1 chapter

Introduction to Food Analysis

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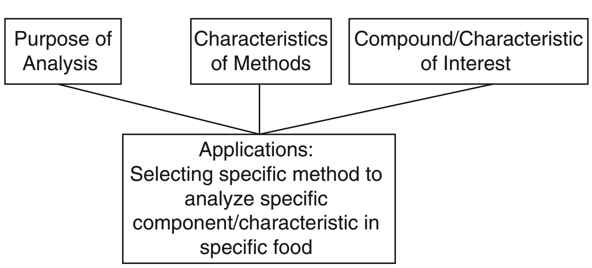
1.1 INTRODUCTION

Investigations in food science and technology, whether by the food industry, governmental agencies, or universities, often require determination of food composition and characteristics. Trends and demands of consumers, the food industry, and national and international regulations challenge food scientists as they work to monitor food composition and to ensure the quality and safety of the food supply. All food products require analysis as part of a **quality management** program throughout the development process (including raw ingredients), through production, and after a product is in the market. In addition, analysis is done of problem samples and competitor products. The characteristics of foods (i.e., chemical composition, physical properties, sensory properties) are used to answer specific questions for regulatory purposes and typical quality control. The nature of the sample and the specific reason for the analysis commonly dictate the choice of analytical methods. **Speed, precision, accuracy**, and **ruggedness** often are key factors in this choice. **Validation** of the method for the specific **food matrix** being analyzed is necessary to ensure usefulness of the method. Making an appropriate choice of the analytical technique for a specific application requires a good knowledge of the various techniques (Fig. 1-1). For example, your choice of method to determine the salt content of potato chips would be different if it is for nutrition labeling than for quality control. The success of any analytical method relies on the proper selection and preparation of the food sample, carefully performing the analysis, and doing the appropriate calculations and interpretation of the data. Methods of analysis developed and endorsed by several nonprofit scientific organizations allow for standardized comparisons of results between different laboratories and for evaluation of less standard procedures. Such **official methods** are critical in the analysis of foods, to ensure that they meet the legal requirements established by governmental agencies. **Government regulations** and **international standards** most relevant to the analysis of foods are mentioned here but covered in more detail in Chap. 2, and nutrition labeling regulations in the USA are covered in Chap. 3. Internet addresses for many of the organizations and government agencies discussed are given at the end of this chapter.



1-1 figure Method selection in food analysis.

1.2 TRENDS AND DEMANDS

1.2.1 Consumers

Consumers have many choices regarding their food supply, so they can be very selective about the products they purchase. They demand a wide variety of products that are of high quality, nutritious, and offer a good value. Also, consumers are concerned about the safety of foods, which has increased the testing of foods for allergens, pesticide residues, and products from genetic modification of food materials. Many consumers are interested in the relationship between diet and health, so they utilize nutrient content and health claim information from food labels to make purchase choices. These factors create a challenge for the food industry and for its employees. For example, the demand for foods with lower fat content has challenged food scientists to develop food products that contain fat content claims (e.g., free, low, reduced) and certain health claims (e.g., the link between dietary fat and cancer; dietary saturated fat and cholesterol and risk of coronary heart disease). Analytical methods to determine and characterize fat content provide the data necessary to justify these statements and claims. Use of fat substitutes in product formulations makes possible many of the lower fat foods, but these fat substitutes can create challenges in the accurate measurement of fat content (1). Likewise, there has been growing interest in functional foods that may provide health benefits beyond basic nutrition. However, such foods present some unique challenges regarding analytical techniques and in some cases questions of how these components affect the measurement of other nutrients in the food (2).

1.2.2 Food Industry

To compete in the marketplace, food companies must produce foods that meet the demands of consumers as described previously. Management of product quality by the food industry is of increasing importance, beginning with the raw ingredients and extending to the final product eaten by the consumer. Analytical methods must be applied across the entire food supply chain to achieve the desired final product quality. Downsizing in response to increasing competition in the food industry often has pushed the responsibility for ingredient quality to the suppliers. Companies increasingly rely on others to supply high-quality and safe raw ingredients and packaging materials. Many companies have **select suppliers**, on whom they rely to perform the analytical tests to ensure compliance with detailed specifications for ingredients/raw materials. These specifications, and the associated tests, target various chemical, physical, and microbiological properties. Results of these analytical tests related to the predetermined specifications are delivered as a **Certificate of Analysis** (COA) with the ingredient/raw material. Companies must have in place a means to maintain control of these COAs and react to them. With careful control over the quality of raw ingredients/materials, less testing is required during processing and on the final product.

In some cases, the cost of goods is linked directly to the composition as determined by analytical tests. For example, in the dairy field, butterfat content of bulk tank raw milk determines how much money the milk producer is paid for the milk. For flour, the protein content can determine the price and food application for the flour. These examples point to the importance for accurate results from analytical testing.

Traditional quality control and quality assurance concepts are only a portion of a comprehensive quality management system. Food industry employees responsible for quality management work together in teams with other individuals in the company responsible for product development, production, engineering, maintenance, purchasing, marketing, and regulatory and consumer affairs.

Analytical information must be obtained, assessed, and integrated with other relevant information about the food system to address quality-related problems. Making appropriate decisions depends on having knowledge of the analytical methods and equipment utilized to obtain the data related to the quality characteristics. To design experiments in product and process development, and to assess results, one must know the operating principles and capabilities of the analytical methods. Upon completion of these experiments, one must critically evaluate the analytical data collected to determine whether product reformulation is needed or what parts of the process need to be modified for future tests. The situation is similar in the research laboratory, where knowledge of analytical techniques is necessary to design experiments, and the evaluation of data obtained determines the next set of experiments to be conducted.

1.2.3 Government Regulations and International Standards and Policies

To market safe, high-quality foods effectively in a national and global marketplace, food companies must pay increasing attention to government regulations and guidelines and to the policies and standards of international organizations. Food scientists must be aware of these regulations, guidelines, and policies related to food safety and quality and must know the implications for food analysis. Government regulations and guidelines in the USA relevant to food analysis include **nutrition labeling regulations** (Chap. 3), **mandatory and voluntary standards** (Chap. 2), **Good Manufacturing Practice** (GMP) regulations (now called Current Good Manufacturing Practice in Manufacturing Packing, or Holding Human Food) (Chap. 2), and **Hazard Analysis Critical Control Point** (HACCP) systems (Chap. 2). The HACCP system is highly demanded of food companies by auditing firms and customers. The HACCP concept has been adopted not only by the US **Food and Drug Administration** (FDA) and other federal agencies in the USA, but also by the **Codex Alimentarius Commission**, an international organization that has become a major force in world food trade. Codex is described in Chap. 2, along with other organizations active in developing international standards and safety practices relevant to food analysis that affect the import and export of raw agricultural commodities and processed food products.

1.3 TYPES OF SAMPLES ANALYZED

Chemical analysis of foods is an important part of a quality assurance program in food processing, from ingredients and raw materials, through processing, to the finished products (3–7). Chemical analysis also is important in formulating and developing new products, evaluating new processes for making food products, and identifying the source of problems with unacceptable products (Table 1-1). For each type of product to be analyzed, it may be necessary to determine either just one or many components. The nature of the sample and the way in which the information obtained will be used may dictate the specific method of analysis. For example, process control samples are usually analyzed by rapid methods, whereas nutritive value information for **nutrition labeling** generally requires the use of more time-consuming methods of analysis endorsed by scientific organizations. Critical questions, including those listed in Table 1-1, can be answered by analyzing various types of samples in a food processing system.

1.4 STEPS IN ANALYSIS

1.4.1 Select and Prepare Sample

In analyzing food samples of the types described previously, all results depend on obtaining a representative sample and converting the sample to a form

Table 1-1 Types of Samples Analyzed in a Quality Assurance Program for Food Products

Sample Type	Critical Questions
Raw materials	Do they meet your specifications? Do they meet required legal specifications? Are they safe and authentic? Will a processing parameter have to be modified because of any change in the composition of raw materials? Are the quality and composition the same as for previous deliveries? How does the material from a potential new supplier compare to that from the current supplier?
Process control samples	Did a specific processing step result in a product of acceptable composition or characteristics? Does a further processing step need to be modified to obtain a final product of acceptable quality?
Finished product	Does it meet the legal requirements? What is the nutritive value, so that label information can be developed? Or is the nutritive value as specified on an existing label? Does it meet product claim requirements (e.g., "low fat")? Will it be acceptable to the consumer? Will it have the appropriate shelf life? If unacceptable and cannot be salvaged, how do you handle it (trash? rework? seconds?)
Competitor's sample	What are its composition and characteristics? How can we use this information to develop new products?
Complaint sample	How do the composition and characteristics of a complaint sample submitted by a customer differ from a sample with no problems?

Adapted and updated from (8, 9).

that can be analyzed. Neither of these is as easy as it sounds! **Sampling** and **sample preparation** are covered in detail in Chap. 5.

Sampling is the initial point for sample identification. Analytical laboratories must keep track of incoming samples and be able to store the analytical data from the analyses. This analytical information often is stored on a **laboratory information management system**, or LIMS, which is a computer database program.

1.4.2 Perform the Assay

Performing the assay is unique for each component or characteristic to be analyzed and may be unique to a specific type of food product. Single chapters in this book address sampling and sample preparation (Chap. 5) and data handling (Chap. 4), while the remainder of the book addresses the step of actually performing the assay. The descriptions of the various specific procedures are meant to be overviews of the methods. For guidance in actually performing the assays, details regarding chemicals, reagents, apparatus, and step-by-step instructions are found in the books and articles referenced in each chapter. Numerous chapters in this book, and other recent books devoted to food analysis (10–14), make the point that for food analysis we increasingly rely on expensive equipment, some of which requires considerable expertise. Also, it should be noted that numerous analytical methods utilize automated instrumentation, including autosamplers and robotics to speed the analyses.

1.4.3 Calculate and Interpret the Results

To make decisions and take action based on the results obtained from performing the assay that determined the composition or characteristics of a food product, one must make the appropriate calculations to interpret the data correctly. **Data handling**, covered in Chap. 4, includes important statistical principles.

1.5 CHOICE AND VALIDITY OF METHOD

1.5.1 Characteristics of the Method

Numerous methods often are available to assay food samples for a specific characteristic or component. To select or modify methods used to determine the chemical composition and characteristics of foods, one must be familiar with the principles underlying the procedures and the critical steps. Certain properties of methods and criteria described in Table 1-2 are useful to evaluate the appropriateness of a method in current use or a new method being considered.

1.5.2 Objective of the Assay

Selection of a method depends largely on the objective of the measurement. For example, methods used for rapid online processing measurements may be less accurate than official methods (see Sect. 1.6) used for nutritional labeling purposes. Methods referred to as reference, definitive, official, or primary are most applicable in a well-equipped and staffed analytical lab. The more rapid secondary or field methods may be more applicable on the manufacturing floor in a food processing facility. For example, refractive index may be used as a rapid, secondary method for sugar

1-2 table **Criteria for Choice of Food Analysis Methods**

Characteristic	*Critical Questions*
Inherent properties	
Specificity/selectivity	Is the property being measured the same as that claimed to be measured, and is it the only property being measured?
	Are there interferences?
	What steps are being taken to ensure a high degree of specificity?
Precision	What is the precision of the method? Is there within-batch, batch-to-batch, or day-to-day variation?
	What step in the procedure contributes the greatest variability?
Accuracy	How does the new method compare in accuracy to the old or a standard method?
	What is the percent recovery?
Applicability of method to laboratory	
Sample size	How much sample is needed?
	Is it too large or too small to fit your needs?
	Does it fit your equipment and/or glassware?
	Can you obtain representative sample?[a]
Reagents	Can you properly prepare them?
	What equipment is needed? Are they stable? For how long and under what conditions?
Equipment	Is the method very sensitive to slight or moderate changes in the reagents?
	Do you have the appropriate equipment?
	Are personnel competent to operate equipment?
Cost	What is the cost in terms of equipment, reagents, and personnel?
Usefulness	
Time required	How fast is it? How fast does it need to be?
Reliability	How reliable is it from the standpoints of precision and stability?
Need	Does it meet a need or better meet a need?
Personnel	Is any change in method worth the trouble of the change?
Safety	Are special precautions necessary?
Procedures	Who will prepare the written description of the procedures and reagents?
	Who will do any required calculations?

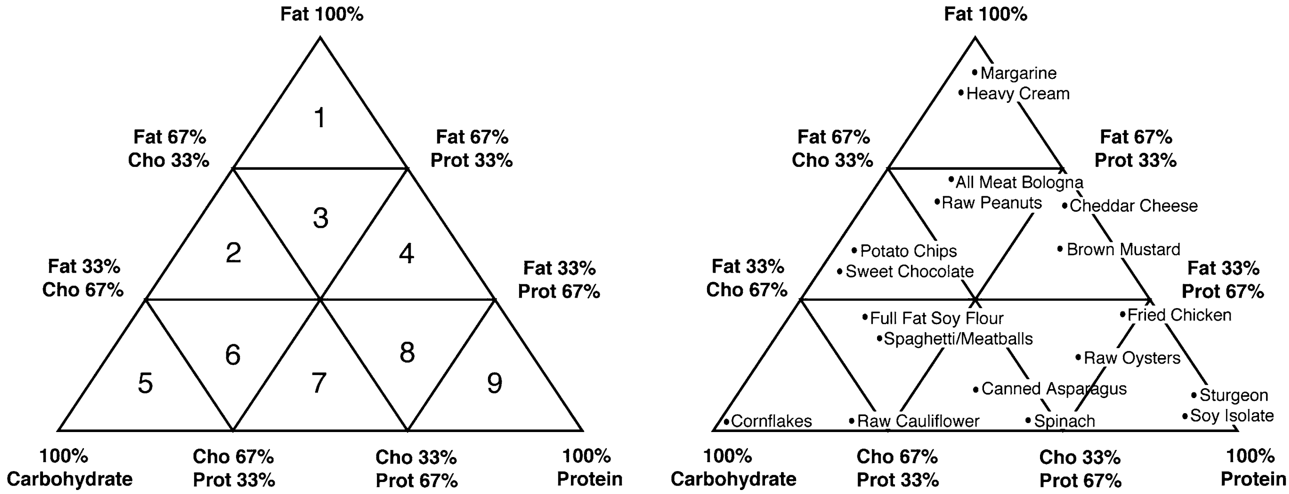
[a]In-process samples may not accurately represent finished product; Must understand what variation can and should be present.

analysis (see Chaps. 6 and 10), with results correlated to those of the primary method, **high-performance liquid chromatography** (HPLC) (see Chaps. 10 and 28). Moisture content data for a product being developed in the pilot plant may be obtained quickly with a moisture balance unit that has been calibrated using a more time-consuming hot air oven method (see Chap. 6). Many companies commonly use unofficial, rapid methods, but validate them against official methods.

1.5.3 Consideration of Food Composition and Characteristics

Proximate analysis of foods refers to determining the major components of moisture (Chap. 6), ash (total minerals) (Chap. 7), lipids (Chap. 8), protein (Chap. 9), and carbohydrates (Chap. 10). The performance of many analytical methods is affected by the **food matrix** (i.e., its major chemical components, especially lipid, protein, and carbohydrate). In food analysis, it is usually the food matrix that presents the greatest challenge to the analyst (15). For example, high-fat or high-sugar foods can cause different types of interferences than low-fat or low-sugar foods. Digestion procedures and extraction steps necessary for accurate analytical results can be very dependent on the food matrix. The complexity of various food systems often requires having not just one technique available for a specific food component, but multiple techniques and procedures, as well as the knowledge about which to apply to a specific food matrix.

A task force of **AOAC International**, formerly known as the **Association of Official Analytical Chemists** (AOAC), suggested a "triangle scheme" for dividing foods into matrix categories (16–20) (Fig. 1-2). The apexes of the triangle contain food groups that were either 100% fat, 100% protein, or 100% carbohydrate. Foods were rated as "high," "low," or "medium" based on levels of fat, carbohydrate, and proteins, which are the three nutrients expected to



1-2 figure Schematic layout of food matrixes based on protein, fat, and carbohydrate content, excluding moisture and ash. [Reprinted with permission from (20), *Inside Laboratory Management*, September 1997, p. 33. Copyright 1997, by AOAC International.]

have the strongest effect on analytical method performance. This created nine possible combinations of high, medium, and low levels of fat, carbohydrate, and protein. Complex foods were positioned spatially in the triangle according to their content of fat, carbohydrate, and protein, on a normalized basis (i.e., fat, carbohydrate, and protein normalized to total 100%). General analytical methods ideally would be geared to handle each of the nine combinations, replacing more numerous matrix-dependent methods developed for specific foods. For example, using matrix-dependent methods, one method might be applied to potato chips and chocolates, both of which are low-protein, medium-fat, medium-carbohydrate foods, but another might be required for a high-protein, low-fat, high-carbohydrate food such as nonfat dry milk (17). In contrast, a robust general method could be used for all of the food types. The **AACC International**, formerly known as the **American Association of Cereal Chemists** (AACC), has approved a method studied using this approach (18).

1.5.4 Validity of the Method

Numerous factors affect the usefulness and validity of the data obtained using a specific analytical method. One must consider certain characteristics of any method, such as specificity, precision, accuracy, and sensitivity (see Table 1-2 and Chap. 4). However, one also must consider how the variability of data from the method for a specific characteristic compares to differences detectable and acceptable to a consumer, and the variability of the specific characteristic inherent in processing of the food. One must consider the nature of the samples collected for the analysis, how representative the samples were of the whole, and the number of samples analyzed (Chap. 5). One must ask whether details of the analytical procedure were followed adequately, such that the results are accurate, repeatable, and comparable to data collected previously. For data to be valid, equipment to conduct the analysis must be standardized and appropriately used, and the performance limitations of the equipment must be recognized.

A major consideration for determining method validity is the analysis of materials used as controls, often referred to as **standard reference materials** or **check samples** (21). Analyzing check samples concurrently with test samples is an important part of quality control (22). Standard reference materials can be obtained in the USA from the National Institute of Standards and Technology (NIST) and from US Pharmacopeia, in Canada from the Center for Land and Biological Resource Research, in Europe from the Institute for Reference Materials and Measurements (IRMM), and in Belgium from the Community Bureau of Reference (BCR). Besides government-related groups, numerous organizations offer check sample services that provide test samples to evaluate the reliability of a method (21). For example, AACC International has a check sample service in which a subscribing laboratory receives specifically prepared test samples from AACC International. The subscribing laboratory performs the specified analyses on the samples and returns the results to AACC International. The AACC International then provides a statistical evaluation of the analytical results and compares the subscribing laboratory's data with those of other laboratories to inform the subscribing laboratory of its degree of accuracy. The AACC International offers check samples such as flours, semolina, and other cereal-based samples, for analyses such as moisture, ash, protein, vitamins, minerals, sugars, sodium, total dietary fiber, soluble and insoluble dietary fiber, and β-glucan. Samples also are available for testing physical properties and for microbiological and sanitation analyses.

The **American Oil Chemists' Society** (AOCS) has a reference sample program for oilseeds, oilseed meals, marine oils, aflatoxin, cholesterol, trace metals, specialty oils suitable for determination of *trans* fatty acids, and formulations for nutritional labeling. Laboratories from many countries participate in the program to check the accuracy of their work, their reagents, and their laboratory apparatus against the statistical norm derived from the group data.

Standard reference materials are important tools to ensure reliable data. However, such materials need not necessarily be obtained from outside organizations. Control samples internal to the laboratory can be prepared by carefully selecting an appropriate type of sample, gathering a large quantity of the material, mixing and preparing to ensure homogeneity, packaging the sample in small quantities, storing the samples appropriately, and routinely analyzing the control sample when test samples are analyzed. Whatever the standard reference materials used, these should match closely the matrix of the samples to be analyzed by a specific method. AOAC International has begun a peer-review program of matching reference materials with respective official methods of analysis.

1.6 OFFICIAL METHODS

The choice of method for a specific characteristic or component of a food sample is often made easier by the availability of **official methods**. Several nonprofit scientific organizations have compiled and published these methods of analysis for food products, which have been carefully developed and standardized. They allow for comparability of results between different laboratories that follow the same procedure and for evaluating results obtained using new or more rapid procedures.

1.6.1 AOAC International

AOAC International is an organization begun in 1884 to serve the analytical methods needs of government regulatory and research agencies. The goal of AOAC International is to provide methods that will be fit for their intended purpose (i.e., will perform with the necessary accuracy and precision under usual laboratory conditions).

This volunteer organization functions as follows:

1. Methods of analysis from published literature are selected or new methods are developed by AOAC International volunteers.
2. Methods are collaboratively tested using multilaboratory studies in volunteers' laboratories.
3. Methods are given a multilevel peer review by expert scientists, and if found acceptable, they are adopted as official methods of analysis.
4. Adopted methods are published in the *Official Methods of Analysis*, which covers a wide variety of assays related to foods, drugs, cosmetics, agriculture, forensic science, and products affecting public health and welfare.
5. AOAC International publishes manuals, methods compilations in specific areas of analysis, monographs, and the monthly magazine *Inside Laboratory Management*.
6. AOAC International conducts training courses of interest to analytical scientists and other laboratory personnel.

Methods validated and adopted by AOAC International and the data supporting the method validation are published in the *Journal of AOAC International*. Such methods must be successfully validated in a formal interlaboratory collaborative study before being accepted as an official first action method by AOAC International. Details of the validation program (e.g., number of laboratories involved, samples per level of analyte, controls, control samples, and the review process) are given in the front matter of the AOAC International's *Official Methods of Analysis*. First action methods are subject to scrutiny and general testing by other scientists and analysts for some time period before final action adoption. Adopted first action and final action methods for many years were compiled in books published and updated every 4–5 years as the *Official Methods of Analysis* (23) of AOAC International. In 2007, AOAC International created an online version of the book as a "continuous edition," with new and revised methods posted as soon as they are approved. The *Official Methods of Analysis* of AOAC International includes methods appropriate for a wide variety of products and other materials (Table 1-3). These methods often are specified by the FDA with regard to legal requirements for food products. They are generally the methods followed by the FDA and the **Food Safety and Inspection Service** (FSIS) of the **United States Department of Agriculture** (USDA) to check the nutritional labeling information on foods and to check foods for the presence or absence of undesirable residues or residue levels.

1-3 table **Table of Contents of 2007 Official Methods of Analysis of AOAC International (23)**

Chapter	Title
1	Agriculture liming materials
2	Fertilizers
3	Plants
4	Animal feed
5	Drugs in feeds
6	Disinfectants
7	Pesticide formulations
8	Hazardous substances
9	Metals and other elements at trace levels in foods
10	Pesticide and industrial chemical residues
11	Waters; and salt
12	Microchemical methods
13	Radioactivity
14	Veterinary analytical toxicology
15	Cosmetics
16	Extraneous materials: isolation
17	Microbiological methods
18	Drugs: Part I
19	Drugs: Part II
20	Drugs: Part III
21	Drugs: Part IV
22	Drugs: Part V
23	Drugs and feed additives in animal tissues
24	Forensic sciences
25	Baking powders and baking chemicals
26	Distilled liquors
27	Malt beverages and brewing materials
28	Wines
29	Nonalcoholic beverages and concentrates
30	Coffee and tea
31	Cacao bean and its products
32	Cereal foods
33	Dairy products
34	Eggs and egg products
35	Fish and other marine products
36	Flavors
37	Fruits and fruit products
38	Gelatin, dessert preparations, and mixes
39	Meat and meat products
40	Nuts and nut products
41	Oils and fats
42	Vegetable products, processed
43	Spices and other condiments
44	Sugars and sugar products
45	Vitamins and other nutrients
46	Color additives
47	Food additives: Direct
48	Food additives: Indirect
49	Natural toxins
50	Infant formulas, baby foods, and enteral products
51	Dietary supplements

1-4 table **Table of Contents of 2010 Approved Methods of AACC International (24)**

Chapter	Title
2	Acidity
4	Acids
6	Admixture of flours
7	Amino acids
8	Total ash
10	Baking quality
11	Biotechnology
12	Carbon dioxide
14	Color and pigments
20	Ingredients
22	Enzymes
26	Experimental milling
28	Extraneous matter
30	Crude fat
32	Fiber
33	Sensory analysis
38	Gluten
39	Infrared analysis
40	Inorganic constituents
42	Microorganisms
44	Moisture
45	Mycotoxins
46	Nitrogen
48	Oxidizing, bleaching, and maturing agents
54	Physical dough tests
55	Physical tests
56	Physicochemical tests
58	Special properties of fats, oils, and shortenings
61	Rice
62	Preparation of sample
64	Sampling
66	Semolina, pasta, and noodle quality
68	Solutions
74	Staleness/texture
76	Starch
78	Statistical principles
80	Sugars
82	Tables
86	Vitamins
89	Yeast

1.6.2 Other Endorsed Methods

The AACC International publishes a set of approved laboratory methods, applicable mostly to cereal products (e.g., baking quality, gluten, physical dough tests, staleness/texture). The AACC International process of adopting the *Approved Methods of Analysis* (24) is consistent with the process used by the AOAC International and AOCS. Approved methods of the AACC International are continuously reviewed, critiqued, and updated (Table 1-4), and are now available online.

The AOCS publishes a set of official methods and recommended practices, applicable mostly to fat and oil analysis (e.g., vegetable oils, glycerin, lecithin) (25) (Table 1-5). AOCS is a widely used methodology source on the subjects of edible fats and oils, oilseeds

Table 1-5 Table of Contents of 2009 Official Methods and Recommended Practices of the American Oil Chemists' Society (25)

Section	*Title*
A	Vegetable oil source materials
B	Oilseed by-products
C	Commerical fats and oils
D	Soap and synthetic detergents
E	Glycerin
F	Sulfonated and sulfated oils
G	Soapstocks
H	Specifications for reagents, and solvents and apparatus
J	Lecithin
M	Evaluation and design of test methods
S	Official listings
T	Recommended practices for testing industrial oils and derivatives

Table 1-6 Contents of Chap. 15 on Chemical and Physical Methods in Standard Methods for the Examination of Dairy Products (26)

15.010	Introduction
15.020	Acidity tests
15.030	Adulterant tests
15.040	Ash tests
15.050	Chloride tests
15.060	Contaminant tests
15.070	Extraneous material tests
15.080	Fat determination methods
15.090	Lactose and galactose tests
15.100	Minerals and food additives
15.110	Moisture and solids tests
15.120	Multicomponent tests
15.130	Protein/nitrogen tests
15.140	Rancidity tests
15.150	Sanitizer tests
15.160	Vitamins A, D2, and D3 in milk products, HPLC method
15.170	Functional tests
15.180	Cited references

and oilseed proteins, soaps and synthetic detergents, industrial fats and oils, fatty acids, oleochemicals, glycerin, and lecithin.

Standard Methods for the Examination of Dairy Products (26), published by the American Public Health Association, includes methods for the chemical analysis of milk and dairy products (e.g., acidity, fat, lactose, moisture/solids, added water) (Table 1-6). *Standard Methods for the Examination of Water and Wastewater* (27) is published jointly by the American Public Health Association, American Water Works Association, and the Water Environment Federation. *Food Chemicals Codex* (28), published by US Pharmacopeia, contains methods for the analysis of certain food additives. Some trade associations publish standard methods for the analysis of their specific products.

1.7 SUMMARY

Food scientists and technologists determine the chemical composition and physical characteristics of foods routinely as part of their quality management, product development, or research activities. For example, the types of samples analyzed in a quality management program of a food company can include raw materials, process control samples, finished products, competitors' samples, and consumer complaint samples. Consumer, food industry, and government concern for food quality and safety has increased the importance of analyses that determine composition and critical product characteristics.

To successfully base decisions on results of any analysis, one must correctly conduct all three major steps in the analysis: (1) select and prepare samples, (2) perform the assay, and (3) calculate and interpret the results. The choice of analysis method is usually based on the objective of the analysis, characteristics of the method itself (e.g., specificity, accuracy, precision, speed, cost of equipment, and training of personnel), and the food matrix involved. Validation of the method is important, as is the use of standard reference materials to ensure quality results. Rapid methods used for quality assessment in a production facility may be less accurate but much faster than official methods used for nutritional labeling. Endorsed methods for the chemical analyses of foods have been compiled and published by AOAC International, AACC International, AOCS, and certain other nonprofit scientific organizations. These methods allow for comparison of results between different laboratories and for evaluation of new or more rapid procedures.

1.8 STUDY QUESTIONS

1. Identify six reasons you might need to determine certain chemical characteristics of a food product as part of a quality management program.
2. You are considering the use of a new method to measure Compound X in your food product. List six factors you will consider before adopting this new method in your quality assurance laboratory.
3. In your work at a food company, you mentioned to a coworker something about the *Official Methods of Analysis* published by AOAC International. The coworker asks you what AOAC International does, and what the *Official Methods of Analysis* is. Answer your coworker's questions.

4. For each type of product listed below, identify a publication in which you can find standard methods of analysis appropriate for the product:
   (a) Ice cream
   (b) Enriched flour
   (c) Wastewater (from food processing plant)
   (d) Margarine

1.9 ACKOWLEDGMENTS

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1.11 RELEVANT INTERNET ADDRESSES

American Association of Cereal Chemists – http://www.aaccnet.org/
American Oil Chemists' Society – http://www.aocs.org/
American Public Health Association – http://www.apha.org/
AOAC International – http://www.aoac.org
Code of Federal Regulations – http://www.gpoaccess.gov/cfr/index.html
Codex Alimentarius Commission – http://www.codexalimentarius.net/web/index_en.jsp

Food Chemicals Codex –
    http://www.usp.org/fcc/
Food and Drug Administration –
    http://www.fda.gov
        Center for Food Safety & Applied Nutrition –
            http://www.cfsan.fda.gov/
            Current Good Manufacturing Practices –
                http://www.cfsan.fda.gov/~dms/cgmps.html
            Food Labeling and Nutrition –
                http://vm.cfsan.fda.gov/label.html
            Hazard Analysis Critical Control Point –
                http://www.cfsan.fda.gov/~lrd/haccp.html
National Institute of Standards and Technology –
    http://www.nist.gov/
U.S. Department of Agriculture –
    http://www.usda.gov/wps/portal/usdahome
        Food Safety and Inspection Service –
            http://www.fsis.usda.gov
            HACCP/Pathogen Reduction –
                http://www.fsis.usda.gov/Science/Hazard_Analysis_&_Pathogen_Reduction/index.asp