate silos*: Sensory analysis worked with in-house panels, not with external panels, and positioned themselves as a testing service rather than as a design service.

Food design would change beginning in the 1970s, primarily because of the cooperation of market research and psychophysics, consumer researchers, and the functionalist agenda. During the 1970s and 1980s sensory researcher took a different path, enjoying acceptance as the in-house specialists. Their in-house roles entailed building their staff, conducting the preliminary in-house testing of products for early-stage development, and occasionally vying with market researchers. Furthermore, food research done by the in-house specialists moved away from representative consumer panelists, which was left to the market research world. The strategy moved the sensory world away from consumer research, toward a focus on execution rather than on business problem-solving.

At the same time, market researchers, focusing as they did on consumer responses, began to recognize the value of psychophysics, not so much as a science but rather as a tool by which to design products. In the world of consumers, marketing researchers already enjoyed a dramatic competitive advantage versus the sensory professional. They did not experience the existential crisis facing the sensory world, namely, the prospect of abandoning one's expertise (descriptive analysis) for another world view (product design). Rather, the problem faced by market researchers was to understand how these new methods, collectively called RSM, response surface methods, could improve what the researcher was already doing, namely, testing one or two products with consumers in order to drive market success.

Some original work had been done in the early 1970s with the sensory professionals at Fermco Biochemics, Inc., on the sweetness and likeability of mixtures of aspartame, cyclamate, and saccharin in a cola beverage, the aforementioned study (Moskowitz et al. 1979.)

The 1970s witnessed the beginning of a three-decade use of large-scale studies to design new food products. These studies involved products as varied as Pizza Hut pizzas (traditional, pan), General Food's Maxwell House Coffee (both roast and ground and instant), Tropicana's Grovestand® Orange Juice, Vlasic's Zesty Pickle®, and indeed the full range of pickles (from level 1–4), Campbell Soup's Prego® (pasta sauce), Campbell Chicken Soup®, Hormel Food's Spam®, Oscar Mayer low fat deli meats, and Diet Dr. Pepper Cherry®, a carbonated beverage.

Reading the above, one might get the impression that the world of the 1970s to about 2010 was open to these new methods of experimental design. The answer is a definite yes as well as a definite no. Several large-scale RSM studies run to optimize products, generated new products, and in some cases major new business opportunities. But the story is more complex. The studies were funded by top management, usually requested either by marketing research convincing R&D or by R&D product development requesting the opportunity to try these new approaches to create products.

The Zeitgeist of the 1970s: Openness and Optimism

Now that we have heard about the actual experience, the interesting things to share are the “why” and the “what” or why did the Zeitgeist encourage or perhaps better, allow, these studies, and what did these studies comprise?

The Zeitgeist of the 1970s was one of optimism. The Vietnam War was finishing, computers were coming on the scene with the first microcomputers to appear in 1976, and many of the top managers in companies realized that the next decade would see more competitors arise to grab revenues and share. Added to that was the generation of young, better educated top managers, and a few middle-managers as well.

Food design in the 1970s might be summarized as optimistic, characterized by open competition, bubbling up with technology that could be used after a short stint of studying, and perhaps most important, an openness to exploration. The business climate was such that the market research suppliers were able to meet with clients and with top management, to present the latter with their arguments about why these new RSM methods, and multiple products were a good thing to try. The deadening effort of preferred supplier contracts “*uber alles*” had not yet taken hold, to destroy the spirit of exploration. In short, people were open to ideas, not wedded to control through process.

What Was and Remains Involved in the RSM Effort

One cannot disguise the reality that creating an array of systematically varied products according to an experimental design demands concentration, resources, and hope. Marketing management must restrain its desire for “quick” hits. Product developers must accept the job of making products, even if in the heart they just “know” from experience that some prototypes in the design will be no good and must stop themselves from rejecting the efforts by their complaints that it is a waste of time and effort to create prototypes which are clearly going to score poorly in a test.

In the end, RSM dictated that the developer should create as few as 6–8 prototypes to as many as 45 or more. The effort takes time and resources, but enlightened management accepted the necessity of disciplined effort. Once the prototypes were developed, it was a matter of testing the products among consumers, a task that turned into a modest extension of what was already being done.

Unexpected Benefits from RSM: Sensory Preference Segmentation and Cost-Based Optimizations

Although the skeptic might criticize what would become relatively high expenses for these tests compared to the in-house preference tests with employees or compared to the competitively bid preference tests or acceptance tests run by market researchers, the outcomes of these large-scale RSM studies proved to the management how valuable the results were in terms of business. In fact, the success of corporations, especially the Campbell Soup Company and Prego, led to one of the most popular TED talks, that was given by Malcolm Gladwell. The talk was a first, celebrating the marriage of psychophysical thinking, product design, and corporate vision, and was repeated and updated 8 years later (Gladwell 2012).

We can enumerate at least three different uses and thus business benefits of the RSM data, beyond simply getting the single best product. These different benefits, often ignored today in the haste to launch, and in the slavery of timelines and budgets, have provided corporations with decades of revenue and powerful business intelligence.

1. *Sensory preference segmentation.* We know that people vary. As noted above, the sensory specialist involved in training descriptive panels ignored this issue as simply not relevant. The conventional market researcher, working in the world of paired preference tests or even single product tests (so-called pure monadic tests) treated the variability as interesting, not as a something relevant directly to business but an "insight," something to include in the report and perhaps some signal of "something going on that could be understood." In other words, no one knew what to do with the variability.

   Psychophysicists had also found individual variability in what people liked, and in fact when one instructed the respondent to rate the "liking" of a set of sugar solutions of different concentrations presented in irregular order, the results looked like the modal curve in the left panel of Fig. 2. The modal curve may have been an average curve, but it was hiding a very important message from nature. It quickly became obvious that people were different in a consistent manner. Some people liked increasing concentrations of sugar water, i.e., they preferred higher sweetness. Others preferred lower concentrations of sugar water, i.e., they preferred lower sweetness. These individual differences appeared to be systematic in the context of the evaluation of an array of different products. When the results from RSM were analyzed to reveal different groups of consumers with clearly different sensory preferences in actual foods, the newly revealed, now intuitively so clearly obvious, drove the development of profitable new lines of related products in the same, in order to satisfy the preferences of the different taste-preference segments.

2. *Optimizing products subject to imposed constraints*. Experimental designs allow the research to create equations relating the ingredients to acceptance, to sensory

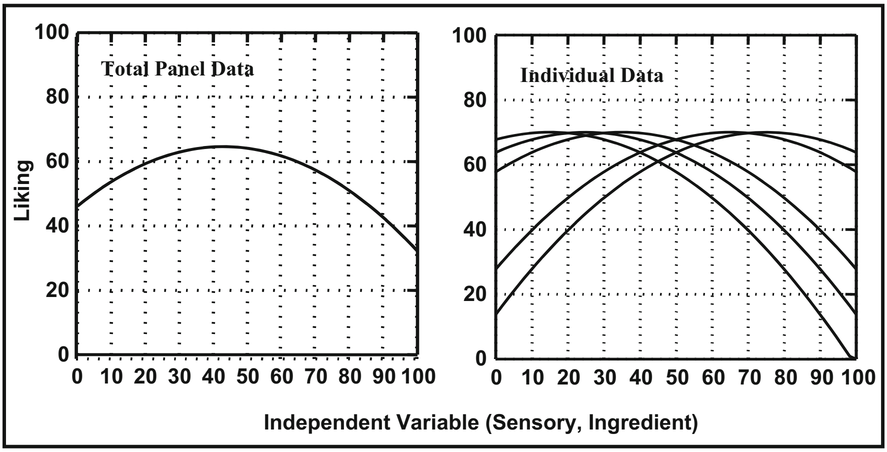


Fig. 2 Sensory-liking curves. The figure shows the typical sensory-liking curve with a single optimum (so-called bliss point), obtained from averaging the results from the total panel (left figure), and the underlying set of sensory-liking curves, one per respondent, which combine to generate the total panel data (right figure)

perceptions, to objective measures (e.g., calories, nutrition), and even to image attributes that one does not ordinary think of as sensory or liking attributes, e.g., "perceived healthfulness." Table 1 shows a large-scale experimental design, used to deal with solving the conundrum of how the company could discover a mixture of ingredients, so that the addition of that mixture to a flagship product allowed it to reduce salt in the product. By using various ingredients, combined by design using RSM, the company could empirically develop the necessary knowledge to reduce the sodium content to the desired level, and yet maintain product acceptability. Such efforts generated many different in-market products, such as orange juice, pizza, coffee, and others mentioned above.

Creating the experimental design and developing products are followed by the evaluation of the prototypes, then the creation of equations relating the ingredients, and combinations of ingredients to each of the ratings, and physical measures (e.g., Na level.) The corporate effort to create the prototypes and test these prototypes with relatively few respondents per prototype (e.g., 300 respondents, each tasting five to eight samples) generates the necessary data.

The equations enable the product designer to identify the precise combination of ingredients which satisfy specific objectives, even when the actual combination of ingredients had not been directly tested but lies within the range of ingredients covered by the prototype. The approach is described extensively in Moskowitz (1994).

Table 2 shows the estimated formulation for four products, with formula levels constrained to lie within the range tested of the six ingredients. The estimated

Table 1 The large-scale experimental design, used to explore 29 alternative formulations of an ingredient to enable the reduction of sodium in a corporation's flagship product

PROD	A	B	C	D	E	F
1	H	H	H	H	H	H
2	H	H	H	L	H	L
3	H	H	L	H	L	L
4	H	H	L	L	L	H
5	H	L	H	H	L	L
6	H	L	H	L	L	H
7	H	L	L	H	H	H
8	H	L	L	L	H	L
9	L	H	H	H	L	H
10	L	H	H	L	L	L
11	L	H	L	H	H	L
12	L	H	L	L	H	H
13	L	L	H	H	H	L
14	L	L	H	L	H	H
15	L	L	L	H	L	H
16	L	L	L	L	L	L
17	H	M	M	M	M	M
18	L	M	M	M	M	M
19	M	H	M	M	M	M
20	M	L	M	M	M	M
21	M	M	H	M	M	M
22	M	M	L	M	M	M
23	M	M	M	H	M	M
24	M	M	M	L	M	M
25	M	M	M	M	H	M
26	M	M	M	M	L	M
27	M	M	M	M	M	H
28	M	M	M	M	M	L
29	M	M	M	M	M	M

formulations were required to obey imposed constraint(s), on the objective amount of sodium (Na), and the estimated subjective ratings, respectively.

3. *Reverse engineering*. The RSM approach enables the product designer and developer to specify a sensory and/or objective profile (e.g., profile of physical measures) and, in turn, identify the approximate formulation which will generate the desired sensory profile as closely as possible. At the same time, the independent variables and the dependent variables must all lie within imposed constraints. The imposed constraint may be simply the levels achieved in the study (e.g., low versus high ingredient level for ingredients or low versus high sensory levels achieved in the study.) The imposed constraint may be more demanding, such as duplicating a sensory profile or objective profile, remaining within the

Table 2 Estimated formulations for four products, specified in terms of being forced to lie within the range tested of the six ingredients and forced to obey imposed constraint(s), on the objective amount of sodium (Na) and/or the subjective ratings

Optimize the liking for: total panel subject to these constraints				
Constraint # 1 – objective	None	Na < 150	Na < 200	Na < 175
Constraint # 2 – subjective	None	None	None	Flavor > 63
Ingredient				
Ingredient # 1	1.3	1.0	1.3	1.1
Ingredient # 2	0.3	0.3	0.3	0.2
Ingredient # 3	2.0	1.2	1.8	1.0
Ingredient # 4	2.0	0.0	0.0	0.0
Ingredient # 5	2.6	2.2	2.2	2.6
Ingredient # 6	3.0	1.7	2.4	3.0
Estimated profile of products				
Na level	286	149	199	174
Rated – liking	73	69	70	65
Rated – Amt solids	76	68	73	77
Rated – like flavor	67	58	64	63
Rated – flavor intensity	63	69	69	67
Rated – saltiness	57	52	55	53
Rated spiciness	45	45	45	48

limits of the independent variables (ingredients) already tested but achieving some predetermined benchmark, such as a basic, high level of acceptance.

The approach, reverse engineering, was suggested by the author as a cost-efficient, rapid, evidenced-based method to translate an "image" profile into an ingredient profile, without need to profoundly understand the product from years of prior experience (Moskowitz 1994). Image profiles might be complicated attributes with specific levels for the rating of "for adults," "for evening," and "seems expensive," respectively. These three attributes (adult, evening, expensive) are neither sensory attributes nor evaluative, liking or purchase attributes. They are something else, a new type of description. Yet, they can be incorporated into the RSM study, optimized, and reverse engineered, respectively.

In some cases, the reverse engineering approach revealed that the self-profiled ideal or the product with so-called perfect JAR scores (i.e., just about right on everything) did not produce the desired, optimal products (author's observations). The experimental design comprised the necessary array of prototypes to create the model. The respondents rated the products both on JAR scales for specific sensory attributes. The respondents also rated the desired "ideal product" on the same scale that they used to profile the products. A product configured to produce the self-designed ideal or a product configured to produce JAR values close to 0 did not end up being the optimal product (Moskowitz 2001), although one might think so from the very simplicity and directness of the experiment (Moskowitz 1972) (Table 3).

Table 3 Estimated formulations, liking, sensory profile, and Na level for a product specified in terms of a goal sensory profile to be matched

A Ingredient Profile	Low	High	Estimated
Ingredient # 1	1	3	2.3
Ingredient # 2	1	3	2.1
Ingredient # 3	1	3	1.7
Ingredient # 4	1	3	3.0
Ingredient # 5	1	3	2.6
Ingredient # 6	1	3	1.9
B goal sensory profile	Goal	Weight	Estimated
Flavor intensity	60	1	63
Saltiness	60	1	56
Spiciness	50	1	45
C imposed constraints			Estimated
Na < 2.7			2.7
Overall liking >65			65
D estimated liking			Estimated
Liking – Overall			65
Liking – Appearance			63
Like – flavor			62

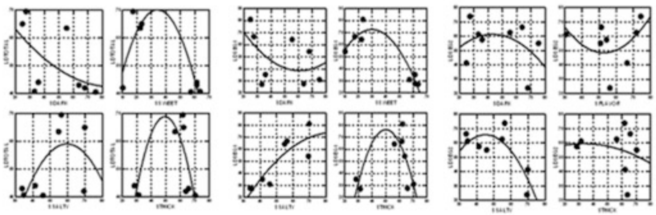
The Industry Pivots to Efficient Designs

The early 1990s witnessed the proliferation of personal computers, the increasing sophistication of company employees, and also a fight between the corporate staff and the increasingly powerful purchasing department. These developments would wreak havoc on the development of smarter, more effective product design. Companies would become more focused on survival in an increasingly competitive environment, where knowledge was created and deployed increasingly faster. To maintain corporate stock prices, most visible and funded efforts focused on cutting costs. Perhaps the most devastating effect was actions of the corporate-purchasing departments, which in their attempt to cut costs insisted on standardizing consumer measurements, limiting knowledge about markets and consumers to a few "approved" vendors.

The immediate effects of these corporate changes were to reduce almost all efforts in product design to small, easy-to-run, inexpensive studies. The foundational studies which ended up making hundreds of millions of dollars, and even in some cases more, were abandoned in favor of so-called beauty contests, to pick the "best performer" from a set of competitors. Optimization turned into these beauty contests, so that when one "optimized" a product, one simply picked the best from a set of candidates, rather than synthesizing the best product using an underlying model embedding one's knowledge.

Product	A	B	C	D	E	F	G	H
Ingredients								
IngA	1	1	1	1	0	0	0	0
IngB	1	1	0	0	1	1	0	0
IngC	1	0	1	0	1	0	1	0
IngD	1	1	0	0	0	0	1	1
Average Overall Liking (Total & Two Segments)								
LD Total	43	41	70	65	44	41	64	42
LD Seg1	28	31	67	81	35	27	64	54
LD Seg2	66	55	74	41	58	61	63	24
Average Attribute Likings from Total Panel								
LD Appear	56	45	73	76	54	48	54	48
LD Taste	40	41	67	65	47	46	58	48
LD Mfeel	50	35	66	77	49	50	60	50
Average Sensory Ratings from Total Panel								
S Dark	64	76	28	25	36	33	56	68
S Aroma	61	51	58	39	52	48	50	51
S Sweet	62	58	18	24	62	64	23	11
S Salty	34	46	57	70	42	35	55	70
S Flavor	52	51	75	67	55	31	72	57
S Taste	43	59	41	41	57	36	41	35
S Thick	66	71	62	63	29	32	57	64
Location of the Eight Prototypes on Sensory Factors								
F1	0.7	0.4	-0.8	-1.0	1.1	1.3	-0.7	-1.0
F2	1.3	1.4	0.0	-1.2	-0.6	-1.3	0.1	0.3

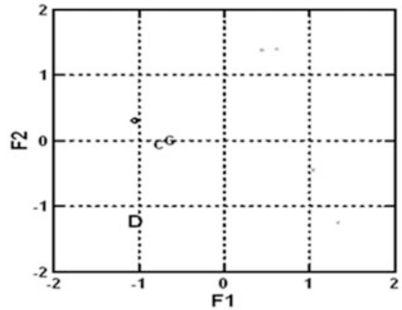
1. Input Data



2. Sensory – Liking Curves, Total & Segments

	Const	INGA	INGB	INGC	INGD
Overall Liking					
LD Total	56	7	-18	8	-8
LD Seg1	67	6	-36	0	-8
LD Seg2	40	8	10	20	-7
Attribute Liking					
LD Appearance	60	12	-12	5	-12
LD Taset	61	3	-16	3	-10
LD Offtaste	54	1	-13	-1	-2
LD Mouthfeel	65	5	-17	3	-12
Sensory					
S Dark	29	0	8	-5	35
S Aroma	43	2	3	8	3
S Sweet	19	0	43	2	-4
S Salty	66	1	-24	-8	0
S Flavor	57	7	-20	12	1
S Thick	44	20	-12	-4	18

3. Models



4. Factor Plot – Segment 2

Fig. 3 (continued)

Smaller Experiments, Agile Thinking

In 2014 the author was invited to participate in a panel on creating healthier products. The request was to present to the audience a feasible method for improving the chances of product success, based upon experimental design. The key was "feasible." The invitation in 2014 was extended during the retrenchment of corporate efforts. The rationale for the invitation was that a few professionals recognized the need for more effective product design which would create products that people wanted, rather than just products introduced by nervous marketers as a knee-jerk reaction to the action of competitors which had just a new entry into the market.

It was at the 2014 IFT meeting on health, held in the winter in Chicago, that the author suggested a new version of experimental design, requiring exactly 8 prototypes and 25 respondents who would test all prototypes in a random order, rating each prototype on a battery of up to 20 attributes (see Fig. 3, Panel 1, Input Data). These rating attributes would comprise a key evaluative criterion (e.g., overall liking), sensory attributes (strength of an attribute such as sweetness), liking attributes (liking of the attribute, e.g., liking of texture), and "image attributes" (more complex attribute such as perceived healthfulness or perceived caloric density, etc.). The actual work for developing the paradigm had begun in 2007, but the nature of the scientific and business communities was such that the relevance of *accurate, affordable, fast* was only really accepted at the start of the second decade of the twenty-first century.

The process appears in Fig. 3, which provides a sense of the data inputs and the key analyses:

1. Section 1 shows part of the data table, revealing the eight prototypes, the formulations assuming that we are working with four variables (A, B, C, $D = A \times B$), 25 respondents who evaluated each of the prototypes on liking, and sensory attributes. Section 1 also shows the results from two sensory preference segments, emerging from clustering the 25 respondents based on the patterns of ingredients which drive the rating of overall liking.
2. Section 2 shows how two sensory attributes "drive" the key evaluative criterion of overall liking, for both the total panel of 25 respondents, and for the two sensory preference segments, respectively.
3. Section 3 shows how the ratings can be deconstructed into the contributions of the independent variables. In our case we are dealing with four independent

Fig. 3 The rapid development approach, limited to 3–7 variables, each tested at two levels, eight prototypes, 25 respondents, with each respondent evaluating every one of the eight prototypes. The figure shows the process from (1) data input (summarized across respondents), to (2) schematic curves showing how sensory attributes drive liking for total and for segments, to (3) models showing how the ingredients drive liking and sensory perceptions, and finally (4) a map of the products for Segment 2, with the size of the letter proportional to the degree of liking assigned by Segment 2 to the particular prototype variables, A, B, C, and D, respectively. The additive constant corresponds to the product defined as all four independent variables set to option 0. Thus, Section 3 shows how the change from option 0 to option 1 "drives" the ratings.

4. Section 4 shows a two-dimensional map. The coordinates of the map are created from the first two factors of the sensory attributes. These factors can be thought of as sensory primaries, although they are of purely mathematical nature. The factors are orthogonal to each other, meaning that they are statistically independent of each other. The factors are estimated after the structure is rotated according to a criterion which makes the solution simple to understand. The convention is a quartimax rotation, but any other rotation will do. Finally, the products can be embedded in this map because each product has two coordinates, for Factor A and for Factor B, respectively. The size of the letters corresponds to the degree of liking of the product. We see the map for Segment 2. The objective of the mapping is to identify the "white space," defined as areas near high levels of liking for the segment but not occupied by a product. The actual mapping exercise generates three maps, one for Total Panel, and one map each for Segment 1 and for Segment 2, respectively. The actual mechanics of the mapping are easier to do with standard statistical programs currently available.

The foregoing approach is certainly small, agile, fast, and cost-effective. It represents a different way of thinking, one more appropriate to the realities which are emerging during the latter part of the second decade of this twenty-first century. The old adage "the perfect is the enemy of the good" has never been truer:

1. *Cost-effective "good" is better than expensive "perfect."* In the interests of project costs, give valuable data, always keeping budget in mind. Appropriate sampling is important but not as important as speed and quality of results. The result of today's emphasis on speed is that companies are forced to accept convenience samples for product testing. Thus, the approach we provide uses convenience samples, not so much to identify the best product, as to identify the best formulation areas, and the nature of the segments. To get a "sense" of what's important, the convenience sample is adequate. This sense of what's important is to guide product developers.
2. *Better is "good."* With one product to test, the researcher either must have remarkable insight about what to recommend or be able to skirt the issue. On the other hand, with eight products, systematically varied, the likelihood is much higher that some of the products will be either good or point the way to "better."
3. *Fast is good.* Speed has never been more important. There is a business adage that it is better to be 80% right and on time than 100% right but late. With the proliferation of computers, artificial intelligence, and do it yourself research, the demands for speed ever increase. What was acceptable a decade ago seems interminably slow. Tomorrow is no excuse. Now is the new "on time." Furthermore, being able to do a study of this type on a weekly basis ensures that the product designer/developer will quickly discover the "right product" or, sadly, discover that there is no "right product." Discovering that it's impossible to do what is requested is as valuable as actually doing what is requested.

The Migration of Systematic Thinking to the Up-Front Design of Ideas

No history of product design can leave out the important topic of design through product description, also known as concept testing and concept optimization. The foregoing history presented the tapestry of product design through the creation of actual designs, the more traditional history to which product designers and developers are accustomed. Product design through description, so-called promise testing, concept testing, and concept optimization, share in this history, but in comparison to the foregoing efforts with actual products, the history of design through description is shorter and far less a history of competing ideas and world views. Our treatment of design at the concept level will not require much space, simply because it has not emerged in a tortured way out of competing histories, nor out of competing groups in the corporation (Moskowitz et al. 2008.)

Promise Testing and Concept Testing

Our short history begins with the evaluation of needs and opportunities. Whether the evaluation was/is formal or informal, the process is pretty much the same. Ideas emerge, whether these ideas deal with the product features, the product benefits to the user, the nature of how the product is purchased, stored, prepared, and so forth. The ideas can even touch upon reasons to buy, generating marketing-oriented rather than design-and-development-oriented ideas.

These ideas are scored, either internally or externally, to provide a set of resource material. From the ratings of these different ideas, so-called promise testing two streams flow. The first is a product concept; the second is a prototype. Both the concept and the prototypes may be created by the same group, R&D, or the product concept may be created by the marketers and delivered to the R&D developers, who put the prototype(s) together, based upon the concept. The path of concept and prototype may be intimately linked through the process or may proceed separately until a final concept/product test is done. That final test measures how well does the product perform, as well as how the product fits the concept or the concept fit the product.

Whether the product developer should work from the specifications provided by the concept or the marketer should work from the product created by developer's best efforts remains a bone of contention in corporations. The traditional approach follows the typical sequence of marketing dictating to developers, but sometimes the developers themselves are far better about sensing the aspects of a "great product," leaving the marketing to describe and market the "newer and better product."

Often the promise tests (also called idea screening), whether done formally or informally, lead quickly to the creation of full test concepts. These concepts are descriptions of products. They may be simple phrases (Fig. 4a) or a densely written paragraph (Fig. 4b).

a

Now you can savor the delicious taste of homemade treats anytime, with new Orchard Desserts.

Orchard Desserts combines real fruit with a crumb topping for a homemade taste.

Simply pop one in the microwave for a tasty, warm, treat anytime.

Choose from three deliciously distinctive varieties: Cranberry, Apple, or Blueberry.

Comes in a package of three convenient 4 oz. portions for $2.39

b

Introducing ***Orchard Desserts...***

Now you can savor the taste of homemade treats anytime!

There's nothing quite like the satisfying taste of homemade snacks and desserts. But sometimes it's hard to find the time to make them. Now you can savor the delicious taste of homemade treats anytime, with new Orchard Desserts.

Orchard Desserts combines real fruit with a crumb topping for a homemade taste. Just sprinkle the crumb topping over the fruit and enjoy. Simply pop one in the microwave for a tasty, warm treat anytime. And because they don't need to be refrigerated they are great for on-the-go.

Choose from three deliciously distinctive varieties: Cranberry, Apple, or Blueberry.

Comes in a package of three convenient 4 oz. portions for $2.39

Fig. 4 (**a**): Example of a concept comprising a simple set of phrases, stacked one atop the other. The respondent reads the concept as a totality and rates the concept on a set of scales. This type of concept format is often used to guide developers, because they need to know what parts of the concept (i.e., product description) are acceptable, and what parts are not, and need to be changed. (**b**): Example of a densely worded concept. This type of concept is often tested by marketing research, primarily to determine the likelihood of product success in the marketplace

The analysis of responses to concepts is usually done by calculating the percent of the respondents who assigned a specific rating denoting high acceptance. For example, one of the most popular ways to identify what a good product idea might be instructs respondents to rate the likelihood of purchase using an anchored five-point scale, with the key evaluative criterion being the percent of respondent who assign a purchase intent rating of either 5 (definitely would purchase) or 4 (probably would purchase). The full scale ranges from 1 (definitely not purchase) to 3 (might/might not purchase) to 5 (definitely purchase). To get a sense of the promise of the product from the concept scores, the researcher compares the distribution of ratings assigned to the test concepts again the distribution of other products, whose market history is known. This comparison allows an estimate of the potential for business success, based upon the previous data, so-called “norms.”

The rating scale need not be a 1–5 scale but might be a scale of value, e.g., select the dollar value that would be appropriate for the product described in the vignette. The respondent would select a dollar value from an array of different dollar values, with these dollar values presented in irregular order. Instead of a value for purchase intent or liking, the respondent assigns a “fair economic value” to the concept.

Experimentally Designed Concepts

We finish this chapter with the use of experimental design, this time to create product ideas rather than to create product prototypes. The method uses the group of research approaches known as conjoint measurement (Moskowitz et al. 2008). In simple terms, the researcher identifies the general features of the products (called variables or silos) and the options or alternatives of each feature (called level or element). Coming up with the variables and levels can be done either by marketing or by R&D.

There are many different experimental designs that one can use. The common feature is that the experimental design mixes and matches the elements, creating different combinations, to produce a variety of product descriptions. The respondent inspects each combination as a new product idea and rates interest or some other evaluative rating. In some newly emerging efforts, the respondent might inspect the combination, rating it on price the respondent would pay, or selecting an end use from a set of different uses, or selecting a feeling or emotion from a list of different feelings.

The analysis proceeds in a straightforward manner, much in the same way as the analysis of the products in Fig. 3, Section 1. The experimental design defines the different combinations or concepts. The experimental design may be one of several types, with the proviso that the elements or messages of the concept are presented in a way that makes the elements statistically independent of each other. This statistical property of independence results from the ability to create concepts which have “true zeros.” The true zero is the total absence of any element from a variable (e.g., message about taste or message about ingredient). The experimental design allows for “true zeros,” namely, that in the test combination an entire variable or silo might be absent. It makes no difference to the respondent, who simply proceeds, giving a “gut reaction.” The analysis uses ordinary least-square regression analysis to relate the presence/absence of each element to the rating of purchase intent, price, or the selection of an emotion or an end use.

There are a variety of alternative ways to set up the design. In the end, however, what is desired is simply the decomposition of the response to the combinations (test

Table 4 Dollar values of different elements for yogurt. The data suggest three different mind-sets and direction for the product designer to go after one, two, or even three different target groups

		Total	Mind-set 1 health	Mind-set 2 sensory	Mind-set 3 science
	Base size	312	128	52	132
	Mind-set 1 – health oriented				
F5	Dairy from organic farmers. They keep their livestock healthy and don't use antibiotics or synthetic hormones	2.52	**2.81**	2.22	2.36
F4	Probiotics (good bacteria) added to dairy drinks (drinkable yogurt, acidophilus milk, or kefir, etc.) are good for your immune system	**2.46**	**2.79**	2.22	2.24
F3	No added sugar like fructose corn syrup or cane sugar – only naturally occurring sugar (lactose)	2.19	**2.58**	1.87	1.94
B1	Provides essential vitamins (A, B12, C, and E) and minerals (potassium, magnesium, and zinc) your body needs	**2.44**	**2.55**	1.61	**2.66**
F6	A treat that is lactose free. Easy to digest, so you can enjoy it carefree	2.04	**2.51**	2.02	1.58
B3	With soy isoflavones. Shown to moderate symptoms of menopause and decrease bone loss	2.34	**2.46**	1.46	**2.57**
B4	Contains the essential nutrient choline. Shown to improve memory and learning	2.28	**2.45**	1.29	**2.51**
B5	Contains essential omega-3 fatty acids, which may reduce your risk of heart disease	2.29	**2.44**	1.61	**2.40**
B2	With inulin. . .known to improve calcium absorption and digestive system balance	2.26	**2.37**	1.53	**2.44**
F2	Made with fresh whole milk	2.03	**2.36**	1.71	1.84
	Mind-set 2 – sensory oriented				
A4	Thick with lots of real fruit blended in	2.24	1.86	**2.70**	**2.44**
A2	Has a refreshing, silky-smooth taste that surprises you with each sip	2.10	1.85	**2.64**	2.13
D6	Recommended by doctors, nutritionists, and dietitians	2.08	2.03	**2.53**	1.94
A1	Available in delicious fruit flavors like raspberry, strawberry, banana, blueberry, pineapple, and papaya	2.31	1.83	**2.49**	**2.70**
A6	Easy to swallow. Even little kids won't have trouble	2.02	1.66	**2.44**	2.22
C6	Pleases your stomach and mind. Worth taking a break for	2.01	1.67	**2.42**	2.18
A3	Wholesome goodness you can see. Seeing is believing	2.06	1.62	**2.39**	**2.35**

(continued)

Table 4 (continued)

		Total	Mind-set 1 health	Mind-set 2 sensory	Mind-set 3 science
	Mind-set 3 – science and nutrition				
C3	Satisfy your hunger this time in a healthy way	2.19	1.69	2.12	**2.70**
C1	All-natural ingredients. A food that's good for your whole family	2.02	1.69	1.99	**2.36**

product ideas) to the part-worth contribution of each idea, each level. From that, one can identify mind-sets (people who respond to different aspects of the product) and can synthesize new-to-the-world combinations of elements or features, satisfying different, marketing-imposed or technology-imposed constraints.

Let us finish this discussion by considering a study of yogurt, whose results are shown in Table 4. The respondents evaluated a set of 48 vignettes or test concepts, created by experimental design, rating each test concept by selecting a dollar value believed to be appropriate. Table 4 shows the results of deconstructing the experimentally designed concepts for yogurt into the dollar values of the different elements.

The product design can now look at the data, either for the total panel of 312 respondents or at subgroups of respondents whose data (dollar values for specific elements) suggest that they attend to different types of elements in the concept. There are respondents who value health, versus respondents who value sensory pleasure, versus respondents who evaluate science. From these groups, the product designer can identify the nature of the product to appeal to each mind-set. The next step consists of translating the winning ideas into actual prototypes.

Conclusion: Where Have We Been, and Where Are We Heading?

Ask a nontechnical person, someone not in the food or beverage industry, how products are designed, one is likely to get a stare of incomprehensibility. To the ordinary consumer "out there" in the population, there is no notion of how products are designed, at least not food products. The same person might have a mental "model" of how cars or electronics are designed, because the media often features a "look behind the product."

We have summarized a century of design in two chapters (also see ► Chap. 1, "The Origin and Evolution of Human-Centered Food Product Research" by Moskowitz and Meiselman in this volume). The upshot is that we have progressed from a quick "cook and look" in the early days to the involvement of professionals; these professionals spanning a range from culinary professionals to statisticians to sensory specialists and market researchers. In a phrase, we have almost the entire corporate "kitchen sink" involved in design, in one way or another.

With all these people involved, one might expect that the odds of a product being successful in the market would be very high. Yet, high failure rates continue to plague the food industry, with numbers above 50% and often far higher bandied about. We would not accept a washing machine with such a failure rate and certainly not an automobile. Any lawyer or doctor who suffers from such a failure rate for "ordinary clients" would probably be hounded out of the profession, accused of malpractice.

The question then is why the failure and where are we heading in the world of product design? As of this writing, 2019, the tools are in place for increased success in product design. The procedures for testing are efficient after more than 60 years of experience by corporate researchers as well as by contract testing services. Segmentation to open new opportunities now enjoys almost 35 years of scientific and business acceptance. Thus, all the "pieces are in place."

What is needed now is the willingness to bring product design to the next level, to treat design as one treats architecture, whether of a house or of a computer chip. That is, the time has come in product design to move beyond the ever-so-attractive "cook and look," limited to the creative mind of the developers and marketers. The time has come to institute formal experimental design, simple, inexpensive but powerful research with the focus on the patterns of acceptance created by an array of related products and no longer to rely on the clever, intuitive, insightful researcher whose job is to "connect the dots" and weave together a "story." We need fewer dots, fewer stories, and in simple terms, more structure, more books of systematized results that can be used again and again to guide development. Science and foundational research should guide us about what to change and how to change the features of products and, in turn, tell us ahead of time what to expect. Testing should confirm the up-front, foundational design "driving" the in-going design, and not end up providing data which needs a storyteller and a story to render the results coherent and compelling to management.

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Human Experience of Eating and Drinking: Perspectives on 50 Years of Measurement Progress

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Contents

Abstract

Major historical trends in the evolution of the measurement of human eating and drinking experiences during the past 50 years are presented. Highlights of progress are summarized from the perspectives of (1) *who* is the focus of measurement, (2) *what* is being measured, (3) *how* we quantify eating and drinking experience, and (4) *where* or under *what conditions* the measurements of eating and drinking take place. Among the major trends highlighted are the shift from trained to consumer panelists; the shift from obtaining simple sensory, liking, and/or hunger/satiety judgments to the measurement of a much wider array of human experiences; the expansion and, perhaps, retraction from advanced scaling measures to simple "indicators" of sensory and hedonic

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intensity; and improvements in the number and variety of situations and contexts in which the measurement of eating and drinking takes place. The goal of these perspectives is to inform the reader about both progress in the field and challenges that remain in the study of human eating and drinking experience.

Keywords

Eating · Drinking · Measurement · Scaling · Consumers · Liking · Context · History

Introduction

The measurement of human eating and drinking experience has evolved along concurrent but separate paths, intersecting at critical points in time to produce the current state of the science. From a disciplinary perspective, the oldest path arose out of psychology, including both the subfield devoted to measuring human experience, i.e., sensory psychology/psychophysics, and the subfield devoted to the study of appetite and eating behavior. A separate pathway evolved somewhat later within food science, focusing on the practical evaluation of the sensory properties of foods and beverages. This chapter will offer some perspectives on the important trends in the evolution of the measurement of eating and drinking experience over the past half century.

Since historical perspectives are predicated on a time origin and on one's personal experiences, it can be noted that those presented here reflect changes in the field since the writer entered Dartmouth College as an undergraduate psychology major in 1967. At that time, the zeitgeist in psychology was behaviorism, and, in psychophysics, it was S. S. Stevens' operational measurement using ratio scaling methods. In the author's view, both were critical approaches for understanding human behavior and how people perceive the world. Following a Ph.D. in taste psychophysics, a research position at Natick Army Labs followed, where it was fortuitous that several other luminaries in the fields of psychophysics and eating and drinking were on staff. Among these scientists were Dr. Herbert Meiselman, Dr. Harry Jacobs, and Dr. Owen Maller. What was learned from this tutelage and the subsequent experiences and collaborations with these and other prominent scientists who came to Natick on sabbaticals during the next 45 years, were critical in shaping the perspectives that follow.

Organization of the Chapter

The historical trends presented here are divided into four topical areas that are critical to any measurement process. These are (1) *who* is the focus of measurement, (2) *what* is measured, (3) *how* the measurement is made, and (4) *where* or under *what conditions* the measurements are made. The coverage of these topics is not meant to be comprehensive, insofar as that would require several volumes. Rather, the coverage is specific to the areas of human eating and drinking that are commonly investigated as part of sensory psychology, psychophysics, and sensory evaluation.

Who Does the Measurement of Eating and Drinking Experience?

From Machines, Experts, and Trained Panels to Consumers

As noted in the opening paragraph, in the 1960s the study of foods and of eating and drinking experience was fractured into disciplinary areas. One focused on the study of sensory responses to basic taste, smell, visual, auditory, and tactile stimuli, typically using naïve subjects (mostly college students) and most often conducted by psychologists working in academia. Allied with this group of chemosensory scientists was another group of appetite and food intake psychologists interested in consumption and eating behavior, who also used naïve subjects to judge palatability (pleasantness/liking), hunger, satiety, and/or the desire to consume foods and beverages. A third group was comprised of food scientists working in industry, government, and academia who were focused on the study of the quality and sensory properties of foods and beverages, commonly using commodity experts and trained panelists.

As noted above, in food science, the characterization of the quality and sensory properties of foods was done either by experts working in specific commodity areas or by trained sensory panelists using descriptive profiling techniques (Cairncross and Sjostrom 1950), such as the Arthur D. Little (ADL) Flavor Profile method (Caul et al. 1958). The use of naïve consumers was reserved for *food preference testing*, where they were deployed to make preference judgments or to judge their liking/disliking of foods and beverages. However, even this limited use of consumers was considered a “recent development” in 1965 (Amerine et al. 1965, pp. 398). The use of consumers to judge *sensory attributes* was simply never done, because of variability in their responses and their lack of knowledge and sophistication in the use of descriptive sensory terminology.

The ADL method was soon followed by other profiling techniques, all of which were based on the use of panelists who were “trained” to varying degrees in both attribute definition and in the assignment of intensity scores, using physical reference standards, e.g., the Texture Profile method (Brandt et al. 1963), Qualitative Descriptive Analysis (QDA) (Stone et al. 1974), the Spectrum method (Meilgaard et al. 1991), and Quantitative Flavor Profiling (Stampanoni 1993). The reader is referred to Murray et al. (2001) and Heymann et al. (2014) for reviews of these and other descriptive profile methods.

In contrast to the above, most psychologists of the time considered the characterization of sensory or evaluative aspects of stimulus objects (foods/beverages) by observers trained in how the attributes were to be judged, how to assign intensity judgments, or what “good quality” meant, to be a biased approach. Foremost among the reasons cited was that such judgments are simply not representative of those of naïve observers (consumers) for whom the products were being developed. The argument of food scientists that training reduced the variability among panelists to the point that the panel operated “like an instrument” was viewed as hyperbole, since the panelists were humans, and human perception is, by its nature, variable. In addition, the small number of panelists that were used in many profiling methods [as few as four were cited for use with the A. D. Little Flavor Profile method (Caul et al. 1958)] was not meaningfully representative of any target population. Although some sensory psychologists used small numbers of subjects, based on the facts that sensory phenomena are rooted in physiology and that neural mechanisms vary little within a species (observer bias, signal detection theory, ROC curves, and the like had yet to be popularized), these subjects were almost always naïve, and the broader field of general psychology typically used much larger numbers (35–100+) of naïve subjects to obtain data on sensory experiences, attitudes, and behavior.

The variability in human perception, even that of experts and trained panelists, led other food scientists to seek instrumental measures as a more reliable substitute for humans. This approach led to a wide variety of mechanical “texture analyzers,” “electronic noses,” and “electronic tongues” and, also, to a tendency to label the physical parameters obtained from these instruments with faux sensory terminology. For example, the General Foods Texturometer (Friedman et al. 1963) and similar (and more recent) mechanical texture analyzers refer to capturing texture “experience” and frequently use such words as *juiciness* to refer to the physical volume of moisture released from a test sample during compression or *chewiness* as a synonym for the total work required to break down the sample upon repeated compression. This approach of using machine parameters to substitute for human experience flies in the face of years of psychophysical research showing that subjective experience is not linearly related to underlying physical continua and that the validity of instrumental measures of sensory experience relies entirely on an associative relationship with human judgment. If one must obtain the latter to validate the former, why bother with the former? The answer often given is that physical measures are less variable. However, if variability is inherent in human experience, then logically any method that does not take into account this variability cannot be an accurate representation of human experience.

At about the time that the emphasis on trained panels and instrumental measures of sensory experiences was reaching its zenith in food science, a number of psychologists, e.g., Howard Moskowitz, a former Natick scientist, began regularly using naïve consumers to evaluate the sensory properties of food in order to optimize food products (see books by Moskowitz 1985 and Moskowitz et al. 2012 and ► Chaps. 1, “The Origin and Evolution of Human-Centered Food Product Research,” and ► 72, “Commercial Product Design: Psychophysics, Systematics, and Emerging Opportunities”). In 1982, Moskowitz and the writer collaborated with others on a study in which *both* a trained panel and a consumer panel was used to descriptively characterize the sensory texture of breads. The results showed that the two panels “differ(*ed*) quantitatively,” but that regression equations accounted for up to 99% of the variability between panels. It was concluded that “predictive relationships that take into account differences in perceptual ranges between the two groups are *possible*” (Cardello et al. 1982). This rather simple notion that data from consumer panelists could be predictively associated with and, perhaps, used instead of trained panel data to characterize the sensory properties of food was enough for the authors to be pilloried in a prominent sensory evaluation textbook of the time.

Unperturbed and confident that consumers could provide useful sensory profile data, the co-authors continued the use of consumers to generate sensory attribute data within their respective research programs. Not unexpectedly, 2 years later, Williams and Langron (1984) published the “free-choice profiling” method that used consumers to profile the sensory attributes of food products. This publication opened the flood gates for the use of consumers to provide sensory descriptive data about foods and other consumer products. Many years later, Worch et al. (2010) conducted a study reminiscent of the Cardello et al. (1982) panel comparison study, comparing sensory profiles from expert and consumer panels. They found that the two panels produced similar discrimination, consensus, and reproducibility and that the product spaces were highly similar. They concluded that “the use of consumers appears to be a good alternative to the classical sensory profile provided by a trained panel” (Worch et al. 2010). Of course, with the passage of 30 years, no outcry was heard from the former critics of using consumers to characterize the sensory experiences of eating and drinking.

Following the publication of William and Langon’s free-choice profiling method, other researchers began to employ naïve consumers to characterize foods and other aspects of eating and drinking experience, using such methods as repertory grid (Thomson and McEwan 1988) and free sorting (Lawless 1989). More recently, this trend has accelerated with the development of a variety of “alternative” or “rapid” sensory methods, e.g., flash profiling, ultraflash profiling, projective mapping/napping, sorted napping, ideal-point profiling, and polarized sensory positioning (see books by Varela and Ares (2014) and Delarue (2015) for details on these methods). The reader is also referred to the recent position paper and commentaries in Food Quality and Preference that address the relative merits of trained versus consumer sensory testing (Ares and Varela 2017a, b; Guerrero 2017; Moskowitz 2017; Labbe 2017; Stone 2017; Symoneaux 2017). Most recently, in a keynote speech to the global sensory community at the 2019 Pangborn Sensory Science Symposium, it was emphatically pronounced that the field of sensory evaluation has been transformed, from one that previously relied on the use of trained and expert panelists, to one focused on the consumer and his/her direct sensory experiences (Ares 2019).

In summary, the measurement of eating and drinking experiences has moved from the almost exclusive domain of experts and trained professionals in the 1960s to a situation today where consumers and consumer-driven product development are the keys to successful food product creation. Eating and drinking experience is no longer subject to a watchful eye from experts or other designated arbiters of quality or sensory characterization. Although trained panelists play an important role in certain quality control and product improvement programs, it is the consumer’s experiences of eating and drinking that now takes precedence in guiding new product development and that currently constitutes the forefront of new methodological research in the field. This change in *who* does the sensory characterization of food, and beverages has been one of the most important and fundamental changes in the measurement of human eating and drinking experience over the past half century.

What Is Measured About Eating and Drinking Experience?

From Simple Sensory Attributes to Complex Experiences

Sensory Attributes, Liking, Hunger, and Satiety

For researchers in the 1960s, the issue of *what* to measure about eating and drinking experience was focused on sensory attributes, liking, and hunger/satiety. Sensory attributes were used by both food scientists and psychologists to characterize the sensory experience of foods, beverages, and model tastants/odorants/texturants, while food attitude psychologists and a small number of food scientists studied liking (see ► Chap. 12, "Measuring Liking for Food and Drink," for a discussion of liking measures). Meanwhile, psychologists studying appetite and eating behaviors (see Herman et al. 2019, and ► Chaps. 11, "Normal Eating," and ► 15, "Satiety") primarily focused on hunger and satiety ratings and their relationship to palatability (liking/pleasantness) and the caloric value of foods/beverages.

As noted above, for many researchers, a common and critical measurement construct was liking (pleasantness), and the tool of choice to measure it was the 9-pt Hedonic Scale, a simple category scale ranging from "dislike extremely" to "like extremely" with a neutral point. This scale evolved from research at the US Army Quartermaster Food and Container Institute (QMFCI) in Chicago and was first used in 1949, as reported by Polemis and Jones (1950), and later documented by Peryam and Girardot (1952). The simplicity in its form, administration, and analysis was instrumental to its subsequent wide acceptance by researchers. From that time forward, until today, scientists investigating eating and drinking experiences have utilized this scale or similar category-type scales to quantify the human hedonic response to foods and beverages. Other, much more sophisticated methods for measuring the hedonic aspect of eating and drinking have been developed (see next section), but their complexity has led to much more limited use.

Food Action and Situational Appropriateness

In 1965, Howard Schutz, then at Hunt-Wesson Foods, but formerly at QMFCI, published a paper suggesting that sensory attributes and liking were insufficient to characterize eating and drinking experience, because the human response to foods and beverages was almost always accompanied by action (e.g., choice, purchase, consumption) toward or away from the target food or beverage (Schutz 1965). To address this "action" element of eating and drinking behavior, Schutz proposed a "food action (FACT) rating scale" as an adjunct to simple liking ratings. The FACT rating scale quantified the frequency of desired consumption of a food using a 9-pt category scale from “I would eat this if I were forced to” to “I would eat this every opportunity I had” (Schutz 1965). However, the FACT rating scale did not provide a direct quantitative (numerical) frequency judgment of how often the food was eaten or was desired to be eaten. As a consequence, it received only minor attention from researchers.

Some years later, Schutz introduced another construct for measuring eating and drinking experience, that of situational appropriateness (Schutz et al. 1975). This construct addressed the intended use or purpose of foods/beverages, e.g., “for breakfast,” “for lunch,” “as a snack,” “with milk,” “with friends,” “when on a diet,” etc. In practice, the method involved an item-by-use (IBU) matrix in which consumers could rate a given food or beverage for how appropriate it is to eat/drink it in a variety of different use situations (see Schutz 1988, 1994 for more detailed expositions of the method’s development and its applications).

For many years, situational appropriateness was used almost exclusively with food *names* as stimuli. However, it was also shown to serve as a valuable adjunct to routine sensory and hedonic evaluation of foods and beverages (Cardello and Schutz 1996). Unlike Schutz’s FACT rating scale, situational appropriateness gained greater popularity over time and is now frequently used to provide important information about the potential use opportunities for foods/beverages and/or to examine how a food’s liking may change in different consumption environments and contexts. The reader is referred to Giacalone (2019) and Giacalone and Jaeger (2019) for recent and comprehensive reviews of the use of IBU (item-by-use) appropriateness ratings in studies of foods and beverages.

Expectations About Eating and Drinking Experiences

At about the same time that Schutz proposed his new measurement constructs for eating and drinking, other consumer psychologists were using the psychological concept of *expectations* as a measurement tool for assessing the role of pre-trial cognitions on post-trial attitudes/evaluations (Sherif and Hovland 1961; Carlsmith and Aronson 1963). The theory underlying the use of this construct was that consumer judgments of products were dependent not only on product characteristics but also on the expectations that the consumer had for the product and the degree to which the product met those expectations, producing either confirmation or disconfirmation of the expectation. The primary measure that these investigators used to index post-trial attitude was not liking, but satisfaction, and the focus of their research was not food, but mostly branded nonfood products and consumer services (e.g., Oliver 1977; LaTour and Peat 1979; Swan and Trawick 1981; Oliver and DeSarbo 1988).

It was a relatively small leap from this theoretical foundation to apply expectation theory to eating and drinking experience and to examine its effect on sensory, liking, and other dependent variables (Cardello et al. 1985; Cardello and Sawyer 1992). The elaboration of the role of expectations in eating and drinking experience (Cardello 1994, 2007) led to a rapid expansion of its use in research on foods and beverages (see Cardello 2007 and Piqueras-Fiszman and Spence 2015 for reviews of this research area, especially when foods/beverages are labeled, branded, packaged, or otherwise associated with extrinsic or environmental elements of the eating and drinking experience).

Satisfaction

As noted above, the original development of expectations as a measurement and explanatory construct was focused on product *satisfaction* as a dependent variable. Although rarely used at the time in applications to eating and drinking, Cardello et al. (2000) suggested that satisfaction may be more appropriate than liking for use in certain eating and drinking situations, because satisfaction captures a more generalized aspect of the eating and drinking experience, one that incorporates extrinsic and situational elements. In addition, the term satisfaction is used frequently by consumers when making food and product evaluations (King and Meiselman 2010), has been linked to behavioral intention (Gotlieb et al. 1994), and is often used to assess the global experience of meals (e.g., Haugaard et al. 2016). Recently, satisfaction has received greater emphasis in the evaluation of a variety of eating- and drinking-related experiences (Grunert et al. 2007; Chi et al. 2013; Andersen et al. 2019a; Anderson and Hyldig 2015; Lagerkvist et al. 2017; Bech-Larsen and Tsalis 2018), and it has recently been incorporated into the degree of satisfaction-difference (DOSD) method (Kim et al. 2018, 2019).

Emotions Evoked by Eating and Drinking

Although psychologists studying eating behavior and obesity had long implicated emotions, especially negative ones, as a critical motivator of eating and drinking behavior, the use of emotions as a post-consumption measurement construct in eating and drinking was rarely addressed (see Köster and Mojet 2015 for a discussion of food/mood/emotion relationships). This changed in the late 1990s with the realization that the emotional experiences evoked by foods and beverages were important characterizing elements of such experiences, leading to the development of a number of lexicons of food-related emotions, i.e., word lists that could be used to describe these varied emotional experiences. Among these were the Consumption Emotions Set by Richins (1997), Laros and Steenkamp's (2005) hierarchy of food emotions, and Thomson and Crocker's (2013) list of 59 "feelings" associated with food and beverage consumption [see Jiang et al. 2014, Meiselman 2015, Cardello and Jaeger 2016, and ▶ Chap. 18, "Emotions of Eating and Drinking" for reviews of self-report emotion lexicons and methods].

Although emotion lexicons placed a semantic lens on the emotions evoked by foods/beverages, the major impact of emotions as a measurement construct came with the development of standardized methods for evaluating the emotional "profiles" of foods and beverages. Among the first of these was the EsSense Profile® method, developed by King and Meiselman (2010). This method consists of a set of 39 emotion words applicable to a wide range of foods and beverages that are rated, along with liking, on 5-pt category scales of intensity. The introduction of this method resulted in a rapid growth in the use of emotions for the affective characterization of eating and drinking experience and was accompanied by the development of a variety of other standardized methods to evaluate emotional responding to sensory stimuli, including the Geneva Emotion and Odor Scale (GEOS) (Chrea et al. 2009), ScentMove® (Porcherot et al. 2010), the PrEmo method® (Desmet et al. 2000), EmoSemio (Spinelli et al. 2014), and the EmoSensory® Wheel (Schouteten et al. 2015). (See the book by Meiselman 2016 and papers/reviews by Meiselman 2015; ▶ Chap. 18, "Emotions of Eating and Drinking" by Meiselman in this volume; Ng and Hort 2015; Cardello and Jaeger 2016; Jaeger and Cardello 2016 for these and other methods to assess the emotional experiences evoked by eating and drinking.)

Conceptualizations and Other Cognitive Elements

Among researchers working in the area of emotional profiling, Thomson et al. (2010) argued that many of the terms used in emotion profiles were not actually *felt* emotions, but rather they were emotional associations or *conceptualizations*. By this, the authors meant that "when someone tells us that a product makes them feel 'happy,' 'passionate,' etc., it's more likely that they are reflecting what the product is *communicating* to them (emotional conceptualizations) rather than *doing* to them (emotional consequences)" (Thomson et al. 2010, italics added). These authors described three different types of conceptualizations: functional (e.g., this product will make me healthier), emotional (e.g., this product will make me happy), and abstract (e.g., this product is upscale). They then proceeded to develop a list of 24 words, e.g., *lively*, *honest*, *traditional*, *youthful*, *trendy*, *pretentious*, and *cheap*, that could be used for conceptual profiling of unbranded products (Thomson and Crocker 2014) and, also, a generalized procedure for the conceptual profiling of packaged, branded, or developmental products (Thomson and Crocker 2015). This approach to conceptual profiling (see also Thomson 2016) led to a rapid increase in the use of cognitions/conceptualizations/associations to characterize eating and drinking experiences, all captured by simply having consumers evaluate words, phrases, or sentences that might apply to the target food/beverage and rating each for the degree to which it applies to the product. Examples of recent studies using cognitive associations and conceptualizations to characterize foods, beverages, and eating and drinking experiences include those cited above and those by Giacalone et al. (2013), Crocker and Thomson (2014), Cardello et al. (2016), and Jaeger et al. (2017a, 2019, 2020). Most recently, Spinelli et al. (2019) have described an expansive "global profiling" approach that uses a wide variety of sensory, emotional, situational, and cognitive variables to assess food products.

Temporal Judgments

Before closing this section, it is important to note that the measurement of eating and drinking experience has also expanded to include judgments over time. Although eating behavior psychologists have routinely obtained judgments of hunger, satiety, and the wanting to consume foods and beverages at discrete intervals over the course of a meal or other consumption situation, it was not until the procedure for obtaining time-intensity (TI) judgments of sensory attributes was developed (Lee and Pangborn 1986) that such judgments were obtained continuously as part of the sensory evaluation of foods and beverages. In TI methods, respondents make judgments (verbal, written, or computer-based) of the intensity of an attribute over the course of sipping, drinking, eating, chewing, or consuming a product. A "dual attribute" method has also been developed to simultaneously collect intensity data about two attributes (Duizer et al. 1996), and, recently, multiple attributes have been tracked using the Temporal Dominance of Sensations (TDS) method, in which consumers select the most dominant sensation at any time (Pineau et al. 2009) (see Di Monaco et al. 2014 for a review of TDS methods). These temporal approaches have now been expanded to obtain experiential aspects of eating and drinking over time using a variety of methods of sensory characterization and profiling, e.g., Temporal Check-All-That-Apply (TCATA) methodology (Castura et al. 2016). (See the next section for further discussions of CATA and TCATA methodologies.)

Thus, during the past half century, *what* is measured about eating and drinking has expanded far beyond simple liking, hunger, and satiety. Now, researchers utilize a wide array of measurement constructs, including *action tendencies* toward foods and beverages, *appropriateness* of the food for a given use/situation, pre-trial *expectations* of its sensory or affective characteristics, *satisfaction* with the overall eating and drinking experience, the *emotions* evoked by foods/beverages, and, most recently, a wide range of cognitive associations (*conceptualizations*) to products. In addition, many of these measures are now routinely collected as a function of time during the eating experience. This explosive expansion in *what* we measure about eating and drinking experience constitutes a seismic change from what was measured 50 years ago. It is a shift that is likely to continue in the years to come, limited only by our ability to identify new perceptual, cognitive, emotional, or other experiences that follow from the acts of everyday eating and drinking.

How Do We Quantify Eating and Drinking Experience?

From Simple Category Methods to Advanced Scaling Methods (and Back Again?)

In light of the exploding array of experiential attributes and measurement constructs available for characterizing aspects of eating and drinking, one must also ask what has changed in terms of *how* to *quantify* this myriad array of experiences. While language can be used to specify and define the qualitative nature of what we are experiencing, quantitative measures are needed to express the intensity of these experiences. Over the past 50 years, how we assign numbers and other scalar values to represent the intensity of experiences has changed dramatically. However, recent developments in the field may indicate a retrenchment in this regard that warrants a word of precaution for the future.

It is not surprising that the first scientific attempt to quantify human sensory experiences can be attributed to the father of psychophysics, Fechner (1860), who proposed an *indirect* method to quantify the intensity of sensory experiences (summing just noticeable differences). Some years later, Galton (1883) developed the most popular *direct* approach, i.e., the rating scale (his 5-point scale to rate perceived sensory intensity included *very faint*, *faint*, *fair*, *good*, and *vivid*). And it was some 40 years later that Freyd (1923) introduced the first graphic rating scale, i.e., a line containing intensity word labels at each end and/or at various distances along it. Taken together with simple ranking and a variety of sensory difference measures, rating scales and graphic rating scales [also known as visual analogue scales (VAS)] were the primary methods for quantifying the magnitude of sensory attributes, liking, hunger, satiety, and other experiential attributes up until the late 1950s/early 1960s.

By the 1960s, the standard methods used to quantify sensory experiences, as described in the preceding paragraph, had come under attack by the mathematician, S. S. Stevens, at Harvard, who had, in 1946, put forward the fundamental tenet that mathematical measurement exists in a hierarchy of four different levels (*nominal*, *ordinal*, *interval*, and *ratio*) and that the way in which numbers are assigned to objects dictates the scale level of the data (Stevens 1946, 1951). Stevens argued that most measurement scales of the time were insufficient to quantify human experience, because they only produced ordinal or interval data. He argued that ratio scales, because they contain both a true zero point and the ratios among the numbers on the scale have mathematical meaning, should be used exclusively to quantify sensory experiences. As a result, Stevens set out on a career-long goal to develop methods that met the criteria of ratio measurement. Magnitude estimation (Stevens 1956), in which individuals freely assign numbers to stimuli in a ratio manner, became the best known of these.

Over time, Stevens and colleagues developed and applied a wide range of ratio methods to scale sensory, affective, and more complex psychological dimensions, and these scaling techniques were soon applied to judgments of taste and smell experience (Ekman and Åkesson 1965; Engen and McBurney 1964). However, in spite of the fact that these scaling methods were mathematically more sophisticated than existing rating scales and, in spite of numerous papers and books championing the use of these methods for the measurement of eating and drinking experiences (e.g., Moskowitz and Sidel 1971; Moskowitz 1974, 1977, 1983; Moskowitz and Chandler 1977), only sporadic attempts were made by food scientists to test and/or apply ratio scaling methods to foods and beverages (e.g., McDaniel and Sawyer 1981; Giovanni and Pangborn 1983; Vickers 1983; Shand et al. 1985; Lavenka and Kamen 1994). The reasons cited for this failure to accept magnitude estimation and other ratio methods were the difficulties involved in their use by naïve subjects, the intricacies of data analysis, and failures to find practical advantages over category and graphic scales in terms of reliability or sensitivity (Pearce et al. 1986; Lawless and Malone 1986).

The practical difficulties with magnitude estimation and related methods soon led investigators to develop simpler direct ratio methods for sensory scaling. These "labeled magnitude scales (LMS)," as they came to be called, placed verbal labels of expressed intensity along a linear graphic scale at specific locations that reflected the numerical ratios among their perceived intensities as obtained by magnitude estimation. Green et al. (1993, 1996) developed the first such scale for measuring oral sensations. A critical characteristic of Green et al.'s LMS and other scales of this type was the presence of an end-point anchor labeled "maximal," "strongest imaginable," or "strongest possible" sensation, which was used as a fixed anchor to place judgments of different subjects on a common sensory "ruler" (Marks et al. 1983). However, this high-end anchor was problematic, because certain sensations, like oral pain, if included in the range of judged sensations, would compress the ratings of simple taste experiences.

As a solution, Bartoshuk and colleagues (Bartoshuk 2000; Bartoshuk et al. 2003, 2005) modified the LMS to broaden the frame of reference by anchoring the end of the scale with the "strongest imaginable sensation *of any kind*," thereby facilitating comparisons among individuals with different perceptual sensitivities. Bartoshuk referred to this modified LMS as the gLMS, "g" standing for "generalized." The gLMS is now the most widely adopted method used by chemosensory scientists to quantify the human experiences of taste, smell, and the other food-allied senses, and its end-point labels have been extended to VAS scales, producing the gVAS (Dionne et al. 2005) (see Snyder et al. 2006, Cardello and Jaeger 2010, Lim 2011, Hayes et al. 2013, and Cardello 2017 for further discussion and reviews of modern scaling methods and issues).

Since the LMS and gLMS had been specifically developed for quantifying *sensory* intensity, Schutz and Cardello (2001) developed a labeled magnitude scale to quantify *hedonic* (affective) intensity. This Labeled Affective Magnitude (LAM) scale provided ratio-level data in place of the interval data of the 9-pt hedonic scale. Other labeled magnitude scales have also been developed over the years to measure such experiential variables as satiety/hunger (Cardello et al. 2005), wetness/dryness, pleasantness/unpleasantness (Guest et al. 2007), and comfort (Cardello et al. 2003). (See Lim et al. 2009 and Schifferstein 2012 for reviews and comparisons of labeled magnitude scales.)

Another method of scaling that has been argued to produce ratio-level data is Best-Worst (BW) scaling by Finn and Louviere (1992), an extension of the indirect, paired comparison method of Thurstone (1929). This method requires subjects to choose the best and the worst from among multiple complete blocked sets of the same stimuli/products. Data are analyzed by subtracting the frequencies of a sample being chosen best or worst by an individual and then aggregating these best-worst scores over the entire respondent sample. After analysis using maximum difference or multinomial logit models, the resultant scale values have been argued to produce ratio-level data (Marley and Louviere 2005). BW scaling has been used to quantify affective and other eating and drinking experiences in numerous studies (e.g., Goodman et al. 2005; Jaeger et al. 2008; Jaeger and Cardello 2009; Mueller et al. 2009; Lagerkvist et al. 2012; Mielby et al. 2012; Crocker and Thomson 2014; Lusk et al. 2015; Loose and Lockshin 2013; Massaglia et al. 2019). Although the BW method is easy for consumers to understand, it is a demanding task (Hein et al. 2008) and requires much greater effort to administer than other scaling methods, due to the need to present each sample multiple times (Jaeger and Cardello 2009). In addition, it is not a direct measure of hedonic intensity, because the raw data are binary and the results are only relative within each study.

Although the majority of the above ratio methods enable greater precision in the measurement of eating and drinking experiences, they have been slow to gain widespread acceptance in the applied research community. The reason most often given for this is that, in applied settings, only a rough order of sensory (or hedonic/ emotional) difference is required. In such cases, simple category ratings, or even ranking, are easier for consumers to use, more convenient to administer, and faster to analyze.

These arguments for ease, convenience, and speed in sensory evaluation are now ubiquitous throughout the field, affecting many aspects of methodology development, e.g., the development of "rapid" methods of sensory testing (see earlier discussion, this chapter) and the increased use of Internet testing to obtain data about eating and drinking experiences (e.g., Piqueras-Fiszman and Spence 2011; Ngo et al. 2012; Woods et al. 2015; Michel et al. 2015; Vidal et al. 2016; Viana et al. 2016; Van Doorn et al. 2017; Kuttschreuter and Hilverda 2019; Rebollar et al. 2019; Postma et al. 2020). Although such data are typically less expensive, faster, and more convenient to collect than traditional approaches, many are more restrictive in the nature of the stimuli that can be presented (only food and beverage names or photographs in the case of Internet testing), and the quality of the obtained data can be poor due to the need to use rapid approaches that often sacrifice accuracy and detail for speed.

This new zeitgeist for faster methods of data collection warrants a precaution from the perspectives of scaling and *how* we measure and interpret the intensity of eating and drinking experiences, especially in light of some recent calls for a de-emphasis of scaling research in sensory and consumer science (e.g., Meiselman 2013). This precaution is required because many of these methods are *not designed* to quantify the intensity of eating or drinking experience; yet, in spite of this, there is a tendency to *infer* such quantification. As one example of the potential problem, the Check-All-That-Apply (CATA) methodology, which is performed exactly as it sounds – the observer is presented with a list of possible sensory, emotional, or other experiential variables, and he/she simply checks all the attributes that are evoked by the product – is an old method for personality and character assessment (Hartshorn and May 1929), but has been reborn as a "rapid" method of product characterization using consumers (Adams et al. 2007; Ares et al. 2010; Dooley et al. 2010; Jaeger et al. 2013; Reinbach et al. 2014; Jaeger and Ares 2014; Ares and Jaeger 2015; Castura et al. 2016). The "CATA" method provides only binary (yes/ no, present/absent) data (nominal scaling), and data analysis revolves around the calculation of the proportion of consumers selecting each of the attributes. In spite of the nominal nature of the data, it has been implied, perhaps inadvertently, that CATA responses "can deliver *measurements* of perceived intensity" (Vidal et al. 2018) or might even "get rid of scaling issues" (Bruzzone et al. 2015).

As previously noted by Meyners and Castura (2014), "an implicit assumption sometimes made (about CATA and TDS data) is that the *true intensity* will correlate with the proportion of consumers selecting the attribute; this is a strong assumption for which we have not found compelling evidence and which is likely to be wrong in many situations." That said, several recent studies *have* shown reasonable correlations between intensity ratings and the proportion of consumers selecting a CATA attribute (Bruzzone et al. 2012, 2015; Reinbach et al. 2014; Vidal et al. 2018; Jaeger et al. 2018). Still, such correlations cannot be misinterpreted as a direct *measure* of intensity (Ares and Jaeger 2015), because no consumer is ever asked to judge the intensity of any attribute using CATA, TDS, BW scaling, or other methods that employ binary judgments, including methods that use emoji and other emoticons to characterize emotional responding (see Vidal et al. 2016; Jaeger et al. 2017a, b, c, 2018; Ares and Jaeger 2017; Jaeger and Ares 2017; Swaney-Stueve et al. 2018; Schouteten et al. 2018, 2019).

In recognition of this drawback, other approaches have been developed, e.g., CATA with intensity (Reinbach et al. 2014) and Rate-All-That-Apply (RATA) (Ares et al. 2014), both of which allow the consumer to first choose/check whether the attribute is relevant to the product and then rate the level of that attribute's intensity on a simple category or ordered metric scale (Ares et al. 2014). Although a theoretical improvement over CATA by requiring the consumer to make a direct judgment of intensity, the level of measurement in these methods is still, at best, ordered metric.

The potential for false inferences of attribute intensity from averages of binary judgments has grown proportionally with the number of studies reporting correlations between direct intensity judgments and CATA or other binary response proportions. Recently, Jaeger et al. (2018) found a strong positive correlation between the frequency of selected emoji (using a CATA approach) and the average intensity of emotion judged by RATA, leading these authors to conclude that this relationship "supports the notion that average frequency of use (%) provides an *indication* of intensity. . ... and could suggest that a stable stimulus–response relationship between these two question formats exists, and may extend to other types of consumer responses, such as situational appropriateness, and conceptual profiling" (Jaeger et al. 2018). Unfortunately, only the *astute* reader will discriminate the word "indication" from *measurement* in the above quote and apprehend the fact that an *indication* is not the same as a *measurement*, to wit, "an *indicant* is a presumed effect or correlate bearing an unknown, but usually monotonic, relationship to some underlying phenomenon; whereas a *measuremen*t is a scaled value of the phenomenon. *Indicants* have the advantage of convenience. *Measures* have the advantage of validity. We aspire to measures, but we are often forced to settle for less" (Stevens 1951, pp. 48).

Applying Stevens' above counsel to the situation today and to the current status of the quantification of eating and drinking experience, one may come to the conclusion that, after 50 years of advances in psychophysics and the measurement of human eating and drinking experience, we are drifting backward and, perhaps, *settling for less*. For the sake of speed and convenience, we seem to have turned away from more precise and theoretically valid scalar techniques and, instead, have started to settle for less – for simple *indicators* and correlates of these experiences instead of *measures* of these experiences. In the process, we may be sacrificing the accuracy and validity of our measurements of eating and drinking experience for the practical goals of greater speed and convenience.

Where and Under *What Conditions* Do We Measure Human Eating and Drinking Experience?

From Sterile Lab Environments to Real and/or Virtual Eating and Drinking Environments

In the 1960s, psychologists and food scientists studied eating and drinking experiences in laboratories, often under sterile conditions, using individual testing booths with food "pass-throughs," so that there was no contact with other human beings nor any semblance of a real-life eating situation. In addition, much of this testing involved "sip and spit" tests using very small samples of the food/beverage. Among the first to question the value of such laboratory tests were appetite psychologists, who compared the results of these tests to those obtained when whole portions of food were eaten in more natural feeding situations (e.g., Lucas and Bellisle 1987) and found, not unexpectedly, that there were large differences in results between the two approaches.

At Natick, where military foods were tested both in sterile lab environments and in actual military field feeding environments (see chapter by ▶ Chap. 50, "Feeding the US Military: The Development of Military Rations"), similar comparisons were made with similar findings (Meiselman et al. 1988), which led Meiselman (1992) to conclude that *where* foods were consumed and under *what conditions* had a powerful influence on judgments of eating and drinking experiences. Over the next 15 years, a number of additional researchers called for the study of eating and drinking experience in more natural settings (contexts) in order to improve the external validity of the research (Rozin and Tuorila 1993; Pliner and Rozin 2000; Köster 2003; Larson and Story 2009).

The defining characteristics of *where* eating and drinking takes place are varied, and they may include lighting, décor, serving vessels, furniture, utensils, the social environment, whether a food is tested by itself or as part of a meal, etc. (see ▶ Chap. 13, "Atmospheric Effects on Eating and Drinking: A Review", for a discussion of these variables). Collectively, these variables are often referred to as the "context" of testing (see Meiselman 2006, 2009, 2019, for books that enumerate the varied elements that define the eating and drinking context and that provide up-to-date summaries of the research in this area).

Although "home use tests" (HUT) of food have been conducted by food scientists for some time (Calvin and Sather 1959; Dunsing 1959), these tests, like others collected in more natural feeding environments, can be time-consuming and expensive (see Boutrolle et al. 2005, 2007 for methods and comparisons of CLT and HUT data). Due to the importance of obtaining data on eating and drinking experiences in real-world situations, but recognizing the high costs of doing research in truly natural environments, researchers soon attempted to develop more real-life contexts in the laboratory. One simple approach to do this was to use "imagined contexts," i.e., having the consumer imagine a real-life situation, aided by written scenarios. Jaeger and Meiselman (2004) were among the first to use this approach, and Jaeger and colleagues expanded these approaches for use in a variety of testing situations (e.g., Jaeger and Rose 2008; Loose and Jaeger 2012). (See Piqueras-Fiszman and Jaeger 2019 for a recent review.) Although the use of written scenarios is an important step toward bringing real-life contexts into the laboratory, Kim et al. (2016) have shown that written consumption scenarios are not as effective as actual (physical) manipulation of the testing environment when trying to mimic "real-world" results.

Written scenarios were followed by the use of graphics or pictures to evoke a desired context (Giacalone et al. 2015; Elzerman et al. 2015). These studies have been followed by other studies in which researchers have used pictorial, graphic, auditory, and other multimodal stimuli to establish more realistic contexts in the laboratory (see recent reviews by Jaeger and Porcherot 2017, Cardello and Meiselman 2018, and Dacremont and Sester 2019 and the book by Meiselman 2019 for research and reviews on the role of context and alterations in context on eating and drinking).

Most recently, "immersive" contexts, in which real-world environments are mimicked using 2-D or 3-D video environments, audio recordings, and ambient aromas, have been developed (Sester et al. 2013; Bangcuyo et al. 2015; Hathaway and Simons 2017; Andersen et al. 2019b; Sinesio et al. 2019; Delarue et al. 2019). A number of these approaches and their applications to eating and drinking were presented at the European Sensory Network workshop on immersive tools at the 2016 EuroSense Conference, including demonstrations of head-worn 3-D virtual reality goggles to augment situational realism in lab-based contexts. The reader is referred to Porcherot et al. (2018), Hartmann and Siegrist (2019), and Hehn et al. (2019) for recent reviews of immersive techniques in the study of eating and drinking.

The shift from sterile, lab-based environments to immersive and more "real-world" environments during the past 50 years and the growing study of the role of context on eating and drinking experience constitute major advances in our ability to provide data that can be generalized to the real world. As the technology and human factors of 3-D and other highly immersive environments improve, so too will the reliability and external validity of the data improve. However, like all technological advances, there are drawbacks that must be overcome, including the development of less intrusive and less distracting interfaces. In addition, we must always be cognizant of the value of *a*situational data, i.e., the ability to draw conclusions about foods and beverages and about eating and drinking experiences that transcend *where or under what specific conditions* the data were obtained. Judicious choice of *where* to collect data on eating and drinking experiences, based on the objectives of the research, will be required in order to balance the critical issues of data generalizability versus data specificity.

Conclusions

In the 1960s, the study of eating and drinking experience consisted primarily of studies using experts and trained panels to evaluate the sensory properties of food while using consumers to judge liking or hunger/satiety. Whether with trained panelists or consumers, the judgments were almost always made in sterile laboratory conditions, and judgments of sensory attributes, liking, and hunger/satiety were almost always made using simple category or graphic rating scales. Today, the situation is greatly different. Trained panels have a much smaller role in the measurement of eating and drinking experience, while consumers are now used to provide a wide range of sensory, affective, cognitive, emotional, and situational responses, before, during, and after product development. Testing today still occurs in the lab and in naturalistic environments, but much more frequently, studies in the laboratory use a variety of immersive techniques, including imagery and 2-D/3-D displays, to provide a more realistic environment that better mimics the intended eating or drinking environment.

While the above changes in *who*, *what*, and *where* we measure human eating and drinking experience can be viewed as important advances in our testing and measurement paradigms, *how* we quantify these experiences has not seen as rapid an improvement, in spite of significant advances in psychophysical scaling methods over the past half century. Today, rating scales, like the 9-pt hedonic scale and graphic rating, are still the predominant scaling approaches used in many research quarters, because they are considered easier to use by consumers, more convenient to administer, and faster than more complex scaling methods. In addition, certain methods of rapid product characterization that involve only nominal judgments and that can produce only intensity *indicators*, rather than direct *measures* of intensity, can create the potential for misinterpretation of these data by the less astute practitioner.

In summary, we can say that our current paradigms for measuring human eating and drinking experiences provide a richer, more complete, and externally valid representation of these experiences. We have also developed the means to obtain these data more quickly and at less cost. The real question for the future is whether some of our eagerness for *simpler* and *faster* methods will result in data that are *less precise*, *less valid*, and *less valuable* for understanding the underlying mechanisms and the meaning of human eating and drinking experience.

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