Food Microbiology and Food Safety
Practical Approaches

Jeffrey Farber
Jackie Crichton
O. Peter Snyder, Jr. *Editors*

Retail Food Safety

International Association for Food Protection®

Springer

Food Microbiology and Food Safety

Series Editor:
Michael P. Doyle

Food Microbiology and Food Safety Series

The Food Microbiology and Food Safety series is published in conjunction with the International Association for Food Protection, a non-profit association for food safety professionals. Dedicated to the life-long educational needs of its Members, IAFP provides an information network through its two scientific journals (Food Protection Trends and Journal of Food Protection), its educational Annual Meeting, international meetings and symposia, and interaction between food safety professionals.

More information about this series at http://www.springer.com/series/7131

Jeffrey Farber • Jackie Crichton
O. Peter Snyder, Jr.
Editors

Retail Food Safety

Springer

Editors
Jeffrey Farber
Bureau of Microbial Hazards
Health Canada
Ottawa, ON, Canada

Jackie Crichton
Consultant
Pakenham, ON, Canada

O. Peter Snyder, Jr.
SnyderHACCP
Roseville, MN, USA

ISBN 978-1-4939-1549-1 ISBN 978-1-4939-1550-7 (eBook)
DOI 10.1007/978-1-4939-1550-7
Springer New York Heidelberg Dordrecht London

Library of Congress Control Number: 2014949135

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Contents

Chapter 1
An Introduction to Retail Food Safety

Jeffrey Farber, Jackie Crichton, and O. Peter Snyder, Jr.

Retail is that step in the food supply chain just before the care and control of a product is handed over to the final customer or consumer.

Retail food outlets take on a number of formats, shapes, and sizes and offer a wide array of products prepared and sold in a variety of formats using many different display methods. Products may originate from domestic suppliers or be imported. They may be sold in the manufacturers original package or they may be assembled, further prepared and/or packaged at store level.

Retail is unique in that the majority of the workforce is made up of part-time workers. For many retail employees, this is their first job and/or something that they will do only for a short time, e.g., until they finish school, "find a real job." Many retail outlets operate 24 h a day, 7 days a week.

Retail is also unique in that customers/consumers have varying degrees of access to the food premises and to products being offered for sale (e.g., products sold bulk self-serve). All of these factors add to the complexity of ensuring food safety at retail.

Food safety has long been a focus of the retail food industry and is increasingly being focused on by consumers and governments worldwide. In some instances the food purchased by the consumer will require further preparation, while in other cases it will be ready to eat. In all instances, the consumer expectation is that the

J. Farber (✉)
Bureau of Microbial Hazards, Health Canada, Ottawa, ON, Canada K1A 0K9
e-mail: jeff_farber@hc-sc.gc.ca

J. Crichton
Consultant, 3062 – 9th Conc N., Pakenham, ON, Canada K0A 2X0
e-mail: mail@jackiecrichton.ca

O.P. Snyder, Jr.
SnyderHACCP, P.O. Box 13734; Roseville, MN 55113, USA
e-mail: pete@snyderhaccp.com

J. Farber et al. (eds.), *Retail Food Safety*, Food Microbiology and Food Safety,
DOI 10.1007/978-1-4939-1550-7_1

products they purchase are safe to consume as purchased or that they will be able to prepare the products in such a way that they will be safe to consume.

Food safety at retail starts with good procurement practices and ends with good recall procedures that can be quickly implemented should a food safety issue occur.

For the most part, all products sold at retail must be sourced from inspected suppliers. To assist in the delivery of safe food, retailers are increasingly relying on third-party verification of suppliers' food safety systems/practices. In fact, many retailers now require that their suppliers, both domestic and import, be certified to a Global Food Safety Initiative (GFSI) benchmarked food safety scheme (see Chap. 4). One requirement of such certification schemes is increased traceability along the food supply chain. Basic traceability is "one up, one down." This means that each entity along the supply chain knows where/from whom their product has been purchased and where/to whom it has been sold. However, retail does not typically have a record of to whom they have sold a product (i.e., the final customer or final consumer) except for a few companies/programs, e.g., club stores, customer loyalty programs. It is important to note that many customers/consumers do not wish companies to have access to their purchasing habits and that for companies to access such information via club cards or customer loyalty programs, customers/consumers must sign agreements allowing companies to access their purchasing information. However, it should be noted that having consumer loyalty programs has been very beneficial in helping to identify the source of foodborne outbreaks.

Retail is a unique environment. The food processing procedures that occur at retail range from simple to complex and so do the food safety practices and procedures that need to be put in place.

This book provides information ranging from the simple and hands-on, to the more scientific and complex. If the information provided causes you to recognize the need for, as well as prompts you to consider taking steps to initiate or improve upon further action food safety in the retail environment, it will have met its goal.

Chapter 2
Control of Pathogens at Retail

G.K. Kozak, Jackie Crichton, and Jeffrey Farber

2.1 Introduction

The Public Health Agency of Canada estimates that each year roughly one in eight Canadians (or four million people) gets sick, with a domestically acquired foodborne illness (Thomas et al. 2013). There are 30 known pathogens that can cause foodborne illness (Thomas et al. 2013) and they are responsible for about 40 % of the foodborne illnesses in Canada. However, the remaining 60 % of the illnesses are caused by unspecified agents (Thomas et al. 2013). These unspecified agents were defined as: agents with insufficient data to estimate agent-specific burden; known agents not yet identified as causing foodborne illness; microbes, chemicals, or other substances known to be in food whose ability to cause illness is unproven, and agents not yet identified (Thomas et al. 2013). Each year, 31 major pathogens acquired in the USA are responsible for 9.4 million episodes of foodborne illness, about 56,000 hospitalizations, and 1,300 deaths (Scallan et al. 2011). For those

G.K. Kozak, M.Sc. (✉)
Evaluation Division, Food Directorate, Tunney's Pasture,
251 Sir Frederick Banting Driveway, Ottawa, ON, Canada K1A 0K9

Bureau of Microbial Hazards, Food Directorate, Health Products and Food Branch,
Health Canada, Ottawa, ON, Canada K1A 0K9
e-mail: gosia.kozak@hc-sc.gc.ca

J. Crichton
Consultant, 3062 – 9th Conc N,
Pakenham, ON, K0A 2X0, Canada
e-mail: mail@jackiecrichton.ca

J. Farber
Bureau of Microbial Hazards, Health Canada, Ottawa, ON, K1A 0K9 Canada
e-mail: jeff_farber@hc-sc.gc.ca

J. Farber et al. (eds.), *Retail Food Safety*, Food Microbiology and Food Safety,
DOI 10.1007/978-1-4939-1550-7_2

involved in food safety, the reduction in occurrence of foodborne illness is the number one priority. Retail stores associated with an outbreak can experience loss of clientele as well as bad publicity, both of which can have a devastating financial impact on the business. This chapter will outline the food safety risks specific to retail, as well as provide useful guidance to help prevent food contamination at various steps in food preparation, handling, and storage in a retail store.

2.2 Pathogens of Concern

2.2.1 Bacteria

Many episodes of foodborne illness are caused by bacteria. While some bacteria can be very beneficial in food industry such as in yogurt and dairy production, there are also harmful bacteria that are known to cause illness. Table 2.1 outlines the characteristics of some major foodborne pathogens. In Canada, *Clostridium perfringens*, nontyphodial *Salmonella* spp., *Campylobacter*, and *Bacillus cereus* have been identified as the top four bacterial agents causing illness (Thomas et al. 2013). In the USA, *C. perfringens*, non-typhodial *Salmonella* spp. *Campylobacter* and *Staphylococcus aureus* were among the top four illness causing microorganisms (CDC 2013), while in Europe, *Campylobacter*, *Salmonella*, Verotoxigenic *E. coli*, and *Yersina* are the most prevalent (European Food Safety Authority 2013). Most of the time, food contaminated with bacteria will smell, look, and taste normal to the consumer. It is impossible to determine the presence of harmful microorganisms by relying on your senses alone. Bacteria can contaminate food in a numbers of ways including through raw foods, contaminated water, soil, people, pests, air dust, dirt, etc.

Food contaminated with pathogenic bacteria can make you ill in two main ways. Firstly, through bacterial infection, when the ingested live bacteria, such as *Salmonella*, multiply in your body to cause illness. Secondly, through foodborne intoxication which occurs when bacteria produce toxins in the food and then the food is ingested with preformed toxin in it. Examples of organisms foodborne intoxication would be *Clostridium botulinum*, *S. aureus* and *B. cereus*.

2.2.2 Viruses

Although bacteria are responsible for many cases of foodborne illness, there are other biological hazards that can be responsible. One of these hazards are viruses, the smallest of all microorganisms. Viruses need to invade living human or animal cells to survive and, as such, they cannot grow or multiply in food. However, their

Table 2.1 Illness characteristics associated with major foodborne pathogens

Pathogen	Food associated	Symptoms	Onset time	Illness duration	Infectious dose
Campylobacter	Raw poultry, raw meat	Diarrhea, abdominal cramps, and vomiting	2–5 days	2–10 days	500 cells
Listeria monocytogenes	Raw/inadequately pasteurized milk, cheeses (particularly soft cheeses), ice cream, raw vegetables, raw poultry and meats (all types), fermented raw meat sausages, hot dogs and deli meats, and raw and smoked fish and other seafood	Develop fever, muscle aches, nausea, vomiting, and, sometimes, diarrhea. May spread to the nervous system, symptoms may include headache, stiff neck, confusion, loss of balance, and convulsions, abortion	Up to 70 days	Days to several weeks	>100 cfu/g
Salmonella nontyphi	Most often meats, poultry, eggs, milk, and dairy products	Nausea, vomiting, abdominal cramps, diarrhea, fever, headache, high fever, from 39° to 40 °C; lethargy, gastrointestinal symptoms, including abdominal pains and diarrhea or constipation; headache, achiness, loss of appetite	6–72 h	2–7 days	As little as one cell
Escherichia coli (O157)	Raw or undercooked ground beef and beef products are the vehicles most often implicated, produce, dairy products	Hemorrhagic colitis is characterized by severe cramping (abdominal pain), nausea or vomiting, and diarrhea that initially is watery, but becomes grossly bloody. In some cases, the diarrhea may be extreme, appearing to consist entirely of blood and occurring every 15–30 min. Fever typically is low grade or absent	3–4 but may range from 1 to 9 days	2–9 days	10–100 cells

(continued)

Table 2.1 (continued)

Pathogen	Food associated	Symptoms	Onset time	Illness duration	Infectious dose
Hepatitis A	Cold cuts and sandwiches, fruits and fruit juices, milk and milk products, vegetables, salads, shellfish, and iced drinks are commonly implicated in outbreaks	Fever, anorexia, nausea, vomiting, diarrhea, myalgia, hepatitis and often jaundice	30 days (range 15–50 days)	Typically 1–2 weeks	10–100 particles
Norovirus	Salad ingredients, fruits, and oysters	Symptoms usually present as acute-onset vomiting (often explosive); watery, nonbloody diarrhea with abdominal cramps and nausea	24 and 48 h	Symptoms generally persist for 12–60 h, with a mean of 24–48 h	1–10 particles
Cyclospora	Imported fresh produce, such as raspberries, basil, and several varieties of lettuce	Watery diarrhea, with frequent, sometimes explosive bowel movements. Other common symptoms include loss of appetite, weight loss, abdominal cramping and bloating, nausea and fatigue	2–14 days (mean 1 week)	Days to months	NA
Vibrio parahaemolyticus	Raw or improperly cooked oysters	Diarrhea, abdominal cramps, nausea, vomiting, fever, and bloody diarrhea	4–90 h; mean of 17 h	2–6 days	ID50 of 100 million cells
Cryptosporidium	Any food touched by an infected food handler or from contact with an environmental source of oocysts	Profuse, watery diarrhea, along with nausea, vomiting, and cramping. Fever can also accompany these symptoms.	3–5 days, up to 2 weeks	2–4 days, but can last up to two weeks	10–100 oocytes

Giardia	Has been isolated from root crops, lettuces, herbs, and strawberries irrigated with wastewater	GI disease. In some people, the results may be more serious (severe diarrhea, dehydration, and loss of weight), and occasionally life-threatening	1–3 weeks	2–6 weeks	As few as 10 cysts
Toxoplasma	Meat can contain cysts; particularly pork, as well as sheep and goat meat	In 80–90 % of healthy humans, infection is asymptomatic and clinical toxoplasmosis is rare. In the remaining 10–20 % cases, a viral-like febrile illness occurs with swollen lymph nodes, a rash, malaise, and 'flu' like symptoms; vertical transmission possible	5–23 days	Several weeks, 90 % asymptomatic	NA

Adapted from (FDA 2012; Public Health Agency of Canada (PHAC) 2013; Food Standards Australia New Zealand (FSANZ) 2013) presence on foods can cause serious illness. In fact, norovirus is the number one foodborne pathogen in Canada and the USA, while in Europe it is among the top three pathogens. Other viruses such as hepatovirus, astrovirus, and enterovirus and others have also been associated with foodborne illness (Vasickova et al. 2005). In addition, some viruses, e.g., norovirus, are highly infectious and can lead to secondary cases and widespread outbreaks (Vega et al. 2014).

2.2.3 Parasites

Parasites are another biological organism that can cause foodborne illness. These organisms often have complicated life cycles, which can involve numerous hosts before they infect humans. With the increase in globalization, a growing number of foodborne parasites have emerged as new agents causing foodborne illness (Robertson et al. 2013). Recent work done by the FAO/WHO to prioritize foodborne parasites, ranked the top foodborne illness associated parasites, as follows; *Taenia solium*, *Echinococcus granulosus*, *E. multilocularis*, *Toxoplasma gondii* and *Cryptosporidium* (FAO 2012).

2.3 How Food Can Become Contaminated at Retail

While food can become contaminated at any stage of the farm-to-fork continuum, this chapter will focus on the major sources of contamination which can occur at the retail level. The intrinsic factors which can affect pathogen survival are outlined in Table 2.2.

Table 2.2 Intrinsic factors affecting the survival and growth of some foodborne bacterial pathogens

Pathogen	Temperature	pH	Water activity (a_w)
Campylobacter	Optimum 42 °C, range 32–45 °C	Optimum 6.5–7.5, range 4.5–9.5	Optimum growth $a_w = 0.997$
Listeria monocytogenes	Optimum 30–37 °C, range −1.5 to 45 °C.	Optimum 6.5–7.5, range 4.0–9.6	Optimum growth $a_w = 0.90$
Salmonella (nontyphi)	5.2–46.2 °C, optimum 35–43 °C	Range 3.8–9.5 optimum, 7–7.5	Min 0.93
			Max >0.99
			Optimum 0.99
Escherichia coli (O157)	Optimum 37 °C, min 7–8 °C, max 46 °C	Optimum 6–7, range 4.4–10.0	Optimum growth $a_w = 0.99$
			Min $a_w = 0.95$
Vibrio parahaemolyticus	20–35 °C; it can grow at temperatures up to 41 °C	Optimum 7.8–8.6; range 4.8–11	a_w range is 0.94–0.99, with an optimum of 0.98

Min minimum, *Max* maximum

2.3.1 Transportation

Since most consumers do not shop directly from the local farmer, the global nature of the food supply can result in food traveling hundreds, if not thousands of kilometers before reaching the local retail store. Over 200 billion metric tons of foods are transported every year globally, by land, sea and air (Bendickson 2007). Most of the food transported has unique container storage, temperature and handling requirements. Food is very vulnerable to contamination during transportation. Some of the risk factors that can be associated with transportation are temperature abuse, unsanitary cargo areas, improper loading/unloading practices, damaged packaging, poor road conditions and human error (Ackerley et al. 2010). When it comes to retail, trucks are the preferred mode of transportation to the store. In the USA, over 80 % of all food shipments and 91 % of temperature controlled freight shipments are transported by truck (Ackerley et al. 2010).

A recent study identified the top five food safety hazards across all modes of transportation; (1) lack of security for transportation units or storage facilities; (2) improper handling practices of food products awaiting shipment or inspection; (3) improper refrigeration or temperature control of food products; improper management of transportation units and storage facilities; (4) improper loading practices and (5) conditions of equipment (Ackerley et al. 2010). The foods most at risk were identified as fresh produce, raw and refrigerated ready-to-eat (RTE) foods, raw meat and raw poultry, eggs and egg products and raw seafood (Ackerley et al. 2010). The global nature of the food supply results in many of the food products spending a large amount of time in the process of transportation. Estrada-Flores et al. (2006) tracked the temperature of frozen fish over 20 days of transport and showed that the temperature of the fish continued to rise to the point that it could support the growth of *Yersinia enterocolitica* and *Listeria monocytogenes*.

There is a strong possibility of cross-contamination when multiple food commodities are shipped together. This can sometimes happen with half-full loads, where companies may ship several food items together (Keener 2003).

2.3.2 Storage

2.3.2.1 Time and Temperature

Microorganisms thrive in warm temperatures. Temperatures between 4 and 60 °C are referred to as the Danger Zone, as these are the temperatures in which microorganisms grow and thrive. Many microorganisms are killed when exposed to temperatures of 60 °C for several minutes. However, temperatures below freezing do not kill most microorganisms, but invoke dormancy, a time during which the microorganisms cannot grow and multiply. It is also important to know that some bacteria such as *L. monocytogenes*, actually grow well at refrigeration temperatures.

Typically, bacteria under the right conditions and temperature have a doubling time of about 20–30 min. Some bacteria need very few cells, e.g., as little as four to five in the case of *Salmonella* spp. to cause illness. This is why even if food is left unattended in the 'Danger Zone' for as little as 2 h, it can lead to foodborne illness. This effect is cumulative, i.e., even if a food is kept at an improper storage temperature for only a few minutes at various stages of production such as shipping, receiving, storage and preparation, it can result in a overall time temperature relationship which can lead to foodborne illness (Canadian Restaurant and Foodservice Association 2013).

2.3.2.2 Water Activity

Pathogenic bacteria need moisture to reproduce and thrive. This is why moist foods such as meats, fish and dairy products are viewed as potentially-hazardous products. Dry foods such as powders have a longer shelf-life because they do not support microbial growth. However, if water is added to these powders (such as water to milk powder), the subsequent product will be susceptible to bacterial growth. It should be noted, however, that there has been an increased concern of late with the entire category of "low moisture" foods as they have been involved in a number of outbreaks in recent years (Association of Food Beverage and Consumer Products companies 2009). It is important to remember that if water is present on food preparation surfaces or utensils, it will help to support bacterial growth (Canadian Restaurant and Foodservice Association 2013).

2.3.2.3 Acidity

Most microorganisms do not grow on foods that are acidic (pH 4.6 or lower) or foods that are alkaline (7.5 or higher). Therefore, if a food falls between these two pH ranges, it is susceptible to bacterial growth. However, *E. coli* O157:H7 can survive in low pH products; therefore acidity cannot be solely relied upon when preserving products. In the hurdle effect, each hurdle aims to inhibit or inactivate unwanted microorganisms (Leistner 2000). When several hurdles are used together, it is very likely that at least one will inhibit a select microorganism. The "higher the hurdle, the greater the number of pathogens needed to overcome it". A food can be made microbiologically safe and stable when one uses multiple hurdles that can be used either in combination singly or synergistically. Hurdle technology will become even more important in the future as the trend toward minimally prepared and healthier, e.g., reduced sodium, food alternatives continue to grow. This would include the use of some newer non-thermal technologies such as high-pressure processing in combination with, e.g., thermal treatments.

2.3.2.4 Product Flow at Retail

When purchasing foods, it is important to ensure that they come from reliable vendors, and from sources that comply with national and local food codes. When receiving a food, employees should ensure that it is within its best before date, and it has come in clean and undamaged packaging. The food should arrive at the temperature which is deemed safe for the product and be free of pests. Foods that should be refrigerated should be done so promptly, while foods that need to be frozen should be frozen. In addition, the potential for cross-contamination between products needs to be addressed.

When a food arrives at retail, it is important to ensure that it is stored in such a way as to limit or prevent bacterial growth, as well as prevent cross-contamination. In a recent FDA report on risk factors at retail, failure to control product holding temperatures and times was a major risk factor and had the highest 'Out of Compliance' percentage, i.e., 52.1 % of produce departments tested were out of compliance. In the meat sector, 19.2 % of meat and poultry departments were out of compliance for holding temperature (FDA 2009). Control of cold-holding temperatures and date marking can provide added protection by slowing the growth of *L. monocytogenes* and establishing a time limit for discarding food before the organism can multiply to potentially dangerous levels (FDA 2009).

Potentially hazardous foods should be stored at a temperature of 4 °C or below. This is important as most microorganisms (with the notable exception of *Yersinia*, nonproteolytic *C. botulinum*, psychrotrophic *B. cereus*, and *Listeria*) do not grow or multiply at that temperature. Studies have shown that almost 30 % of retail inspections find improper holding times or holding temperatures, refrigeration that is broken or old refrigeration that was designed when the maximum cold-holding temperature was 45 °F/7 °C (Parsons 2010). When refrigerating foods, it is important to load them properly to prevent cross-contamination. Raw foods such as meat should be stored separately from RTE foods and raw meats should be stored in the bottom of the refrigerator so that they do not drip onto other foods. In addition, refrigerators should not be overcrowded so that the air can circulate freely. When loading the display case, it is important not to overstock or block any vents. Freezing food is important in maintaining freshness and preventing microbial contamination. Frozen food that has been thawed should not be refrozen, as bacteria may have already begun to multiply.

In Canada, shelf life information is required on food packaging on foods having a durable shelf life less than 90 days. This food is required by the *Food and Drug Regulations* in Canada to be labeled with "packaged on" with a date and durable life information, "packaged on" and "best before" date info (Health Canada 2013).

2.4 Preparation

Microbial contamination can occur during food preparation at the retail level. Food contamination can occur during washing, peeling, cutting, mixing, portioning, plating, and decorating of food. For example, one study found that between 1992 and

2006, 4 % of all gastroenteritis was as a result of the consumption of prepared salads, affecting over 3,400 people (Little and Gillespie 2008).

When thawing foods such as meat or chicken, it is important to thaw them at a temperature at which pathogenic bacteria cannot multiply. As such, food should be thawed at 4 °C or colder, microwaved (but only if that food will immediately be further prepared), or submerged in cold running water only if packaged (Canadian Restaurant and Foodservice Association 2013).

During and following cooking food passes through the danger zone. It is important that this transition occurs as quickly as possible and under controlled conditions, i.e., cooking and chilling/cooling should be done as quickly as possible to achieve the desired temperature. Table 2.3 provides a list of recommended safe internal temperatures that one can use for cooked foods.

Food should be rotated to ensure that there are no cold zones or spots which would suggest uneven heat distribution. The use of a food thermometer is necessary to ensure that the proper temperature has been achieved. Sometimes food that has been cooled has to be reheated again. According to the USA FDA Food Code, potentially hazardous food that has been already heated and cooled must be reheated to a minimum internal temperature of 74 °C for at least 15 s. This temperature must be achieved within 2 h (FDA 2009). Cooked or reheated food which is not requested for immediate consumption must be held at 57 °C or higher to be kept out of the bacterial danger zone. Alternatively, food that must be kept at a cool temperature should be kept at 5 °C or lower (FDA 2009).

Cutting or peeling of food can also spread microbes if the cutting utensil is contaminated. In these cases, the utensil can move the contamination to multiple sources.

Food handlers are also a potential source of contamination. In fact, food handlers have been identified as a source in various foodborne outbreaks. Contamination

Table 2.3 Safe internal temperatures for cooked foods

Food	Safe internal temperature
Food mixtures containing, meat, poultry, fish, eggs, and other potentially hazardous foods	74 °C (165 °F)
Pork, lamb, veal, beef (whole cuts)	71 °C (160 °F)
Rare roast beef	63 °C (145 °F); hold for 3 min
Poultry	85 °C (185 °F)
Poultry cuts	74 °C (165 °F)
Stuffing in poultry	74 °C (165 °F)
Ground meat	71 °C (160 °F)
Ground poultry	74 °C (165 °F)
Eggs	63 °C (145 °F)
Fish	70 °C (158 °F)
Shrimp	74 °C (165 °F)
Reheating temperature	74 °C (165 °F)[a]
Hold hot food	60 °C (140 °F) or higher

Adapted from Health Canada and Retail Council of Canada (2013)
[a]Foods should only be reheated once

commonly occurs through the fecal–oral route starting with the infected food handler. The food handler may exhibit obvious signs of illness, such as vomiting, but even if the ill food handler immediately leaves the work environment, residual vomitus can contaminate food, contact surfaces, and fellow workers unless the clean-up process is meticulous (Todd et al. 2008). It is of vital importance that employees do not handle food when they are ill. The USA Food Code requires that employees report to a person in charge if they recently had a foodborne illness or any other illness with similar symptoms.

A large study of outbreaks caused by foodservice workers identified that 80,682 cases of confirmed illness occurring between 1927 to the first quarter of 2006 were caused by food workers (Greig et al. 2007). The FDA Food Code outlines methods to prevent contamination by food workers. These methods include hand washing and the prevention or minimization of bare hand contact with food. The Code also provides a list of situations in which hands should be washed, such as before food preparation and after handling dirty equipment. The Food Code also indicates that hand washing should take at least 20 s and include running warm water, soap, friction between hands for 10 and 15 s, rinsing, and drying with clean towels or hot air. As hand washing does not remove all pathogens from hands (Michaels 2002), the Food Code also specifies that bare hand contact should be prevented when working with ready-to-eat food (i.e., foods that are safe to eat without further cooking) and minimized when working with non-RTE food by the use of barriers such as disposable gloves, deli tissue and utensils. A recent study observed a 5–30 % compliance with the hand washing guidelines in the FDA Food Code, in various food facilities, such as assisted living, restaurants, and childcare settings (Strohbehn et al. 2008). Although retail stores were not studied, one can assume that the results can be applied across the foodservice industry. Employees should wash their hands before starting work or touching raw or potentially hazardous food, utensils, or using disposable gloves. Washing is also encouraged during food preparation and when switching between handling raw and cooked and RTE foods. Hands should also be washed after handling raw foods including eggs, visiting the washroom, coughing, sneezing, sanitizing equipment, taking a break, etc.

2.5 Susceptible Populations and Foodborne Illness

In the USA, vulnerable groups were estimated to represent almost 20 % of the population (Gerba et al. 1996). People who are highly susceptible include the elderly, pregnant women and children, and people with a weakened immune system (due to factors such as illness). The effects of illness for these groups can lead to much more severe consequences and even life-threatening complications. Prominent sequelae associated with foodborne infections could include irritable bowel syndrome, inflammatory bowel diseases, reactive arthritis, hemolytic-uremic syndrome, chronic kidney disease, Guillain–Barré Syndrome, neurological disorders from acquired and congenital listeriosis, and toxoplasmosis and cognitive and development deficits due to severe acute illness or diarrheal malnutrition (Batz et al. 2013). There is a lot of food safety information available for all at-risk groups (U.S. Department of Health and Human Services 2013; Government of Canada 2014).

2.6 Conclusions

The food safety controls available and put in place at the retail level are used to control all microorganisms rather than any one specific pathogen.

These major controls include:

1. Sourcing and procurement (from inspected sources)
2. Protecting food from contamination and cross-contamination (from receiving through to sale to the consumer)
3. Temperature control (to kill and/or limit the growth of microorganisms, both pathogens and spoilage organisms)
4. Cleaning and sanitizing (to minimize the transfer of pathogens)
5. Durable life dating (products with a shelf life of less than 90 days)
6. Product rotation (earliest best before date used/sold first) and
7. Employee training (in the processes and handling practices available at retail to control the growth and transfer of pathogens)

References

Ackerley N, Sertkaya A, Lange R (2010) Food transportation safety: characterizing risks and controls by use of expert opinion. Food Prot Trends 30(4):212–222

Association of Food Beverage and Consumer Products companies (2009) Control of *Salmonella* in low-moisture foods. http://www.gmaonline.org/downloads/technical-guidance-and-tools/SalmonellaControlGuidance.pdf. Accessed 20 Feb 2014

Batz M, Henke E, Kowalcyk B (2013) Long-term consequences of foodborne infections. Infect Dis Clin North Am 27:599–616

Bendickson NJ (2007) Transportation and food distribution security. http://www.asse.org/newsroom/naosh07/docs/trans_transfood.pdf. Accessed 20 Nov 2013

Centers for Disease Control and Prevention (2013) CDC 2011 estimates: findings. CDC estimates of foodborne illness in the United States. http://www.cdc.gov/foodborneburden/2011-foodborne-estimates.html. Accessed 3 March 2014

Canadian Restaurant and Foodservice Association (2013) Food safety code of practice: for Canada's foodservice industry. CRFA, Toronto

Estrada-Flores S, Smale N, Tanner D (2006) Temperature regulations during the transport of perishables in Australia. 13th World Congress of Food Science & Technology, IUFOST

European Food Safety Authority (2013) The European Union Summary report on trends and sources of zoonoses and zoonotic agents and food-borne outbreaks in 2011. EFSA J 11:3129

FAO (2012) Multicriteria-based ranking for risk management of foodborne parasites. Meeting on 3–7 Sep. http://www.fao.org/fileadmin/user_upload/agns/news_events/Parasite%20report%20final%20draft-25October2012.pdf. Accessed 21 Feb 2014

Food Standards Australia New Zealand (2013) Agents of foodborne illness, 2nd edn. FSANZ, Canberra

Food and Drug Administration (2009) FDA report on the occurrence of foodborne illness risk factors in selected institutional foodservice, restaurant, and retail food store facility types. http://www.fda.gov/downloads/Food/GuidanceRegulation/RetailFoodProtection/FoodborneIllnessRiskFactorReduction/UCM224682.pdf. Accessed 18 Nov 2013

Food and Drug Administration (2012) Bad bug book, foodborne pathogenic microorganisms and natural toxins, 2nd edn. FDA, Washington, DC

Gerba CP, Rose JB, Haas CN (1996) Sensitive populations: who is at greatest risk? Int J Food Microbiol 30:113–123

Government of Canada (2014) Tips for vulnerable populations http://www.healthycanadians.gc.ca/eating-nutrition/safety-salubrite/index-eng.php#a2. Accessed 10 Feb 2014

Greig JD, Todd EC, Bartleson CA et al (2007) Outbreak where food workers have been implicated in the spread of foodborne disease. Part 1. Description of the problem, methods, and agents involved. J Food Prot 70(7):1752–1761

Health Canada and Retail Council of Canada (2013) Retail guidance document; pathogen control (including *Listeria monocytogenes*) in ready-to-eat refrigerated foods. http://www.retailcouncil.org/sites/default/files/documents/retail-guidance-doc_EN.pdf. Accessed 20 Feb 2014

Keener L (2003) Transportation: the squeaky wheel of the food safety system. Food Safety Magazine. Oct/Nov 2003

Leistner I (2000) Basic aspects of food preservation by hurdle technology. Int J Food Microbiol 55:181–186

Little CL, Gillespie IA (2008) Prepared salads and public health. J Appl Microbiol 105:1729–1743

Michaels B (2002) Handwashing: an effective tool in the food safety arsenal. J Food Quality 9:45–53

Parsons BE (2010) Prepared foods: fast and easy for the consumer but prepared safely? *Food Safety Magazine*. June/July 2010

Public Health Agency of Canada (PHAC) (2013) Pathogen safety data sheets and risk assessment. http://www.phac-aspc.gc.ca/lab-bio/res/psds-ftss/index-eng.php. Accessed 21 Feb 2014

Robertson LJ, Sprong H, Ortega YR, van der Giessen JWB, Faver R (2013) Impacts of globalisation on foodborne parasites. Trends Parasitol 30(1):37–52

Scallan E, Hoekstra RM, Angulo FJ et al (2011) Foodborne illness acquired in the United States-major pathogens. Emerg Infect Dis 17(1):7–15

Strohbehn C, Sneed J, Paez P et al (2008) Hand washing frequencies and procedures used in retail food service. J Food Prot 71(8):1641–1650

Thomas MK, Murray R, Flockhart L (2013) Estimates of the burden of foodborne illness in Canada for 30 specified pathogens and unspecified agents, circa 2006. Foodborne Pathog Dis 10(7):639–648

Todd EC, Greig JD, Bartleson CA et al (2008) Outbreaks where food workers have been implicated in the spread of foodborne disease. Part 5. Sources of contamination and pathogen excretion from infected persons. J Food Prot 71(21):2582–2595

U.S. Department of Health and Human Services (2013) Who is at risk. www.foodsafety.gov.poisoning/risk. Accessed 19 Feb 2014

Vasickova P, Dvorska L, Lorencova A (2005) Viruses as a cause of foodborne diseases: a review of the literature. Vet Med (Praha) 50(3):89–104

Vega E, Barclay L, Gregoricus N et al (2014) Genotypic and epidemiologic trends of norovirus outbreaks in the United States, 2009 to 2013. J Clin Microbiol 52:147–155

Chapter 3
Potential Food Safety Risks: Total Store and by Department

Jackie Crichton

3.1 Introduction

When identifying potential food safety risks at retail, it is important to recognize that these potential risks vary based on a number of factors. These factors include: the store format, the nature of the products offered for sale, the grouping of such products into departments, the number and complexity of the food preparation steps that occur within the store, and the manner in which products are displayed. It should also be noted that from a food safety management perspective, and in all instances, the requirements of the regulatory authority having jurisdiction should take precedence, i.e., should be consulted and adhered to.

Retail food stores are typically divided into departments. For the most part, departments are groupings of like products. Such groupings may, however, vary significantly from one store to another based on a company's sales and marketing philosophy and the level to which cross-merchandising is done.

Regardless of format, the identification and management of potential food safety risks starts at the point of sourcing and procurement. It is important that the nature and history of the product category, the specific supplier, and the specific product be taken into consideration (e.g., product recalls associated with the product category in general, the specific supplier, or the specific product).

When identifying potential food safety risks within a retail food store, it is important to follow product from the point of receipt at the store, through to the point of purchase by the consumer. In some store formats, all products are received, stored, and displayed in the original manufacturer's fully labelled, consumer-ready package

J. Crichton (✉)
Consultant, 3062 – 9th Conc N., Pakenham, ON, Canada K0A 2X0
e-mail: mail@jackiecrichton.ca

J. Farber et al. (eds.), *Retail Food Safety*, Food Microbiology and Food Safety,
DOI 10.1007/978-1-4939-1550-7_3

(i.e., packages are not opened at the store level). This is the least complex of all store or department formats. In other store formats, almost all products may be prepared in-store. In-store preparation within these formats, or within departments within these formats, may range from simple "thaw and sell" to "portioning only" to complex, multi-step and multi-ingredient, preparation that may or may not require a cook step in order to result in a safe final product. It is important to note that most retail food stores are not designed to allow for straight line, or dedicated line production. Time, including cleaning and sanitizing, rather than location, is frequently the means of separation of production.

Regardless of whether potential food safety risks are identified as being specific to an incoming product or a product further processed within the store, the steps available to and used in the management of the potential food safety risks at the store level are similar across all store formats and departments.

Table 3.1 provides an example of a Total Store by Department by Process Recap. This table can be used as a starting point to identify and manage potential food safety risks for any retail location.

When the terms "product" or "products" are used in this Chapter, they are intended to include both ingredient(s) and finished product(s).

3.2 Potential Food Safety Risks: Biological, Chemical (Including Allergen), Physical

The potential food safety risks to be identified and managed fall into three categories:

1. Biological (e.g., microbiological—bacterial, viral, parasitic)
2. Chemical (e.g., microbial toxins, allergens, non-food chemicals, improperly used chemicals)
3. Physical (e.g., pits, metal, glass, wood, jewellery, wound coverings)

Information on specific biological risks is available on the Health Canada website Health Canada—*Food-Related Illnesses*. The U.S. Food and Drug Administration—*Bad Bug Book* is also a source of information.

It is important to note that the food safety management practices put in place at retail are generally intended to manage all potential food safety risks, rather than any specific microorganism, chemical, or physical risk. Health Canada and the Retail Council of Canada have released a joint document entitled *Retail Guidance Document—Pathogen Control (including Listeria monocytogenes) in RTE Refrigerated Foods* (2013). The Retail Guidance Document provides an overview of food safety management at retail.

Table 3.1 Total store—departments and processes

		Department						
	Process	Grocery[a]	Produce (includes cut fruit and juice)	Bakery (in-store)	Meat and poultry (raw)	Fish and seafood	Traditional deli (portion only)	Home meal replacement (HMR) includes salad bar/buffet
1.	Sourcing/procurement: food/ingredients, equipment, chemicals	x	x	x	x	x	x	x
2.	Receiving							
	– Ambient	x	x	x				x
	– Refrigerated	x	x	x	x	x	x	x
	– Frozen	x		x	x	x		x
3.	Storage							
	– Ambient	x	x	x				x
	– Refrigerated	x	x	x	x	x	x	x
	– Frozen	x		x	x	x		x
4.	Preparation							
	– Thaw and sell			x	x	x		x
	– Portion only		x	x	x	x	x	x
	– Portion and assemble/mix only			x	x	x		x
	– Reheat (from fully cooked)			x				x
	– Cook/bake			x				x
	– Chill/cool			x				x
5.	Package/label							
	– Label only			x	x	x	x	x
	– Package and label		x	x	x	x	x	x

(continued)

Table 3.1 (continued)

		Department						
	Process	Grocery[a]	Produce (includes cut fruit and juice)	Bakery (in-store)	Meat and poultry (raw)	Fish and seafood	Traditional deli (portion only)	Home meal replacement (HMR) includes salad bar/buffet
6.	Display							
	(a) *Service*							
	– Ambient			x				
	– Refrigerated			x	x	x	x	x
	– Frozen			x	x	x		x
	(b) *Self-serve packaged*							
	– Ambient	x	x	x				x
	– Refrigerated	x	x	x	x	x	x	x
	– Frozen	x		x	x	x		x
	(c) *Self-serve bulk*							
	– Ambient		x	x				
	– Refrigerated		x	x				
	– Frozen					x		
	(d) *Self-serve salad bar/buffet*							
	– Ambient							x
	– Refrigerated							x
	– Frozen							
	(e) *Product sampling*							
	– Staffed	x	x	x	x	x	x	x
	– Unstaffed/silent	x	x	x	x	x	x	x
7.	Checkout/front end	x	x	x	x	x	x	x

[a]Grocery: includes shelf-stable, refrigerated and frozen commercial bakery, commercial dairy, and frozen foods received in fully labelled consumer-ready packages

Note: This table is only provided as an example. The combination of processes that occur in any given retail location will vary based on company philosophy. Particular attention should be paid to cross-merchandizing of products in order to ensure appropriate handling, temperature controls, etc.

3.2.1 Identification and Management of Potential Food Safety Risks—Total Store

The following factors apply across all store formats and all departments.

3.2.1.1 Sourcing and Procurement

Regulations generally require that food products be sourced and procured from inspected sources (i.e., inspected by federal, provincial, or municipal government as appropriate to the product). The means of identifying and managing potential food safety risks prior to procurement include requesting copies of inspection reports from potential suppliers and checking for product recalls associated with the product category, specific company, or specific product. Product recall notifications are posted on the Canadian Food Inspection Agency website (CFIA—*Food Recalls and Allergy Alerts*) and are also available from other international sources. Retailers may also require third party food safety certification of their suppliers (e.g., to an appropriate GFSI benchmarked scheme—see Chap. 4).

Materials (e.g., packaging), equipment, and chemicals should be appropriate to the intended purpose and used as per manufacturer or supplier instructions.

3.2.1.2 Temperature Control and Rotation (also Referred to as Time/Temperature)

Across all departments, from receiving through to point of sale, the two most important factors available to retail for the control of microbial growth are temperature and product rotation.

It is imperative that potentially hazardous foods be maintained at a temperature that will minimize the opportunity for the growth of pathogens and the production of microbial toxins.

Potentially hazardous products are those that will support the growth of pathogens or the production of microbial toxins. The Canadian Food Inspection System Implementation Group—*Food Retail and Food Services Code 2004* provides the following definition:

> Potentially Hazardous Food: any food that consists in whole or in part of milk or milk products, eggs, meat, poultry, fish, shellfish (edible mollusca and crustacea), or any other ingredients, in a form capable of supporting growth of infectious and/or toxigenic microorganisms. This does not include foods which have a pH level of 4.6 or below and foods which have a water activity of 0.85 or less.

Potential food safety risks associated with a lack of temperature control and rotation include the growth of pathogens to unsafe levels and the production of microbial toxins (e.g., *Salmonella* spp., *Listeria monocytogenes*, *Staphylococcus aureus*).

Product temperature guidelines are provided on the Government of Canada—Healthy Canadians website along with *Recommended Storage Times*. Temperature

Guidelines are also provided in the Canadian Food Inspection System Implementation Group—*Food Retail and Food Services Code 2004*. Temperatures may also be specified in provincial/state regulations. It is important to be aware of and comply with the temperature requirements of the regulatory jurisdiction in which a store is located. Temperatures may vary somewhat from one jurisdiction to another. Generally:

- Products that do not have storage instructions on the label are shelf-stable and are maintained at ambient/room temperature
- Products labelled "keep refrigerated" are maintained at 4 °C or below
- Products labelled "frozen" are maintained at−18 °C or frozen solid

In those instances where a thaw-and-sell product is a potentially hazardous product (i.e., requires temperature control once it is thawed), it is important to ensure that the product temperature does not go above 4 °C during the thawing process. Non-potentially hazardous thaw-and-sell products that are intended for sale at ambient temperature may be thawed at ambient.

Product rotation, on a First In First Out/First Expired First Out basis, minimizes the potential for microbial growth and toxin production and also aids in saleability, maintenance of product quality, and reduces the potential for infestation as applicable to the specific product.

It is imperative that product be received at retail at the appropriate temperature and with adequate durable life.

On a product-specific basis, it is important that product be:

- Reheated, cooked, or baked to the appropriate temperature
- Held hot at 60 °C or above
- Chilled to the appropriate temperature within the appropriate time frame and then maintained at 4 °C or below
- Rotated to minimize the opportunity for growth of pathogenic microorganisms and the production of microbial toxins

3.2.1.3 Labelling/Service Case Tags/Signage

Food labels assist in the management of potential food safety risks by providing retailers and consumers with a variety of information. Depending on the product and the level at which it is packaged, such information may include, but is not limited to: product description; net quantity; storage instructions; durable life information; name and address of the responsibly party; ingredient and allergen information and preparation instructions.

Details in regard to Canadian food labelling requirements can be found in the Food and Drug Regulations, the Consumer Packaging and Labelling Regulations, the Canadian Food Inspection Agency—*Guide to Food Labelling and Advertising* as well as in other commodity-specific legislation.

Details in regard to labelling requirements in the United States can be found in the *Federal Food*, *Drug and Cosmetics Act*, the *Fair Packaging and Labeling Act*, the *Nutrition Labelling and Education Act*, U.S. Food and Drug Administration—

Guidance for Industry—Food Labeling Guide as well as other commodity-specific legislation. Similar legislation and guidance exists in other jurisdictions and should be accessed for specific requirements.

Supplier packaged products that arrive at the store level in consumer-ready packages are fully labelled for retail sale (e.g., canned and jarred goods, boxed cereals, commercial bakery and dairy, frozen entrees, frozen vegetables, refrigerated processed meat). Such products arrive at the store level ready to be placed on retail shelves or in appropriate retail display units.

In some instances, products arrive at store level labelled with all required information except the durable life date (e.g., some thaw-and-sell products, case-ready fresh meat that arrives at store level in a modified atmosphere master pack). The durable life date is applied to such products at store level based on instructions provided by the supplier.

Products may also arrive at the store level in master packs, bulk containers, loaves, chubs, etc., for further preparation at retail. Further preparation may include any or all of the following: portioning; assembly or mixing; reheating (from fully cooked); cooking or baking from raw and chilling for refrigerated sale or cooling for ambient sale. Following preparation, products may be sold from service cases or packaged for sale from self-serve cases. In some instances, products may also be offered for sale from bulk self-serve display units.

When packaged at the store level, it is the responsibility of the store to ensure proper labelling of the finished product. Products sold from service cases or bulks self-serve display units are "labelled" by way of case tags or signage.

Labelling, service case tags, and signage are also means of providing consumers with information in regard to the presence of allergens.

3.2.1.4 Protection from Contamination and Cross-Contamination

The grouping of like products and processes into departments may aid in minimizing the potential risks of contamination and cross-contamination. Having said this, retail locations are rarely in the position of being able to devote a given storage unit, preparation area, or line to one product-type or process. The segregation of products (e.g., raw from ready-to-eat) in storage is generally accomplished by way of physical separation (e.g., raw stored below ready-to-eat or on separate footprints). The separation of product preparation processes may, however, frequently be accomplished by way of time in conjunction with cleaning and sanitizing rather than by use of a dedicated location, production line, or equipment.

Protection from damage, contamination, and cross-contamination includes ensuring that equipment is in good repair and functioning appropriately.

3.2.1.5 Cleaning and Sanitizing (Also See Chap. 9. Sanitation and Sanitation Issues at Retail)

Cleaning and sanitizing is the number one control available at retail to minimize the transfer of microorganisms. Cleaning and sanitizing also minimizes the transfer of allergens.

The process of cleaning and sanitizing is generally a three-step process:

- Clean/wash (using a chemical detergent or degreaser)
- Rinse (using potable water)
- Sanitize (using a chemical sanitizer or extremely hot water)

Depending on the sanitizer and/or the concentration of the sanitizer used, the sanitize step may be followed by a rinse step.

It is important to minimize the "splash" during cleaning and sanitizing as this may spread microorganisms from one surface to another.

Cleaning and sanitizing applies to all food contact surfaces, e.g., preparation tables, utensils, and in food preparation areas, is also recommended for non-food contact surfaces, e.g., preparation table legs, service case door handles.

Cleaning alone, or housekeeping, applies to all areas of the store, both food and non-food.

3.2.1.6 Water/Ice

Water for food contact (including the making of ice, misting of produce, etc.), cleaning, and sanitizing is required by regulation to be from potable sources.

3.2.1.7 Employee Training (also see Chap. 10. Retail Food Handler Certification and Food Handler Training)

Employee training to a level appropriate to his or her respective job function(s) is an important factor in the management of potential food safety risks. Employees may be a source of potential food safety risks. When properly trained, employees have the potential to minimize potential food safety risks within a retail environment. It is recommended that such training include personal health, hygiene, and habits, as well as food handling practices applicable to the employee's role within the store and specific department.

3.3 Identification and Management of Potential Food Safety Risks—by Department

3.3.1 Grocery (Including Shelf-Stable, Refrigerated and Frozen Commercial Bakery, Commercial Dairy and Frozen Foods Received Fully Labelled for Retail Sale)

From a retail food safety perspective, product that is received, stored, and displayed in the original manufacturer's fully labelled, consumer-ready package is typically considered to be among the lowest risk product in a store. This is because the product is not opened at store level. Such product is received, stored, and displayed at the appropriate temperature as indicated on the manufacturer's label and rotated on a First In First Out/First Expired First Out basis. The product inside the package may be a finished/ready-to-eat product (e.g., loaf of bread, processed meat) or it may be a product that requires in-home preparation (e.g., case-ready raw meat) or assembly prior to consumption, e.g., cake mix. In some instances, the product may require refrigeration after opening, e.g., salad dressing.

The potential food safety risks (i.e., biological, chemical, and physical) associated with these products are largely controlled by the manufacturer at the time of production and packaging, or, by the consumer by way of in-home handling practices leading up to consumption, e.g., assembly; temperature control including storage, cooking, reheating.

The management of potential food safety risks associated with grocery products is largely by way of sourcing and procurement, temperature control and rotation, protection from damage and potential contamination should damage occur, and the removal of implicated product from distribution/sale at the time of a recall.

The type of product described here as Grocery may also be sold in other departments and should be treated appropriately, e.g., if chip dip labelled "Keep Refrigerated" is sold in the grocery aisle alongside chips, or milk is sold at the checkout/front end, it would need to be sold from a display unit that maintains the internal temperature of the product at 4 °C or below.

3.3.2 Produce (Including In-Store Cut Fruit/Vegetables and Juice)

From a retail perspective, whole produce, including tree nuts, that arrives at the store and is sold to consumers as whole produce, without any in-store preparation other than in some instances trimming, is considered low risk. Having said this, it is important to remember that produce is grown in soil, fertilized, irrigated and exposed to various environmental factors (e.g., wildlife, pests) and has been associated with a number of food safety recalls and outbreaks (*Cyclospora* and basil, *E. coli* and lettuce, *Salmonella* and sprouts, etc.).

It is generally recognized that whole produce should be washed, peeled and/or cooked prior to consumption. Some whole produce has been washed prior to arriving at store level, while some has not. It is, therefore, recommended that whole produce be washed with cool, potable, running water prior to further processing at the store level (i.e., prior to cutting or juicing). A produce brush is recommended when washing firm textured produce prior to further processing. Sinks, cutting surfaces, knives, produce brushes, juicers and other food contact equipment should be cleaned and sanitized at a frequency that minimizes the risk of transfer of microorganisms.

In-store cut produce (e.g., cut watermelon, cut cantaloupe, shredded cabbage, cut lettuce) and juice made in-store should be refrigerated at 4 °C or below to minimize the potential growth of pathogens. The Food Marketing Institute (FMI)—*A Total Food Safety Management Guide A Model Program For Category*: *Raw Sold as*

Ready To Eat Product: *Fresh-Cut Produce* (2003) provides details in regard to the preparation of cut produce at retail.

Juice made in-store is not pasteurized and, therefore, should be labelled as "unpasteurized". In fact, unpasteurized juices have been involved in foodborne outbreaks (Kozak et al. 2013, Mihajlovic et al. 2013). For additional information see: Canadian Food Inspection Agency—*Code of Practice for the Production and Distribution of Unpasteurized Apple and other Fruit Juice/Cider in Canada*; Health Canada—*Unpasteurized fruit juice and cider*; Healthy Canadians—*Unpasteurized Juice and Cider*.

From receiving through to retail sale, iced produce presents a unique potential food safety risk. If not contained, the ice itself, as well as the drip from thawing ice, has the potential to transfer microorganisms to other produce items, work surfaces, and utensils. It is important that any ice coming into contact with produce be made from potable water.

Some produce is misted with water at the store level. It is important that water used for misting be potable. Misting may be done manually using spray bottles or hoses, or it may be done automatically by way of misters built into display units. Regardless of the manner in which misting is accomplished, it is important to clean and sanitize the equipment used on a scheduled basis. At the time of a boil water order, or other water-related incident, it is important to cease misting and to remove potentially contaminated product from sale pending instructions from the regulatory authority having jurisdiction.

Potential biological food safety risks associated with produce include but are not limited to: bacteria, e.g., *E. coli O157*:*H7*, *L. monocytogenes*, *Salmonella* spp.; viruses (e.g., norovirus, hepatitis A); and parasites (e.g., *Cyclospora*, *Cryptosporidium*).

Potential chemical food safety risks include but are not limited to: pesticide residues, allergens (e.g., bulk peanuts and nuts sold in the department), non-food chemicals, and improperly used chemicals. Potential physical risks include, but are not limited to, pits and stems in ready-to-eat cut produce or juice.

Health Canada provides information on produce food safety on its website. See Health Canada—Food and Nutrition—*Produce Safety*. Similar information is also available on the websites of other jurisdictions, e.g., United States Department of Agriculture—*Food Safety*—*Produce Food Safety Resources*; United Kingdom Food Standards Agency—Horticultural Development Company—*Monitoring food safety of fresh produce*.

3.3.3 Bakery (In-Store)

In-store bakery production and products may range from simple to complex. Some products arrive at the store level as finished products that are ready to be unpackaged and sold whole or portioned at the store level.

Some products arrive at the store level frozen and are slacked off (defrosted) at the store level prior to sale. Depending on the nature of the product, slacking off may occur at ambient temperature or under refrigerated conditions. Such products are known as thaw-and-sell products. They may be sold in the original manufacturer's package or may be opened, in some instances decorated, and sold whole or portioned.

Bake-off products arrive at the store frozen and, as the name indicates, are baked at the store level. Depending on the product, additional steps such as proofing may be required at the store level. Ingredients may also be added prior to or following baking. Some products arrive at the store level as dry mixes. Water and possibly other ingredients are added at the store level prior to baking. Following baking, additional ingredients or decorations may be added at the store level.

Some products arrive at the store level as frozen or refrigerated wet mixes. If frozen, such mixes are defrosted at the store level. Wet mixes are portioned and baked at the store level. Additional ingredients may be added pre- or post-portioning and baking.

Scratch bakery products are prepared at the store level from basic ingredients, e.g., flour, baking powder, baking soda, yeast, etc.

In some instances, the outputs from the above may be used as ingredients or further assembled into finished products, e.g., cake layers that are iced/assembled into a finished cake.

In each of the above instances, the finished product may be:

- Shelf-stable or require temperature control for food safety reasons (e.g., refrigerated, frozen, hot hold)
- Sold whole or portioned or
- Sold from a variety of display cases, i.e., service case, store-packaged self-serve, or bulk self-serve

While many bakery products, e.g., bread, buns, are considered low-risk from a microbial food safety perspective, products that contain eggs, real dairy products, e.g., cream fillings, custard, meat, poultry, or seafood in a form capable of supporting the growth of pathogens or the production of toxins, are generally viewed as potentially higher risk products.

Produce used as an ingredient or to decorate bakery items should be thoroughly washed prior to use.

The potential biological hazards associated with bakery ingredients or finished products include but are not limited to *S. aureus*, *Salmonella* spp., and *E. coli O157:H7*.

The potential for the presence of undeclared allergens is also higher in the bakery department than in some other departments. Priority allergens should be segregated from other ingredients and finished products. Food contact equipment should be cleaned and sanitized prior to and following contact with a known allergen. There is also the potential for physical hazards, e.g., pits, stems, wood, bolts, or metal shavings from equipment.

Sinks, mixers, mixing bowls, cutting surfaces, knives, glazing brushes, and other food contact equipment should be cleaned and sanitized at a frequency that minimizes the risk of transfer of microorganisms or allergens.

Direct hand contact with ready-to-eat bakery products should be kept to a minimum. This may be accomplished by the use of gloves, utensils, wax paper, inverted bakery bags, or other means.

3.3.4 Meat and Poultry (Raw, Fresh, or Frozen)

From a retail food safety perspective, the raw meat and poultry department is perhaps the lowest risk department. Raw meat and poultry, from inspected sources, arrives at the store level and is sold to the consumer raw. No processes occur within the store to reduce the microbial load on such raw products prior to sale to the consumer.

Raw meat and poultry are received at the store in a variety of formats:

- Primals and subprimals (e.g., tenderloin, short loin, striploin, chuck)
- Carcasses (e.g., halves, quarters)
- Trim or tubes of course grind
- Whole poultry (bulk pack or case ready)
- Poultry cuts (bulk pack or case ready)
- Case ready (i.e., packaged and in some instances fully labelled for retail sale at plant level)
- Frozen (e.g., sausages, or breaded products that are slacked off at retail prior to sale, frozen turkeys)
- Modified-atmosphere packaged (individual or master package)
- Breaded, stuffed, or marinated product (supplier or in-store prepared)
- Multi-ingredient raw products (meat or meat and vegetable kabobs)

The raw product received at the store level may be portioned or ground and sold from a service case or, packaged and sold from a self-serve case. The product is, however, ultimately sold to the consumer raw. Cooking is the critical control step that results in a safe product and it occurs in the consumer's home prior to consumption. Having said this, the store does have the responsibility of sourcing from inspected sources, maintaining the product at an appropriate temperature, rotating the product, protecting the product from damage, contamination, and cross-contamination (e.g., species-to-species, allergen transfer), labelling with the appropriate nomenclature, storage instructions, durable life and, in some instance, safe handling instructions as well as other required labelling information.

A number of retail locations have moved away from in-store grinding of meat. For those locations where in-store grinding is still done, it is recommended that the following documents be referenced: the Canada Beef—*The Ground Meat Management Manual for Retail Meat Operations*; the FMI—*A Total Food Safety Management Guide A Model Program for Category: Raw*, *sold ready to cook product: Ground Beef* (2003).

If ready-to-eat product, or cooked product that requires only reheating prior to consumption is sold from the raw meat and poultry department, there is the potential for cross-contamination of these products. The production and packaging of these products should be separated, in conjunction with cleaning and sanitizing, by time or location from the production and preparation of raw product.

If frozen products (e.g., frozen turkeys, frozen sausages) are thawed at retail for refrigerated sale, controls should be in place to ensure that the internal product temperature does not go above 4 °C. This may be accomplished by defrosting such products in a refrigerated unit. Procedures should also be in place to ensure that drip from defrosting product does not contaminate other products.

If breaded, stuffed, or marinated products are sold from the department, care should be taken not to allow breading, stuffing, or marinade to come into contact with other products. If vegetables are used as ingredients, they should be washed prior to further preparation. Potential biological risks that may be associated with raw meat and poultry include, but are not limited to, *E. coli O157:H7*, *Salmonella* spp., and *Campylobacter jejuni*. Potential chemical risks that may be associated with raw meat and poultry include, but are not limited to, undeclared allergens (e.g., stuffing, breading, spice mixes), non-food chemicals, and improperly used chemicals.

Potential physical risks that may be associated with raw meat and poultry include, but are not limited to, metal tags, metal fragments from grinders or other equipment, broken glass, plastic and broken needles.

Food safety controls within the raw meat and poultry department include, but are not limited to, temperature control, rotation, cleaning and sanitizing, segregation of species, and protection from contamination and cross-contamination.

The Canadian Food Inspection Agency—*Food–Meat and Poultry Products* webpage provides links to a variety of information in regard to the regulatory requirements for meat and poultry in Canada. Similar information is available on the websites of other jurisdictions, e.g., United States Department of Agriculture—Food Safety and Inspection Services; United Kingdom Food Standards Agency—*Butchers*; Food Standards Australia New Zealand—*Food Safety Programs*; European Food Safety Authority—*Meat Inspection*.

3.3.5 Fish and Seafood

The potential food safety risks associated with a fish and seafood department are dependent on the product offerings sold from the department. Such offerings might include:

- Single ingredient raw fish or seafood (raw refrigerated or frozen, live)
- Multi-ingredient raw fish or seafood (e.g., fish/seafood kabobs, fish/seafood/vegetable kabobs, marinated, seasoned, stuffed, breaded)
- Fish or seafood may be cooked (e.g., fried or steamed in-store)
- Ready-to-eat fish or seafood salads (supplier or in-store prepared)

There are also potential food safety risks associated with the manner in which fish and seafood are received and sold. In some instances, raw fish and seafood is received packed in ice. Ice may also be used for storage or display purposes. Such ice should be made from potable water and handled in a manner that does not contaminate other products or food contact surfaces including cutting surfaces, utensils, packaging, etc.

The raw product received at the store level may be sold whole or portioned or have ingredients added at the store level. For raw product, the critical control point is in the consumer's home at the time of cooking.

If ready-to-eat products, or cooked products that require only reheating prior to consumption, are sold from the fish and seafood department, there is the potential for cross-contamination of these products. The production, packaging, and display of these products should be done in a manner that minimizes the risk of potential contamination or cross-contamination, e.g., segregation, separation, separate utensils.

If frozen fish or seafood products are to be thawed at retail, controls should be in place to ensure that the internal product temperature does not go above 4 °C. This may be accomplished by defrosting such products in a refrigerated unit. Procedures should also be in place to ensure that drip from defrosting product does not contaminate other products.

Live product should be segregated from other products in the department. The instructions provided by product and equipment suppliers should be adhered to. Fish and seafood products may be sold from a service case, or, packaged and sold from a self-serve case. In some, but not all, jurisdictions frozen seafood may be sold bulk self-serve.

Potential biological risks that may be associated with fish and seafood include, but are not limited to, bacteria (e.g., *Clostridium botulinum*, *Vibrio* spp., *Salmonella* spp., *Shigella* spp., *C. jejuni*), parasites (e.g., nematodes, roundworms, tapeworms), and viruses (e.g., hepatitis A, norovirus).

Potential chemical risks that may be associated with fish and seafood include, but are not limited to, undeclared allergens (e.g., stuffing, breading, marinades, spice mixes), non-food chemicals, and improperly used chemicals and toxins (e.g., paralytic shellfish poison and diarrhetic shellfish poisoning). Potential physical risks that may be associated with fish and seafood include but are not limited to: hooks, netting, metal fragments, and wood.

Food safety controls within the fish and seafood department include, but are not limited to, attaining an appropriate temperature if cooked in store, maintaining the product at an appropriate temperature, rotating the product, protecting the product from damage, contamination and cross-contamination (e.g., raw to ready-to-eat, species to species, allergen transfer), labelling with the appropriate nomenclature, storage instructions, durable life, and other required labelling information.

The *Canadian Food Inspection Agency—Retail Food—Information Bulletin—Seafood* provides an overview of fish and seafood requirements at retail. Additional resource materials include: Canadian Food Inspection Agency—*Quality Management Program* (*QMP*); Fisheries and Oceans Canada—*Fact Sheet—Food Safety Tips for Buying and Storing Fish and Seafood*; Fisheries and Oceans Canada—*Seafood Safety Controls*. Similar resources are available from other jurisdictions, e.g., United States Food and Drug Administration—*Seafood Guidance Documents & Regulatory Information*; Food Standards Australia New Zealand—*Safe Seafood Australia*.

3.3.6 Traditional Deli (Portioning Only)

In a traditional deli-department refrigerated or frozen ready-to-eat products, sourced from inspected suppliers, are received at the store level and may be sold whole or portioned prior to refrigerated sale. Such products include:

- Processed meat
- Cheese
- Supplier prepared ready-to-eat products (e.g., salads, cabbage rolls, sausage rolls, sandwiches)

These products may be sold from a service case or packaged at the store level for sale from a self-serve case.

Processed meat and cheese may be portioned (e.g., pre-sliced) prior to being placed in a service case, or it may be sliced on-demand at the request of the consumer. A combination of the two methods may also be used. Pre-slicing allows for cleaning and sanitizing of equipment to occur between chubs of meat or blocks of cheese, thereby limiting potential transfer of microorganisms from one chub or block to another. On-demand slicing does not allow for cleaning and sanitizing between chubs or blocks. Having said this, most stores do allocate separate slicers for meat versus cheese slicing and clean and sanitize these slicers frequently throughout the day. It is also important to make sure that all products coming into the department have been sourced from inspected suppliers that meet or exceed government requirements.

If supplier prepared products that are intended to be sold refrigerated are received frozen, such products should be slacked off under refrigerated conditions such that the internal product temperature does not go above 4 °C (e.g., meat pies, sausage rolls).

Potential biological risks that may be associated with deli products include, but are not limited to, bacteria (e.g., *L. monocytogenes*, *E. coli O15*:*H7*, *Salmonella* spp.) and viruses (e.g., hepatitis A, norovirus).

Potential chemical risks that may be associated with deli-products include but are not limited to: undeclared allergens, non-food chemicals, and improperly used chemicals.

Potential physical risks that may be associated with deli-products include, but are not limited to, metal fragments, broken glass, or plastic.

Food safety controls within the traditional deli department include, but are not limited to, maintaining the product at an appropriate temperature; rotating the product; protecting the product from damage, contamination, and cross-contamination, and labelling with the appropriate product description, storage instructions, durable life, and other required labelling information.

Direct hand contact with ready-to-eat foods should be kept to a minimum. This may be accomplished by the use of gloves, utensils, wax paper, inverted deli bags, or other means.

In recent years, much of the food safety focus has been on the control of *L. monocytogenes* in retail delis. In November 2012, the FMI in the USA published a document titled *FMI Listeria Action Plan for Retail Delis*. It is important to note that the procedures put in place at retail to address *L. monocytogenes* also apply to the potential food safety risks posed by other pathogens and visa-versa (also see Chap. 5.)

3.3.7 Home Meal Replacement (HMR: Prepared In-Store, Includes Salad Bar/Buffet)

The HMR department has the potential to be the highest risk department in a store. This is due to the range of products that may be prepared in the department (e.g., ready-to-eat; ready-to-reheat), the complexity of the processes used (e.g., raw to ready-to-eat; cooking; chilling; reheating), and the manner of display (e.g., refrigerated, hot display), etc. The products sold from this department may include, but are not limited to,

- Cooked meat, poultry, fish or seafood, individual or multi-ingredient mized dishes prepared from raw (BBQ'd, smoked, fried, baked, broiled, grilled, steamed, etc.)
- Ready-to-eat salads prepared from multiple ingredients (fruit, vegetables, meat, poultry, fish, seafood, eggs, cheese, salad dressing, croutons, etc.)
- Refrigerated or hot sandwiches (vegetables, meat, poultry, fish, seafood, eggs, cheese, mayonnaise, supplier or in-store prepared multi-ingredient fillings, etc.)
- Cooked vegetables, with or without breading or cheese or other ingredients
- Pizza
- Fresh pasta; pasta dishes
- Fried rice dishes
- Sushi

The above products may be sold from a service case or they may be packaged and sold from a self-serve case. Many of the products may be displayed either refrigerated or hot. In some instances, the hot product may be chilled for storage and later use (e.g., reheated for sale or used as an ingredient in another product) or may be sold at refrigerated temperatures. In some instances, product may be frozen at the store level and offered for sale as a frozen product.

The combination of products being prepared and sold, as well as the number and complexity of the processes undertaken in the HMR department, needs to be taken into consideration when identifying potential food safety risks and the management of such potential risks.

Potential biological risks that may be associated with HMR products include, but are not limited to, bacteria (e.g., *L. monocytogenes*, *E. coli O15*:*H7*, *Salmonella* spp., *Bacillus cereus*, *S. aureus*) and viruses (e.g., hepatitis A, norovirus).

Potential chemical risks that may be associated with HMR products include, but are not limited to, undeclared allergens, non-food chemicals, and improperly used chemicals. Potential physical risks that may be associated with HMR products include, but are not limited to, metal fragments, broken glass, or plastic.

Food safety controls within the HMR department include, but are not limited to, attaining and/or maintaining the product at an appropriate temperature, rotating the product, protecting the product from damage, contamination, and cross-contamination, and labelling with appropriate product description, storage instructions, durable life, and other required labelling information.

Direct hand contact with ready-to-eat foods should be kept to a minimum. This may be accomplished by the use of gloves, utensils, wax paper, inverted deli bags, or other means.

Health Canada and the Retail Council of Canada have released a joint *Retail Guidance Document—Pathogen Control* (*including Listeria monocytogenes*) *in RTE Refrigerated Foods* (2013). The Retail Guidance Document provides an overview of food safety management at retail, including the HMR department.

3.3.8 Bulk Self-Serve (Including Buffet and Salad Bar)

Bulk self-serve may itself be a department or it may be a display method used for specific products in various departments (e.g., whole produce in the produce department, buns, or pastries in the bakery department). Products are displayed such that the consumer selects and packages the amount of product that they wish to purchase. Buffets and salad bars are also forms of bulk self-serve.

When considering bulk self-serve of any food within a retail food store, it is important to consult the requirements of the regulatory authority having jurisdiction. Some jurisdictions do not allow bulk self-serve or allow only certain bulk self-serve products to be offered for sale (e.g., non-potentially hazardous products; products intended to be washed, peeled, or cooked; individually wrapped products such as candies). Some jurisdictions also have requirements in regard to the staffing and equipment design (e.g., height of display and sneeze guards, utensils) for such departments.

The potential food safety risks associated with bulk self-serve products that are offered for sale include those associated with the product that is being displayed, plus those associated with consumer access to, or handling of the product. Management of such potential food safety risks include, but are not limited to, temperature control, rotation, cleaning and sanitizing, protection from contamination and cross-contamination (e.g., covered display units, provision of separate utensils for each product), and monitoring of the department/display by staff with corrective actions taken as necessary. The posting of signage, such as allergen awareness and consumer safe food handling practices (e.g., use of utensils), are generally encouraged and may be required by some jurisdictions.

3.3.9 Product Sampling

Product sampling may take place in any or all departments within a store. There are two forms of sampling: staffed sampling (also referred to as demos) and unstaffed sampling (also known as silent sampling).

Regardless of the method of sampling used, it is important to identify and manage the potential food safety risks associated with the product that is being sampled (e.g., temperature control, cleaning and sanitizing, protection from contamination and cross-contamination, known or potential presence of allergens).

Silent sampling is discouraged, or not allowed, by some regulatory jurisdictions.

3.3.10 Checkout/Front End

Checkouts/Front End should be maintained in a manner that minimizes the risk of contamination or cross-contamination of foods. This includes, but is not limited to, the cleaning and sanitizing of checkout belts.

Food and non-food items should be packed in a manner that minimizes the risk of contamination or cross-contamination of food products. This includes, but is not limited to, the packing of chemicals (e.g., cleaners, detergents) separate from food.

It is also recommended that raw meat be packaged separate from, or in a manner that minimizes the risk of coming into contact with, other food products, especially ready-to-eat products.

Packing refrigerated and frozen products separate from hot products will assist in maintaining products at an appropriate temperature during transport to the consumer's home.

3.4 Conclusion

Potential food safety risks that are under the control of a retail location vary significantly based on the store format, the nature of the products offered for sale, the grouping of such products into departments, the number and complexity of the food preparation steps that occur within the store, and the manner in which products are displayed.

The general product flow is as follows:

1. Product is sourced and procured from inspected sources.
2. Product is received at the store level.
3. Product may be stored in the appropriate storage area or unit, or may go straight to a retail display area or unit (ambient, refrigerated, frozen).
4. Product may undergo various preparation steps at the store level prior to being displayed in the appropriate retail display unit. Such preparation steps may

include, but are not limited to, portioning, assembly, mixing, cooking, baking, chilling, cooling, and reheating.

5. Product may be packaged and labelled prior to display at retail.
6. Product is displayed in the appropriate area or unit (ambient, refrigerated, frozen). Display method may be: service, packaged self-serve, bulk self-serve, buffet.
7. Product is selected by, and in some instances packaged by, the consumer.
8. Product goes through the checkout process. Packaging at checkout may be done by a retail employee or by the consumer.

In summary, the management of potential food safety risks that are under the control of a retail location include, but are not limited to, the following:

1. Sourcing and Procurement (e.g., food from inspected sources, equipment, chemicals)
2. Temperature control and rotation (time/temperature) (e.g., receiving, storage, preparation/processing, display)
3. Labelling/service case tags/signage
4. Protection from contamination and cross-contamination
5. Cleaning and sanitizing
6. Water/Ice
7. Employee training

Similar to other food sectors, it is generally recognized and accepted that a Hazard Analysis Critical Control Point (HACCP)-based approach should be taken in regard to identifying and managing potential food safety risks at retail. Chap. 8 of this book. (Retail HACCP-based Systems) provides details in regard to the development and implementation of HACCP-based programs at retail.

References

Canada Beef. The ground meat management manual for retail meat operations—managing food safety. http://www.canadabeef.ca/pdf/safety.pdf

Canadian Food Inspection Agency. Code of practice for the production and distribution of unpasteurized apple and other fruit juice/cider in Canada. http://www.inspection.gc.ca/food/processed-products/manuals/code-of-practice/eng/1340636187830/1340637184931

Canadian Food Inspection Agency (CFIA) Food recalls and allergy alerts. http://www.inspection.gc.ca/about-the-cfia/newsroom/food-recalls-and-allergy-alerts/eng/1299076382077/1299076493846

Canadian Food Inspection Agency. Guide to food labelling and advertising. http://www.inspection.gc.ca/food/labelling/guide-to-food-labelling-and-advertising/eng/1300118951990/1300118996556

Canadian Food Inspection Agency. Food–meat and poultry products. http://www.inspection.gc.ca/food/meat-and-poultry-products/eng/1300124955992/1300125034322

Canadian Food Inspection System Implementation Group. Food retail and food services code 2004. http://epe.lac-bac.gc.ca/100/206/301/cfia-acia/2011-09-21/cfis.agr.ca/english/indexe.shtml; http://epe.lac-bac.gc.ca/100/206/301/cfia-acia/2011-09-21/cfis.agr.ca/english/regcode/frfsrc-amendmts/codeang-2004.pdf

Canadian Food Inspection Agency. Quality Management Program (QMP). http://www.inspection.gc.ca/food/fish-and-seafood/quality-management/eng/1299826346241/1299826407518
Consumer Packaging and Labelling Regulations. http://lois-laws.justice.gc.ca/eng/regulations/C.R.C.,_c._417/
European Food Safety Authority. Meat inspection. http://www.efsa.europa.eu/en/topics/topic/meatinspection.htm
Fisheries and Oceans Canada. Fact Sheet—food safety tips for buying and storing fish and seafood. http://www.dfo-mpo.gc.ca/aquaculture/sheet_feuillet/safety-securite-eng.htm
Fisheries and Oceans Canada. Seafood safety controls. http://www.dfo-mpo.gc.ca/fm-gp/sustainable-durable/aquaculture/safety-controls-eng.htm
Food and Drug Regulations. http://laws-lois.justice.gc.ca/eng/regulations/C.R.C.,_c._870/index.html
Food Marketing Institute (FMI) (2003) A total food safety management guide a model program for category: raw sold as ready to eat product: fresh-cut produce
Food Marketing Institute (FMI) (2003) A total food safety management guide a model program for category: raw, sold ready to cook product: ground beef
Food Marketing Institute (FMI) (2012) FMI listeria action plan for retail delis. http://www.fmi.org/docs/food-safety-best-practice-guides/listeria-action-plan-for-retail-delis.pdf?sfvrsn=9
Food Standards Australia New Zealand. Food safety programs. http://www.foodstandards.gov.au/industry/safetystandards/documents/Guide%20321%20FoodSafetyPrograms-WEB.pdf
Food Standards Australia New Zealand. Safe seafood Australia. http://www.foodstandards.gov.au/publications/documents/Safe%20Seafood%202edn-WEBwc%20.pdf
Government of Canada—Healthy Canadians. Safe internal cooking temperatures and recommended storage Times. http://healthycanadians.gc.ca/eating-nutrition/safety-salubrite/cook-temperatures-cuisson-eng.php
Government of Canada—Healthy Canadians. Unpasteurized juice and cider. http://healthycanadians.gc.ca/eating-nutrition/safety-salubrite/unpasteurized-pasteurises-eng.php
Kozak GK, MacDonald D, Landry L, Farber JM (2013) Foodborne outbreaks in Canada linked to produce: 2001 through 2009. J Food Prot 76:173–183
Health Canada—Food and Nutrition. Produce safety. http://www.hc-sc.gc.ca/fn-an/securit/kitchen-cuisine/safety-salubrite/index-eng.php
Health Canada—Food and Nutrition. Unpasteurized fruit juice and cider. http://www.hc-sc.gc.ca/fn-an/securit/facts-faits/unpast_fruit_juices-jus_fruits_cidre_nonpast-eng.php
Health Canada. Food-related illnesses. http://www.hc-sc.gc.ca/fn-an/securit/ill-intox/index-eng.php
Health Canada and the Retail Council of Canada (2013) Retail guidance document—pathogen control (including listeria monocytogenes) in RTE refrigerated foods. http://www.retailcouncil.org/sites/default/files/documents/retail-guidance-doc_EN.pdf; http://www.retailcouncil.org/grocery
Mihajlovic B, Dixon B, Couture H, Farber J (2013) Qualitative microbiological risk assessment of unpasteurized fruit juice and cider. Int Food Risk Anal J 3:6
United Kingdom Food Standards Agency. Butchers. http://www.food.gov.uk/business-industry/butchers/#.UiSqghZYVgs
United Kingdom Food Standards Agency—Horticultural Development Company. Monitoring food safety of fresh produce. http://www.food.gov.uk/multimedia/pdfs/microbial.pdf
United States Department of Agriculture. Food safety—produce food safety resources. http://www.fns.usda.gov/food-safety/produce-safety-resources
U.S. Food and Drug Administration. Bad bug book. http://www.fda.gov/Food/FoodborneIllnessContaminants/CausesOfIllnessBadBugBook/default.htm
U.S. Food and Drug Administration. Guidance for industry—food labeling guide. http://www.fda.gov/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/LabelingNutrition/ucm2006828.htm
United States Food and Drug Administration. Seafood guidance documents & regulatory information. http://www.fda.gov/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/Seafood/ucm2006751.htm

Chapter 4
The Applications and Uses of GFSI-Benchmarked Food Safety Schemes in Relation to Retail

Lucia E. Anelich and Kevin P. Swoffer

4.1 Introduction

The Global Food Safety Initiative (GFSI) was established in 2000 by the CIES—The Food Business Forum, which is now known as the Consumer Goods Forum (CGF). It is a business-driven initiative that is managed by the CGF and was founded following a number of food safety issues in Europe that had significantly impacted upon consumer confidence. The GFSI provides a platform for collaboration between some of the world's leading food safety experts from retailer, manufacturer and food service companies, service providers associated with the food supply chain, international organisations, academia and government (http://www.mygfsi.com/) (GFSI 2013). This collaboration is achieved mainly through the establishment of Working Groups that address specifically identified issues that are deemed important to the intent of the GFSI. The mission of the GFSI has remained unchanged since 2000 and is to drive continuous improvement in food safety to strengthen consumer confidence worldwide.

4.2 Bench-Marking System

One of the main objectives of the GFSI was to reduce the number of audits that suppliers were required to undergo to meet an increasing number of different retailer requirements. The auditing carried out by retail technologists or companies

L.E. Anelich (✉)
Anelich Consulting, PO Box 36536, Menlo Park 0102, South Africa
e-mail: la@anelichconsulting.co.za

K.P. Swoffer
KPS Resources Ltd., Walnut House, Forge Lane, Marshside, Canterbury, Kent CT3 4EF, UK
e-mail: kswoffer@yahoo.co.uk

J. Farber et al. (eds.), *Retail Food Safety*, Food Microbiology and Food Safety,
DOI 10.1007/978-1-4939-1550-7_4

commissioned by retailers lead to significant "audit fatigue" in the food industry, which resulted in high costs, waste of valuable time and unnecessary duplication, and it was not uncommon for some manufacturers to receive up to 20 food safety audits per annum from multiple customers. Simultaneously, ensuring the safety of foods supplied to retailers and hence, to the consumer remained of paramount importance. The ultimate goal of the GFSI therefore became "once audited, accepted everywhere". The approach decided upon to provide a means of achieving this goal, was to introduce a bench-marking process where owners of food safety schemes, based on the Hazard Analysis and Critical Control Point (HACCP) System, could apply to the GFSI for bench marking of their schemes. The bench-marking process would be carried out against specific requirements contained in a Guidance Document published by the GFSI. The intention was for retailers and other sectors of the food industry to accept food supplied by a supplier certified to one of the bench-marked schemes in lieu of the preferred scheme or standards of that company; the principle being that the bench-marking system created equivalence across the approved schemes, thereby offering a comparable level of food safety. In this way, flexibility was introduced into the marketplace and suppliers could decide on which GFSI recognised food safety scheme to implement, whilst food safety audits were reduced without compromising the safety of the food supplied. This approach also offered a level of confidence to the retailers and other sectors of the food industry in that these recognised schemes had undergone a rigorous and independent evaluation. The Guidance Document is revised as needed to incorporate updated requirements for food, feed and service provision schemes. To date, a number of pre- and post-farm gate food safety schemes have been approved by the GFSI and such lists are regularly updated on the GFSI website (http://www.mygfsi.com).

4.3 Certification and Accreditation

The GFSI does not undertake any certification or accreditation activities. However, it does require that third-party certification audits carried out against a GFSI bench-marked scheme are conducted by Certification Bodies that are accredited by an Accreditation Body; the Accreditation Body in turn is required to be a member of the International Accreditation Forum (IAF). Through this membership, assurance is given to users, of the competence and impartiality of the body accredited and hence the certifications provided (http://www.iaf.nu//articles/About/2) (IAF 2013).

Concerns about effectiveness of third-party audits and particularly auditor competence have been expressed by a number of parties in recent years. However, there are a number of processes in place to provide assurance that third-party audits are carried out by technically competent and professional auditors.

In accordance with the requirements of the GFSI Guidance Document, all recognised schemes must have in place criteria for the appointment, management and continued integrity of any food safety auditor operating within the framework of their schemes. This includes requirements in relation to qualification, sector knowledge, training and work experience; in addition, there are also requirements regarding continuous professional development and the maintenance of legislative and sector specific knowledge.

Certification Bodies working within the framework of any recognised GFSI scheme require accreditation to internationally recognised ISO standards. These standards clearly define the requirements of how a Certification Body operates an effective management system and therefore controls and manages its auditors. As these standards are used for the accreditation of organisations, national Accreditation Bodies regularly undertake surveillance assessments to ensure continued compliance with the ISO standard's requirements. These surveillance assessments include a detailed review of audit documentation and witness assessment of auditors.

In addition to the controls undertaken by Accreditation Bodies, schemes recognised by the GFSI are also required to have in place a series of measures to monitor Certification Body performance, which include a risk-based programme of Certification Body office audits and supplier audits to review the performance of the Certification Body's auditors.

The competence and performance of food safety auditors is critically important to the integrity of the GFSI and the GFSI recognised schemes. Stakeholder consultation has been used by GFSI to prioritise work streams for their Technical Working Groups and auditor competence has been identified as an area which is critically important for the effectiveness of food safety audits. In 2011 the GFSI Board mandated that a Technical Working Group be formed specifically focussing on food safety auditor competence and following work carried out by this Group during 2011, the Auditor Competence Scheme Committee was formed in 2012. The purpose and role of this Committee was to continue to develop competence assessment methodology and credentialing of GFSI recognised scheme auditors, to investigate the possible personal certification of food safety auditors and to work with other interested parties involved in this area of work.

4.4 Global Markets Capacity Building Programme

In 2008 the GFSI recognised that there were many food businesses across the world, in both developed and developing countries, which were finding difficulty in implementing HACCP-based food safety management schemes. Both small and large, less developed businesses fall into this category and these would benefit significantly from a single, internationally recognised programme that would assist them, through continuous improvement process to develop to the point where the implementation of a GFSI recognised food safety management scheme could be considered. This programme was launched in 2011 and became known as the Global Markets Capacity Building Programme (GMCBP). In this way, capacity building in food safety is achieved, whilst access to local markets is facilitated and a system for mutual acceptance along the supply chain at this "entrance level" is created. The programme is based on key requirements extracted from the GFSI Guidance Document, but is primarily based upon the Codex General Principles of Food Hygiene Code of Practice (CAC/RCP 1-1969, Rev 4-2003). The programme is designed as a noncertification assessment process, which is carried out within a defined time period. It consists of three tiers of work, i.e. Tier One where a series of food safety requirements known as the GFSI Basic Level Requirements should be implemented by the food business within a period of 12 months. Thereafter, the food business should progress to the next tier, Tier Two, where a second series of food safety requirements, the GFSI Intermediate Level Requirements should be implemented, also within a 12-month period. Therefore within a 2-year period, the food business should be in a position to progress to full certification to a GFSI recognised food safety scheme. A number of documents have been developed by the GMCBP Technical Working Groups, which serve the purpose of providing guidance to the food business and assessors establishing compliance to the GFSI Basic and Intermediate Level Requirements.

Although the GFSI has issued guidance documents in the form of a downloadable "toolkit", a number of organisations have developed training manuals and courses for suppliers wishing to implement the GMCBP. Numerous pilot programmes to test market readiness of the GFSI Basic and Intermediate Level Requirements have been successfully carried out in many regions of the world, including Ukraine, Egypt, Russia, Chile, Kazakhstan and Malaysia. Many of the pilot programmes of the GMCBP were undertaken in partnership with organisations such as the United Nations Industrial Development Organization (UNIDO) and the International Finance Corporation (IFC), who have worked with major retailers in those countries, supporting the training programmes in order to build capacity within the suppliers to those retailers. These pilot programmes have been successful in that not only are suppliers trained, but their businesses are initially assessed against the GFSI Basic and/or Intermediate Level Requirements. Thereafter they are mentored for a period of time by experienced consultants to assist with the implementation of the Basic and/or Intermediate Level Requirements. At the end of the mentorship period, the suppliers are re-assessed and these assessment results are compared with their initial assessments. Significant improvement has been found consistently for all the pilot programmes conducted and levels of up to 45 % and 33 % improvement for Basic Level and Intermediate Level, respectively, have been recorded (personal communication, Ali Badarneh, UNIDO). More recently, UNIDO has expanded its work to include a number of selected African countries in which to run similar programmes of which the first pilot project occurred in Zambia in May 2102. This is being done in conjunction with specific South African retailers, who are expanding extensively in to the rest of Africa.

4.5 Benefits of the GFSI Approach for the Retail Sector

The GFSI has been in place for over 14 years and has grown significantly in the last 6 years where large corporate retailers, food manufacturers and food service companies have recognised the benefits of the GFSI approach.

One of the original objectives of the GFSI was to reduce the number of food safety audits, which has been successfully introduced, especially when in 2007 a number of multinational retailers agreed to utilise any of the GFSI recognised schemes. Since 2007 a number of other very large organisations have also used this approach which has led to reduced duplication, increased efficiency and significant cost saving, especially within the food production sector.

Other benefits gained by companies implementing GFSI recognised food safety schemes include improved product safety, better access to market, improved consumer confidence, decrease in product recalls and associated costs, attainment of preferred buyer status, improved corporate image, enhanced production efficiency and improvement with legislative compliance.

The GFSI was introduced in 2000 to work with a number of food safety schemes and the GFSI approach does promote "healthy competition" between scheme owners and it could be argued that this has driven continuous improvement of supporting systems and procedures both within the schemes and the GFSI itself.

The sixth version of the GFSI Guidance Document introduced the broadening of the scopes of schemes GFSI can recognise and it is envisaged that by mid-2014 any food and feed industry schemes can apply for GFSI recognition. The GFSI scopes of recognition will also cover relevant food industry service sectors such as Storage and Distribution, which will mean that there will be a complete linkage of food safety requirements across the total supply chain.

References

Global Food Safety Initiative (GFSI). http://www.mygfsi.com/. Accessed 12 Apr 2013

International Accreditation Forum (IAF). http://www.iaf.nu//articles/About/2. Accessed 19 May 2013

Chapter 5
Listeria monocytogenes, Listeriosis and Control Strategies: What the Retail Deli and Food Safety Manager Need to Know

Susan R. Hammons and Haley F. Oliver

5.1 Introduction to *Listeria* spp., *L. monocytogenes*, and Listeriosis

5.1.1 Overview of Listeria *Species*

Listeria is a bacterial genus with 10 recognized species which include *L. monocytogenes*, *L. welshimeri*, *L. grayi*, *L. innocua*, *L. ivanovii*, *L. marthii*, *L. rocourtiae*, *L. seeligeri* (McLauchlin and Rees 2009), *L. weihenstephanensis* (Lang Halter et al. 2013), and *L. fleischmannii* (den Bakker et al. 2013). *L. monocytogenes* and *L. ivanovii* are pathogenic to warm-blooded animals and thus *L. monocytogenes* can causes disease in humans and animals. Evidence exists that links *L. ivanovii* to disease in humans, but disease is very rare (Elischerova et al. 1990; Cummins et al. 1994; Lessing et al. 1994; Snapir et al. 2006). *Listeria* spp. are commonly considered saprophytes (organisms that live on dead or decaying organic matter); they live in and can easily be isolated from soil as confirmed in a recent study (Strawn et al. 2013). *L. innocua* and *L. seeligeri* are commonly isolated *Listeria* species (Sauders et al. 2012). Because nonpathogenic *Listeria* spp. can be more common than *L. monocytogenes* in some environments, it has become a common practice in food manufacturing to test for *Listeria* spp. in the processing environment as a *L. monocytogenes* management tool. The premise of this testing strategy is that if any *Listeria* spp., notably nonpathogenic species which are presumed to be more prevalent, can be controlled or eliminated in the food handling environment (e.g., on food and non-food contact surfaces), the risk of the environment and subsequently food product being

S.R Hammons • H.F. Oliver (✉)
Department of Food Science, Purdue University, Philip E. Nelson Hall of Food Science,
745 Agriculture Mall Drive, West Lafayette, IN 47907, USA
e-mail: hfoliver@purdue.edu

J. Farber et al. (eds.), *Retail Food Safety*, Food Microbiology and Food Safety,
DOI 10.1007/978-1-4939-1550-7_5

contaminated with *L. monocytogenes* is very low. Recent and ongoing studies by our group indicate, however, *L. monocytogenes* is more frequently recovered from food- and nonfood contact surfaces in retail delis compared to the nonpathogenic *Listeria* spp. (Simmons et al. unpublished).

5.1.2 L. monocytogenes *is a Human Foodborne Pathogen That Can Contaminate Ready-to-Eat Foods*

Listeria monocytogenes is a foodborne pathogen which causes relatively few illnesses annually in the United States and Canada, but it has one of the highest case fatality rates among foodborne pathogens, i.e., as many as 20–30 % of cases result in death (Rocourt et al. 2003). The Center for Disease Control and Prevention (CDC) estimates approximately 1,600 cases of listeriosis, 1,500 hospitalizations, and 260 deaths occur annually in the USA (Scallan et al. 2011). Health Canada estimates 178 cases per year in Canada (Thomas et al. 2013). Approximately 99 % of listeriosis cases result from contaminated food (Scallan et al. 2011). Ready-to-eat (RTE) deli meats, followed by dairy products, and frankfurters that have not been reheated are the highest risk food categories that may result in listeriosis in the USA (FDA/FSIS 2003). A 2003 survey conducted in the USA found that RTE meats handled in retail delis were six times more likely to be contaminated with *L. monocytogenes* than the equivalent product prepackaged and shelf-ready (Gombas et al. 2003). Recent studies have shown that *L. monocytogenes* can be prevalent and persistent in retail deli environments (Hoelzer et al. 2011b; Simmons et al. unpublished). Understanding how and where *L. monocytogenes* can live in the retail environment and implementing effective control strategies—sanitation procedures, management practices, and quality controls—are among the best strategies to help prevent illness and protect public health.

5.1.3 Listeriosis Symptoms and Mechanism of Disease

Listeriosis is caused by consuming food contaminated with live *L. monocytogenes* cells (Farber and Losos 1988). As an opportunistic pathogen, *L. monocytogenes* causes two forms of disease (Lecuit 2007). In healthy adults, the infection may result in febrile gastroenteritis. This is a mild, self-limiting disease and symptoms include fever, headache, vomiting, diarrhea, or arthralgia (joint pain). However, *L. monocytogenes* can cause an invasive infection in immunocompromised hosts. Immunodeficiency can result from many conditions including HIV infection, chemotherapy, pregnancy, intentional immunosuppression for organ transplant, and advanced age. *L. monocytogenes* attaches to and invades the epithelia cells of the small intestine, and can migrate to the mesenteric lymph nodes, and then to the liver and spleen via the blood stream (Farber and Losos 1988; Lecuit 2007). Victims of invasive listeriosis may remain asymptomatic for days to months. Early symptoms can include mild flu-like fever, nausea, headaches, and body aches between 3 and 70 days after consumption of contaminated food. Disease progresses as the bacteria cross the blood–brain barrier, resulting in meningitis (inflammation of the membrane around spinal and brain tissues) and/or encephalitis (swelling of the brain). Symptoms may include confusion, seizures, or impaired motor function. Approximately 20–30 % of listeriosis cases result in death (Rocourt et al. 2003; Silk et al. 2012).

Globally, listeriosis will remain an important foodborne illness due to the fact that the vulnerable population is growing. Advances in medicine and nutrition help immunocompromised persons with advanced age, disease, or under medical treatment live longer. European Union member countries reported a 19 % increase in listeriosis cases from 2008 to 2009 (EFSA 2011). In the USA and Europe, there has been a significant increase in the number of listeriosis cases in adults >65 years of age (Little et al. 2010). Among listeriosis cases that occurred in the USA between 2004 and 2009, over 50 % of cases were in adults >65 years of age; this increased to 58 % of reported cases from 2009 to 2011. Specifically, there were 400 cases of listeriosis in adults >65 years and 234 of nonpregnancy associated cases in adults <65 years from 2004 to 2009. However, from 2009 to 2011, there were 950 cases and 474 nonpregnancy associated cases in adults >65 and <65 year of age, respectively (Silk et al. 2012, 2013).

Pregnant women are 8–18 times more likely to suffer an invasive infection than healthy, nonpregnant women (Southwick and Purich 1996; Silk et al. 2012). During the third trimester of gestation, the mother's immune system is naturally suppressed to prevent her body from rejecting the fetus. An infected mother may experience flu-like symptoms (e.g., fever, nausea, body aches), but the greatest danger is to the fetus since *L. monocytogenes* has a tropism for the placenta resulting in fetal infection (Smith 1999). High levels of *L. monocytogenes* in the placenta can result in spontaneous abortion or still birth; infected surviving neonates may suffer mental retardation (Farber and Losos 1988; Southwick and Purich 1996; Lecuit 2007). While the overall rate of listeriosis has not significantly increased or decreased in the USA since 2004, there was a significant increase in pregnancy-associated listeriosis in Hispanic women from 2004 to 2009 (Silk et al. 2012), and 43 % of pregnancy-associated listeriosis cases from 2009 to 2011 occurred in Hispanic women (Silk et al. 2013).

5.2 *L. monocytogenes* in Foods and Food Systems

5.2.1 L. monocytogenes *Prevalence in the Environment*

Raw ingredients and water are both potential sources of contamination (Lawrence and Gilmour 1995; Ojeniyi et al. 1996). Researchers have isolated *L. monocytogenes* from 20 to 35 % of ruminant farm environment samples and from >20 % of cattle fecal samples (Nightingale et al. 2004, 2005). *L. monocytogenes* also can be isolated from a number of nonruminant species' feces such as poultry (Weber et al. 1995), wild birds (Fenlon 1985), swine (Hayashidani et al. 2002; Yokoyama et al. 2005), horses (Weber et al. 1995; Gudmundsdottir et al. 2004), farmed fish (Miettinen and Wirtanen 2005), and some domestic animals. *L. monocytogenes* in ruminants and on farms contributes directly to human disease (e.g., consumption of contaminated raw milk (Ryser 1999)) and indirectly by introduction into food processing plants or onto vegetables through contaminated manure (e.g., Fenlon et al. 1996; Rorvik et al. 2003). In a recent study on produce farms, *L. monocytogenes* was detected in 17.5 % of fields. Soil cultivation, irrigation, and presence of wildlife within a given number of days prior to sampling, all increased the likelihood of a soil sample testing positive for the presence of *L. monocytogenes* (Strawn et al. 2013).

5.2.2 Cross-Contamination and Growth of **L. monocytogenes** *in Food*

The common occurrence of *L. monocytogenes* in nature and agricultural systems contributes to the frequent introduction of the pathogen into foods. *L. monocytogenes* is a salt- and acid-tolerant organism and can grow at and below refrigeration temperatures with little oxygen (McLauchlin and Rees 2009). It is, however, sensitive to extreme acidity, pressure, and high temperature (McLauchlin and Rees 2009). Cooking kills *L. monocytogenes*, thus preventing disease. As *L. monocytogenes* can be killed by heat, contaminated raw ingredients rarely cause illness directly when food is heat treated. The more likely source of *L. monocytogenes* on foods is cross-contamination during processing after heating (e.g., slicing, casing removal, or packaging), which transfers the pathogen onto already cooked, RTE products (Lawrence and Gilmour 1995; Pradhan et al. 2011). Departments that handle raw meat products and RTE foods must pay particular attention to prevent cross-contamination. For example, 15–34 % of raw chicken sampled at retail was positive for *L. monocytogenes* (Cook et al. 2012). Poor food handling practices could result in products such as deli meat becoming inadvertently contaminated with *L. monocytogenes*. Cross-contamination alone does not create a risk of listeriosis. The infectious dose or dose response (the number of cells required to cause illness) varies and is not conclusive (McLauchlin et al. 2004). In general, it is thought to be high so the few cells transferred to foods during cross-contamination are not typically enough to cause illness (Vazquez-Boland et al. 2001). However, if the food product supports the growth of *L. monocytogenes*, the few transferred cells may multiply during storage (even at refrigeration temperature) to potentially infectious levels before consumption.

5.2.3 *Ready-to-Eat Foods Are Most Likely to Causes Listeriosis*

The majority of listeriosis cases (99 %) are linked to food (Scallan et al. 2011). Risk assessment models, epidemiological studies, and product testing have identified the greatest risk of listeriosis from delicatessen meats, contaminated cheeses, unpasteurized (raw) fluid milk, un-reheated frankfurters, smoked seafood, and cooked crustaceans (Rocourt and Cossart 1997; FDA/FSIS 2003; EFSA 2007; Lianou and Sofos 2007). These RTE products have the highest risk per serving for causing listeriosis due to three factors: (1) processing after cooking exposes the product to the environment and increases the risk of cross-contamination, (2) these foods support *L. monocytogenes* growth during refrigerated storage, and (3) consumption without cooking or re-heating allows any bacteria present on the food to be ingested and potentially cause disease. A risk assessment identified delicatessen meats as the highest risk per capita and per serving for causing listeriosis (FDA/FSIS 2003). Specifically, the U.S. Food and Drug Administration (FDA) and the U.S. Food Safety and Inspection Service (FSIS) estimated that about 90 % of human listeriosis cases in the USA are caused by the consumption of contaminated deli meats (FDA/FSIS 2003). From 1998 to 2011, there were 38 confirmed outbreaks of listeriosis (CDC 2013a). Of these outbreaks, 13 were associated with RTE meat products (e.g., deli meats, hotdogs). The most significant outbreak among these occurred in 1998, when 101 people became ill and 21 subsequently died from consumption of contaminated hotdogs and deli meats produced at a single plant (Mead et al. 2006). However, recent outbreaks in the USA have been linked with soft-ripened cheese (six cases) (CDC 2013b), aged ricotta salata cheese (22 cases) (CDC 2012a), and fresh cantaloupe (147 cases) (CDC 2012b). The 2011 cantaloupe-associated listeriosis outbreak caused 33 deaths and one miscarriage; this was the most deadly foodborne disease outbreak in the USA in 10 years. It is important to note that these products are typically considered RTE, although there are recommended handling guidelines for some products (e.g., washing cantaloupe).

5.3 *L. monocytogenes* in the Retail Deli Environment

5.3.1 *Risk Assessment Predicts That Most Deli Meat-Associated Cases of Listeriosis are from Deli Meats Sliced or Handled in Retail Delis*

A study in the USA in the early 2000s found that luncheon meats sliced at retail were found to be six times more likely to carry *L. monocytogenes* than prepackaged meats; deli salads three times more likely, and seafood salads five times more likely to be contaminated if handled at retail rather than manufacturer packaged (Gombas et al. 2003). Two independent risk assessments conducted in the USA concluded that approximately 83 % of listeriosis cases were caused by RTE meats contaminated in retail delis (Endrikat et al. 2010; Pradhan et al. 2010). A recent USDA/FDA risk assessment concluded that implementing effective food safety practices in delis to control growth, cross-contamination, and potential sources of *L. monocytogenes* in addition to continued sanitation will prevent illness from foods handled at retail (USDA-FSIS and FDA 2013).

Retail delis have very different operating conditions and expectations than a typical RTE food production/manufacturing facility. *L. monocytogenes* may enter the deli on customers' and workers' shoes, cart wheels, raw meats, fresh produce, and RTE meats handled in the store. Studies conducted in the US in 2009–2011 found that 55–65 % of retail delicatessen establishments have *L. monocytogenes* on food contact and nonfood contact surfaces (Sauders et al. 2009; Hoelzer et al. 2011b; Simmons et al. unpublished). In some deli departments, contamination may be found on almost 40 % of all surfaces tested (Simmons et al. unpublished). Deli meats, salads, and cheeses may be sliced, repacked, or portioned for customers in retail stores. All of these processes expose the food to the environment, food handlers, and equipment, any of which may carry or transfer bacterial cells to the food if sanitation and hygiene procedures are not properly carried out.

5.3.2 Nonfood Contact Surfaces Are More Likely to Be Contaminated

The likelihood of *L. monocytogenes* contamination varies based on the type of surface (Table 5.1). Nonfood contact surfaces (NFCS) (e.g., floors, drains, walls) harbored *L. monocytogenes* on 15–20 % of samples, while only 2–4 % of food contact surfaces (FCS) (e.g., slicer blades, utensils, cutting boards, countertops) were contaminated (Sauders et al. 2009; Hoelzer et al. 2011b; Simmons et al. unpublished). NFCS are more likely to be contaminated due to (1) the foot traffic which may introduce and spread the bacteria; (2) many are soil collecting points from the entire environment (e.g. drains); and (3) infrequent cleaning may allow pathogen growth. Irrespective of the surface type, ineffective cleaning and sanitation can allow *L. monocytogenes* to grow and persist, potentially remaining for months or years in the deli environment (Simmons et al. unpublished).

5.3.3 Transient v. Persistent **L. monocytogenes** *Contamination: the Difference Between Short- and Long-Term Challenges*

In delis with *L. monocytogenes* contamination, distinguishing between transient and persistent contamination patterns determines which actions are needed to eliminate the organism. Transient organisms, those that can be introduced and

Table 5.1 *L. monocytogenes* prevalence across different sites in the retail deli (adapted from Hoelzer et al. 2011b)

Sample location	Percent positive samples (95 % CI)[a]		Total positives	Total samples tested
Food of food contact surfaces				
Product (food)	1.5	(0.6–3.1)	7	462
Slicer	2.7	(0.9–6.3)	5	183
Utensils (bowl, cutting board, others)	4.2	(2.2–7.0)	13	314
Bowl[b]	4.8	(0.6–16.2)	2	42
Cutting board[b]	7.1	(3.3–13.1)	9	127
Other utensils (e.g., knife, spoon, tongs)[b]	1.4	(0.2–4.9)	2	145
Multiple food contact areas (e.g., cutting board)	5.9	(0.7–19.7)	2	34
Deli case	6.9	(4.1–10.9)	17	246
Raw meat/seafood display	9.1	(0.2–41.3)	1	11
Subtotal	3.6	(2.6–4.8)	45	1,250
Non-food contact surfaces				
Sink	13.5	(9.5–18.3)	34	252
Dairy case	13.6	(9.5–18.6)	32	236
Floor/drains	27.4	(23.8–31.1)	163	596
Deli area drain/floor[c]	16.1	(10.5–23.2)	23	143
Raw meat preparation area drain/floor[c]	39.4	(31.7–47.7)	60	152
Seafood area drain/floor[c]	25	(13.2–40.3)	11	44
Produce area drain/floor[c]	24	(15.8–33.8)	23	96
Walk in cooler drain/floor[c,d]	34	(25.2–43.6)	37	109
Other drain/floor areas[c]	17	(8.1–29.8)	9	53
Floor in dry aisle	7.9	(4.8–12.2)	18	228
Floor adjacent to entrance	13.9	(8.3–21.4)	17[f]	122
Walk in cooler	20.6	(15.3–26.7)	43	209
Walk in cooler shelves	6.1	(2.3–12.9)	6	98
Walk in cooler door handle	0	(0.0–84. 2)	0	2
Walk in cooler drain (K1)/floor (K2[c])	34	(25.2–43.6)	37	109
Cart wheels	7. 6	(3.5–13.9)	9	119
Produce preparation area	10.5	(1.3–33.1)	2	19
Milk crates	34.3	(19.1–52.2)	12	35
Miscellaneous areas (e.g., shopping baskets, icemaker, etc.)	0	(0.00–15.4)	0	23
Subtotal	17	(15.2–18.8)	293	1,731

[a]Exact binominal confidence interval
[b]Individual subcategories that are part of "utensils"
[c]Individual subcategories that are part of "floor/drain"
[d]Results shown twice, as subcategory of "floor/drain" and of "walk-in cooler"

distributed by daily activity (e.g., shoes, carts, contaminated product), can be controlled or eliminated by routine sanitation. The key to effectively managing these organisms is through validated and verified sanitation programs. Managers and employees should aim to prevent recontamination by controlling potential sources (e.g., raw meat, traffic flow from contaminated areas, contaminated products). Persistent *L. monocytogenes* are much more difficult to eliminate and control. Persistent contamination is when the same *L. monocytogenes* strain remains in the environment for months or years by colonizing the deli environment in "niches." These niches can occur in equipment, close fitting metal to metal or metal to plastic parts, worn rubber door seals, cracked floors and walls (Miettinen et al. 2001; Tompkin 2002; Holah et al. 2004; Wulff et al. 2006; Ferreira et al. 2011), and about any surface that cannot be or is not routinely cleaned and sanitized. Persistent *L. monocytogenes* contamination of FCS and other environmental surfaces from which bacterial cells may be transferred to foods is among the most important and direct routes of contamination of RTE meat and poultry products (Lawrence and Gilmour 1995; Miettinen et al. 2001; USDA-FSIS 2003). *L. monocytogenes* can remain in the environment over time due to ineffective sanitation, which can result in biofilm formation. Biofilms are complex matrices of bacteria, carbohydrates, and proteins that allow the bacteria to survive, grow, and potentially be released into the environment over long periods of time. Tartar buildup on teeth is a common example of a biofilm. A biofilm is "stronger" than single bacteria cells and it can be resistant to destruction by soaps and sanitizers. A mature biofilm slowly releases living cells, which can spread throughout the environment, potentially forming biofilms on other surfaces or become a source of cross-contamination in foods. Removing biofilms requires significant mechanical force (e.g., scrubbing).

Studies by our group have shown that in many retail stores, the same strain is often found on both FCS and NFCS (Sauders et al. 2009; Hoelzer et al. 2011b; Simmons et al. unpublished). We use techniques such as Pulsed-Field Gel Electrophoresis (PFGE) and ribotyping to essentially DNA fingerprint *L. monocytogenes* isolates recovered from environmental samples. We have found *L. monocytogenes* isolates with the same DNA fingerprint on the slicer, deli case, sink, and utensils in the same store (Hoelzer et al. 2011b). In a very recent study by our group, PFGE showed that for 11 of 30 stores studied, one or more PFGE types were isolated at least three times. This is strong evidence for persistence of *L. monocytogenes* in these stores. In some stores, PFGE patterns for isolates from NFCS were distinct from patterns of isolates from FCS, suggesting limited cross-contamination between these sites in some stores. Persistent *L. monocytogenes* strains have been recovered in delis up to 1.5 years after first isolation (Hoelzer et al. 2011b) and in manufacturing facilities up to 12 years after initial isolation (Orsi et al. 2008). Persistent *L. monocytogenes* strains living in a biofilm in slicers in a RTE deli manufacturing facility was the cause of a 2008 Canadian listeriosis outbreak which resulted in 57 illnesses and 22 deaths (Weatherill et al. 2009).

5.3.4 L. monocytogenes *Is Transmitted by Hands, Gloves, Equipment, and Food Products*

Whether dealing with transient or persistent *L. monocytogenes*, transmission routes through the deli are control points to prevent cross-contamination. Bacterial transmission refers to how bacteria move through an environment—to and from food, FCS and NFCS including equipment, tools, and workers. As discussed earlier, cooking and other treatments kill *L. monocytogenes*, so foods are typically free of foodborne pathogens unless contaminated after thermal processing. Controlling the transfer of bacteria from contaminated surfaces and products to RTE foods prevents foodborne illness. The most comprehensive contamination and transmission pattern studies in retail delis to date were conducted in mock deli environments (Gibson et al. 2013; Maitland et al. 2013). Fluorescent compounds were used to mimic *L. monocytogenes* contamination on different surfaces, while volunteers performed a sequence of common deli tasks such as slicing, weighing, packaging, and serving ham to customers under different contamination source scenarios. By tracking the spread of fluorescence, researchers identified potential transmission routes based on the source of contamination. Other transmission studies used expert elicitation (Hoelzer et al. 2011a), direct observation of deli task sequencing (Lubran et al. 2010), and statistical modeling (Hoelzer et al. 2012) to characterize the movement of *L. monocytogenes* in this environment.

Worker hands and gloves are the most likely vehicle to transfer contamination to any deli surface (Hoelzer et al. 2011a; Gibson et al. 2013; Maitland et al. 2013). Clean gloves provide a sufficient barrier from contamination present on bare hands, but contaminated gloves may transfer contamination similar to bare hands (Maitland et al. 2013). In the USA, frequent hand washing and glove changes, particularly after contact with NFCS, which are most likely to harbor *L. monocytogenes* (Sauders et al. 2009; Simmons et al. unpublished; Hoelzer et al. 2011a), are needed to comply with the Food Code (FDA (2013)). Lubran et al. (2010) observed hand washing occurred at only 2–17 % of the recommended frequency in retail delis, highlighting a clear opportunity to improve compliance.

Slicers come into contact with the vast majority of RTE meat and cheese sold from a deli counter. The slicer may be a source of contamination in two ways: (1) transfer point for *L. monocytogenes* from contaminated products onto previously uncontaminated products (Gibson et al. 2013; Maitland et al. 2013), or (2) they may harbor an environmental niche for persistent *L. monocytogenes* growth (Weatherill et al. 2009). For example, if someone were to slice a contaminated meat chub, *L. monocytogenes* cells may remain on the slicer blade, carriage tray, and/or support trays (Gibson et al. 2013; Maitland et al. 2013). These bacteria could remain on the slicer until the next chub is sliced, slowly transferring onto the noncontaminated product. The first 10 slices served to a customer and the remaining unsliced chub returned to the service case may all contain *L. monocytogenes* due to product–product cross-contamination via the slicer (Gibson et al. 2013; Maitland et al. 2013).

The slicer harboring persistent *L. monocytogenes* is a more concerning scenario, as all products handled on the slider may become contaminated. Persistent contamination may indicate inadequate equipment maintenance, poor equipment design, or ineffective sanitation processes.

Transferring bacteria from floors and drain covers to FCS was not detected in a mock deli (Maitland et al. 2013). This study was limited to a group of volunteers without previous food service experience working in a controlled environment for a brief period of time. From practical experience, we are concerned about scenarios such as untied shoe laces dragging on the floor, dropped utensils, or customer-interrupted trash clean-up, which may require inadvertent employee contact with floors or drains creating opportunities for NFCS to FCS transmission not observed in the mock deli environment. In our most recent study, we found the same DNA fingerprint from *L. monocytogenes* isolated from the floor and from FCS (Simmons et al. unpublished). While these studies cannot determine the direction of transfer (e.g., from the drain to the sink or from the sink to the drain), it underscores that this pathogen can be transmitted throughout the deli environment and that control strategies are critical to prevent it from contaminating foods.

5.4 Control Strategies to Eliminate *L. monocytogenes* and Prevent Listeriosis

Preventing listeriosis from foods handled at retail is a complex process and difficult to measure. The first step is full cooperation and participation in food recalls. RTE foods are routinely tested by manufacturers and regulatory agencies, and those that are contaminated with *L. monocytogenes* are recalled to remove them from the market to ensure public safety. However, deli personnel must understand that RTE products processed (e.g. sliced, re-portioned, or packaged) at retail are at risk for cross-contamination in stores and manufacturing-based controls alone are not enough to prevent all listeriosis cases. The 2013 US Interagency Retail *L. monocytogenes* Risk Assessment Workgroup recommended five targets for reducing the risk of listeriosis from retail foods: (1) control growth through the use of growth inhibitors in products and temperature control during storage; (2) control cross-contamination during routine deli operations; (3) control contamination at its source: incoming products, the environment, or niches; (4) continue sanitation to eliminate *L. monocytogenes* from the environment; (5) identify key routes of contamination to RTE foods, such as the slicer (deli meats and cheeses) or serving utensils (deli salad) (USDA-FSIS and FDA 2013).

Business managers and merchandizers determine which products will be sold (RTE meats with or without growth inhibitors; pasteurized or unpasteurized cheeses), the number of labor hours allocated to sanitation, which chemicals are used, and many other factors which can impact upon the safety of retail products and prevalence and persistence of *L. monocytogenes*. However, immediate supervisors and managers drive the quality of food safety practices more than any other factor (Neal et al. 2012). Managers who are committed to improving food safety in their stores can begin with the following five strategies.

1. *Temperature control of product in compliance with the Food Code*. The USA FDA Food Code contains the primary regulatory guidelines for ensuring food safety at retail. Key strategies to control *L. monocytogenes* growth include monitoring and maintaining deli service cases and walk-in cold storage rooms at temperatures below 41 °F (<5 °C) (FMI 2008, 2012; USDA-FSIS and FDA 2013). While *L. monocytogenes* can grow at refrigeration temperatures, reduced temperatures significantly reduce its growth rate. Maintaining product at refrigeration temperatures is among the most effective strategies to prevent *L. monocytogenes* from reaching high levels in foods and subsequently cases of foodborne listeriosis (USDA-FSIS and FDA 2013).
2. *Prevent cross-contamination*. Observational studies, (e.g., Lubran et al. 2010), underscore the need to increase the frequency of hand washing. Hand washing is a foundational component of a positive food safety culture. Aside from teaching employees why hand washing is important, managers can develop product handling strategies that minimize hand contact with NFCS and develop peer-to-peer accountability systems to encourage hand washing. It is also important to consider the flow of people and products near RTE foods (e.g., raw meat department, produce department). Because *L. monocytogenes* can be present in raw products (e.g., raw chicken), it is important to limit access to the deli to required departmental employees only (FMI 2008, 2012). Color coding equipment is a good practice to prevent cross-contamination between raw and RTE foods (e.g., cut raw poultry on yellow cutting boards, fresh produce on green). Similarly, for cleaning equipment, equipment intended for FCS should be labeled and reserved for only these surfaces (e.g., buckets, brushes). Separate equipment should be available for NFCS as these are more likely to harbor *L. monocytogenes*, e.g., 1 in 4 floor drains is contaminated with *L. monocytogenes* (Simmons et al. unpublished). Furthermore, the deli department should have its own cleaning equipment and should not provide or borrow equipment from other departments (e.g., brooms and hoses used in the raw meat department should not be shared with deli, dairy, bakery, or produce).
3. *Make the deli easier to clean and maintain*. Sanitation is a difficult, tedious, and time-consuming job. While it is difficult to change some aspects of the process, there are some obvious strategies to make it easier to do and more effective. It is important to remove "clutter" from the area. This can include unused and/or broken equipment, storage of chemicals below sinks, excess carts, old cleaning equipment, milk crates, etc. In short, personnel should be equipped with the tools and supplies needed to perform the job and the rest removed. Excess equipment and clutter have to be cleaned and cleaned around which significantly reduces (1) the likelihood that an area will be cleaned well or (2) cleaned at all. There should be designated space for cleaning equipment including hanging racks for brooms and shelves for sanitizers and detergents. An excellent example of an area that is typically challenging is under the single- and three-basin sink. This area is (1)

already difficult to clean, (2) often wet from dishwashing, and (3) a common storage area for chemicals and equipment. Results from our most recent study found that the floor wall juncture underneath the single-basin sink is one of the most common NFCS persistently contaminated with *L. monocytogenes*, i.e., >27 % of samples tested were positive for *L. monocytogenes* (Simmons et al. unpublished).

Our group is working to identify design challenges, practices, and other risk factors that increase the likelihood that a deli will harbor *L. monocytogenes*. While some effort has been made to enhance the hygienic design of delis and deli equipment, there is significant opportunity for improvement. Many challenges in the deli department that could result in niches require significant capital investments to remediate. For example, *L. monocytogenes* can routinely be found in pooled water on the floor, which results from improperly sloped floors. It is inarguably a good investment to fix the floor to enhance food safety and to reduce the risk of worker injury (e.g., due to slip hazard), however, the reality is that many delis have these challenges and they are not often a priority. If components of the deli environment or equipment are worn, damaged, or rusted, no amount of chemical or scrubbing will make it microbiologically clean. Well-repaired equipment, floors, and walls are easier to clean effectively, reducing the risk of harboring persistent *monocytogenes* in retail stores. In the interim, scheduled preventative maintenance of equipment and the deli is a viable strategy (FMI 2008, 2012). Preventive maintenance includes, but is certainly not limited to, replacing striated, nicked, or worn slicer blades; removing and replacing loose seals or caulking around sinks and walls; repairing damaged floor tiles; replacing worn or rusted components of cold rooms and deli cases; and making sure drains are free flowing.

4. *Verify cleaning was performed and performed correctly*. Sanitation remains one of the most important and obvious strategies to enhance food safety and to prevent disease. While it is difficult, time consuming, and hard work, creating a culture that champions the importance of sanitation is key. There is a big disparity between "saying" cleaning/sanitizing has occurred and "verifying" that it actually did. Cleaning and sanitation checklists, including employees' initials for accountability (FMI 2008, 2012), are good record-keeping strategies to track action. Visual inspection of surfaces after cleaning is also a good practice. Sanitizers are ineffective on surfaces that have visible soil or potential biofilms. Biofilms and some soils are difficult to visually see in many cases but there are cost effective, easy-to-use tools that can help identify challenges. Two common options are ATP (adenosine triphosphate; the "energy currency of all life") tests and protein test strips. These rapid tests detect general organic soils on a surface in 15–60 s, indicating if a surface is sufficiently clean to be sanitized. Our studies have identified a correlation between the ATP response value and the probability of detecting *L. monocytogenes* on a cleaned deli surface (Hammons et al. unpublished). ATP does not detect *L. monocytogenes*, but *L. monocytogenes* is more likely to be found in the presence of soils. While no one enjoys inspection and auditing processes, internal auditing programs can be a great way to identify opportuni-

ties for improvements that could enhance food safety. Our studies have found that engaging managers from nearby stores or other departments within the organization brings new perspectives which can help identify areas which need help or additional resources without the cost associated with third-party auditing services. Third-party audits, however, are an important way to verify food safety practices and to formally identify and address gaps.

5. *Provide leadership and support for food safety measures*. The leadership of the organization must create a culture that supports and values food safety. Food safety has to be championed within each service area by providing food safety training, education, and resources to all employees. Managers and other members of the leadership team must allocate sufficient labor hours to support effective cleaning during operating hours and after closing, and adjust sanitation schedules during busy periods. Budgeting for regular maintenance, chemicals, and tools needed to support sanitation should be routine and never viewed as crisis management (FMI 2008, 2012). Most importantly, lead by example. Supervisors and managers committed to excellence in food safety who follow and enforce health code compliance even when it is inconvenient, positively influence employees to do the same (Neal et al. 2012).

References

Centers for Disease Control and Prevention (2012a) Multistate outbreak of listeriosis linked to imported Frescolina Marte brand ricotta salata cheese (final update) http://www.cdc.gov/listeria/outbreaks/cheese-09-12/. Accessed 24 Dec 2013

Centers for Disease Control and Prevention (2012b) Multistate outbreak of listeriosis linked to whole cantaloupes from Jensen Farms, Colorado http://www.cdc.gov/listeria/outbreaks/cantaloupes-jensen-farms/index.html. Accessed 24 Dec 2013

Centers for Disease Control and Prevention (2013a) Foodborne outbreak online database (FOOD). http://wwwn.cdc.gov/foodborneoutbreaks/Default.aspx. Accessed 24 Dec 2013

Centers for Disease Control and Prevention (2013b) Multistate outbreak of listeriosis linked to Crave Brothers farmstead cheeses (final update). http://www.cdc.gov/listeria/outbreaks/cheese-07-13/index.html. Accessed 24 Dec 2013

Cook A, Odumeru J, Lee S, Pollari F (2012) *Campylobacter*, *Salmonella*, *Listeria monocytogenes*, Verotoxigenic *Escherichia coli*, and *Escherichia coli* prevalence, enumeration, and subtypes on retail chicken breasts with and without skin. J Food Prot 75:34–40

Cummins AJ, Fielding AK, McLauchlin J (1994) *Listeria ivanovii* infection in a patient with AIDS. J Infect 28:89–91

den Bakker HC, Manuel CS, Fortes ED, Wiedmann M, Nightingale KK (2013) Genome sequencing identifies *Listeria fleischmannii* subsp. *coloradonensis* subsp. nov., isolated from a ranch. Int J Syst Evol Microbiol 63:3257–3268

Elischerova K, Cupkova E, Urgeova E, Lysy J, Sesevickova A (1990) Isolation of *Listeria ivanovii* in Slovakia. Cesk Epidemiol Mikrobiol Imunol 39:228–236

Endrikat S, Gallagher D, Pouillot R, Hicks Quesenberry H, Labarre D, Schroeder CM et al (2010) A comparative risk assessment for *Listeria monocytogenes* in prepackaged versus retail-sliced deli meat. J Food Prot 73:612–619

European Food Safety Authority (EFSA) (2007) The community summary report on trends and sources of zoonoses, zooonotic agents, antimicrobial resistance, and foodborne outbreaks in the European Union in 2006. EFSA J. doi:10.2903/j.efsa.2007.130r

European Food Safety Authority (EFSA) (2011) The European Union summary report on trends and sources of zoonoses, zoonotic agents, and food-borne outbreaks in 2009. EFSA J. doi:10.2903/j.efsa.2011.2090

Farber JM, Losos JZ (1988) *Listeria monocytogenes*: a foodborne pathogen. CMAJ 138:413–418

Fenlon DR (1985) Wild birds and silage as reservoirs of *Listeria* in the agricultural environment. J Appl Bacteriol 59:537–543

Fenlon DR, Wilson J, Donachie W (1996) The incidence and level of *Listeria monocytogenes* contamination of food sources at primary production and initial processing. J Appl Bacteriol 81:641–650

Ferreira V, Barbosa J, Stasiewicz M, Vongkamjan K, Moreno Switt A, Hogg T et al (2011) Diverse geno- and phenotypes of persistent *Listeria monocytogenes* isolates from fermented meat sausage production facilities in Portugal. Appl Environ Microbiol 77:2701–2715

Food Marketing Institute (FMI) (2008) Guidance for the control of *Listeria monocytogenes* risks in retail food stores. http://www.fmi.org/forms/store/ProductFormPublic/search?action=1&Product_productNumber=2137. Accessed 16 Oct 2013

Food Marketing Institute (FMI) (2012) FMI *Listeria* action plan for retail delis. http://www.fmi.org/docs/food-safety-best-practice-guides/listeria-action-plan-for-retail-delis.pdf?sfvrsn=9. Accessed 16 Oct 2013

Food and Drug Administration and Food Safety Inspection Service (2003) Quantitative assessment of the relative risk to public health from foodborne *Listeria monocytogenes* among selected categories of ready-to-eat (RTE) foods. http://www.foodsafety.gov/~dms/lmr2-toc.html. Accessed 11 Jul 2013

Food and Drug Administration (2013) Food Code 2013. http://www.fda.gov/food/guidanceregulation/retailfoodprotection/foodcode/ucm374275.htm. Accessed 26 Dec 2013

Gibson KE, Koo OK, O'Bryan CA, Neal JA, Ricke SC, Crandall PG (2013) Observation and relative quantification of cross-contamination within a mock retail delicatessen environment. Food Control 31:116–124

Gombas DE, Chen Y, Clavero RS, Scott VN (2003) Survey of *Listeria monocytogenes* in ready-to-eat foods. J Food Prot 66:559–569

Gudmundsdottir K, Svansson V, Aalbaek B, Gunnarsson E, Sigurdarson S (2004) *Listeria monocytogenes* in horses in Iceland. Vet Rec 155:456–459

Hammons S, Stasiewicz M, Simmons C, Roof SE, Wright E, Warchocki S et al. (unpublished) Non-selective rapid test response correlates to probability of *Listeria monocytogenes* contamination on pre-operation surfaces in retail delis. J Food Prot

Hayashidani H, Kanzaki N, Kaneko Y, Okatani A, Taniguchi T, Kaneko K et al (2002) Occurrence of yersiniosis and listeriosis in wild boars in Japan. J Wildl Dis 38:202–205

Hoelzer K, Oliver HF, Kohl LR, Hollingsworth J, Wells MT, Wiedmann M (2011a) Structured expert elicitation about *Listeria monocytogenes* cross-contamination in the environment of retail deli operations in the United States. Risk Anal 32:1139–1156

Hoelzer K, Sauders BD, Sanchez MD, Olsen PT, Pickett MM, Mangione KJ et al (2011b) Prevalence, distribution, and diversity of *Listeria monocytogenes* in retail environments, focusing on small establishments and establishments with a history of failed inspections. J Food Prot 74:1083–1095

Hoelzer K, Pouillot R, Gallagher D, Silverman MB, Kause J, Dennis S (2012) Estimation of *Listeria monocytogenes* transfer coefficients and efficacy of bacterial removal through cleaning and sanitation. Int J Food Microbiol 157:267–277

Holah JT, Bird J, Hall KE (2004) The microbial ecology of high-risk, chilled food factories; evidence for persistent *Listeria* spp. and *Escherichia coli* strains. J Appl Microbiol 97:68–77

Lang Halter E, Neuhaus K, Scherer S (2013) *Listeria weihenstephanensis* sp. nov., isolated from the water plant *Lemna trisulca* taken from a freshwater pond. Int J Syst Evol Microbiol 63:641–647

Lawrence LM, Gilmour A (1995) Characterization of *Listeria monocytogenes* isolated from poultry products and from the poultry-processing environment by random amplification of polymorphic DNA and multilocus enzyme electrophoresis. Appl Environ Microbiol 61: 2139–2144

Lecuit M (2007) Human listeriosis and animal models. Microbes Infect 9:1216–1225

Lessing MP, Curtis GD, Bowler IC (1994) *Listeria ivanovii* infection. J Infect 29:230–231

Lianou A, Sofos JN (2007) A review of the incidence and transmission of *Listeria monocytogenes* in ready-to-eat products in retail and food service environments. J Food Prot 70:2172–2198

Little CL, Gormley FJ, Rawal N, Richardson JF (2010) A recipe for disaster: outbreaks of campylobacteriosis associated with poultry liver pate in England and Wales. Epidemiol Infect 138: 1691–1694

Lubran MB, Pouillot R, Bohm S, Calvey EM, Meng J, Dennis S (2010) Observational study of food safety practices in retail deli departments. J Food Prot 73:1849–1857

Maitland J, Boyer R, Gallagher D, Duncan S, Bauer N, Kause J et al (2013) Tracking cross-contamination transfer dynamics at a mock retail deli market using GloGerm. J Food Prot 76:272–282

McLauchlin J, Rees C (2009) *Listeria*. In: Garrity G (ed) Bergey's manual of systematic bacteriology, 2nd edn. Springer, New York

McLauchlin J, Mitchell RT, Smerdon WJ, Jewell K (2004) *Listeria monocytogenes* and listeriosis: a review of hazard characterisation for use in microbiological risk assessment of foods. Int J Food Microbiol 92:15–33

Mead PS, Dunne EF, Graves L, Wiedmann M, Patrick M, Hunter S et al (2006) Nationwide outbreak of listeriosis due to contaminated meat. Epidemiol Infect 134:744–751

Miettinen H, Wirtanen G (2005) Prevalence and location of *Listeria monocytogenes* in farmed rainbow trout. Int J Food Microbiol 104:135–143

Miettinen MK, Palmu L, Bjorkroth KJ, Korkeala H (2001) Prevalence of *Listeria monocytogenes* in broilers at the abattoir, processing plant, and retail level. J Food Prot 64:994–999

Neal JA, Binkley M, Henroid D (2012) Assessing factors contributing to food safety culture in retail food establishments. Food Prot Trends 32:468–476

Nightingale KK, Schukken YH, Nightingale CR, Fortes ED, Ho AJ, Her Z et al (2004) Ecology and transmission of *Listeria monocytogenes* infecting ruminants and in the farm environment. Appl Environ Microbiol 70:4458–4467

Nightingale KK, Fortes ED, Ho AJ, Schukken YH, Grohn YT, Wiedmann M (2005) Evaluation of farm management practices as risk factors for clinical listeriosis and fecal shedding of *Listeria monocytogenes* in ruminants. J Am Vet Med Assoc 227:1808–1814

Ojeniyi B, Wegener HC, Jensen NE, Bisgaard M (1996) *Listeria monocytogenes* in poultry and poultry products: epidemiological investigations in seven Danish abattoirs. J Appl Bacteriol 80:395–401

Orsi RH, Borowsky ML, Lauer P, Young SK, Nusbaum C, Galagan JE et al (2008) Short-term genome evolution of *Listeria monocytogenes* in a non-controlled environment. BMC Genomics 9:539

Pradhan AK, Ivanek R, Grohn YT, Bukowski R, Geornaras I, Sofos JN et al (2010) Quantitative risk assessment of listeriosis-associated deaths due to *Listeria monocytogenes* contamination of deli meats originating from manufacture and retail. J Food Prot 73:620–630

Pradhan AK, Ivanek R, Grohn YT, Bukowski R, Wiedmann M (2011) Comparison of public health impact of *Listeria monocytogenes* product-to-product and environment-to-product contamination of deli meats at retail. J Food Prot 74:1860–1868

Rocourt J, Cossart P (1997) *Listeria monocytogenes*. In: Doyle MP, Beuchat LR, Montville TJ (eds) Food microbiology, fundamentals and frontiers, 1st edn. ASM, Washington, DC

Rocourt J, BenEmbarek P, Toyofuku H, Schlundt J (2003) Quantitative risk assessment of *Listeria monocytogenes* in ready-to-eat foods: the FAO/WHO approach. FEMS Immunol Med Microbiol 35:263–267

Rorvik LM, Aase B, Alvestad T, Caugant DA (2003) Molecular epidemiological survey of *Listeria monocytogenes* in broilers and poultry products. J Appl Microbiol 94:633–640

Ryser E (1999) Foodborne listeriosis. In: Ryser ET, Marth EH (eds) *Listeria*, listeriosis, and food safety, 2nd edn. Marcel Decker, New York

Sauders BD, Sanchez MD, Rice DH, Corby J, Stich S, Fortes ED et al (2009) Prevalence and molecular diversity of *Listeria monocytogenes* in retail establishments. J Food Prot 72:2337–2349

Sauders BD, Overdevest J, Fortes E, Windham K, Schukken Y, Lembo A et al (2012) Diversity of *Listeria* species in urban and natural environments. Appl Environ Microbiol 78:4420–4433

Scallan E, Hoekstra RM, Angulo FJ, Tauxe RV, Widdowson MA, Roy SL et al (2011) Foodborne illness acquired in the United States—major pathogens. Emerg Infect Dis 17:7–15

Silk BJ, Date KA, Jackson KA, Pouillot R, Holt KG, Graves LM et al (2012) Invasive listeriosis in the Foodborne Diseases Active Surveillance Network (FoodNet), 2004–2009: further targeted prevention needed for higher-risk groups. Clin Infect Dis 54:S396–S404

Silk BJ, Mahon BE, Griffin PM, Gould LH, Tauxe RV, Crim SM et al (2013) Vital signs: *Listeria* illnesses, deaths, and outbreaks—United States, 2009–2011. MMWR 62:448–452

Simmons C, Stasiewicz M, Wright E, Worchocki S, Roof S, kause J et al (accpted) *Listeria monocytogenes* and *Listeria* spp. Contamination patterns in retail delicatessen establishments in three US states. J Food Prot doi: 10.4315/0362-028X.JFP-14–183

Smith JL (1999) Foodborne infections during pregnancy. J Food Prot 62:818–829

Snapir YM, Vaisbein E, Nassar F (2006) Low virulence but potentially fatal outcome—*Listeria ivanovii*. Eur J Intern Med 17:286–287

Southwick FS, Purich DL (1996) Intracellular pathogenesis of listeriosis. N Engl J Med 334:770–776

Strawn LK, Grohn YT, Warchocki S, Worobo RW, Bihn EA, Wiedmann M (2013) Risk factors associated with *Salmonella* and *Listeria monocytogenes* contamination of produce fields. Appl Environ Microbiol 79:7618–7627

Thomas MK, Murray R, Flockhart L, Pintar K, Pollari F, Fazil A et al (2013) Estimates of the burden of foodborne illness in Canada for 30 specified pathogens and unspecified agents, circa 2006. Foodborne Pathog Dis 10:639–648

Tompkin RB (2002) Control of *Listeria monocytogenes* in the food-processing environment. J Food Prot 65:709–725

USDA-FSIS (2003) Control of *Listeria monocytogenes* in ready-to-eat meat and poultry products; final rule. Fed Regist 68:34208–34254

USDA-FSIS and FDA (2013) Interagency risk assessment: *Listeria monocytogenes* in retail delicatessens—executive summary. http://www.fsis.usda.gov/wps/wcm/connect/d394b3c0-37b1-484e-a1c3-392a22756993/Lm-Retail-Interpretive-Summary.pdf?MOD=AJPERES. Accessed 11 Nov 2013

Vazquez-Boland JA, Kuhn M, Berche P, Chakraborty T, Dominguez-Bernal G, Goebel W et al (2001) *Listeria* pathogenesis and molecular virulence determinants. Clin Microbiol Rev 14:584–640

Weatherill S, Carsley J, Schlech III WF, Griffiths MW, Tompkin RB, Doyle M (2009) Report of the independent investigator into the 2008 listeriosis outbreak. http://www.cpha.ca/uploads/history/achievements/09-lirs-rpt_e.pdf. Accessed 12 Dec 2013

Weber A, Potel J, Schafer-Schmidt R, Prell A, Datzmann C (1995) Studies on the occurrence of *Listeria monocytogenes* in fecal samples of domestic and companion animals. Zentralbl Hyg Umweltmed 198:117–123

Wulff G, Gram L, Ahrens P, Vogel BF (2006) One group of genetically similar *Listeria monocytogenes* strains frequently dominates and persists in several fish slaughter- and smokehouses. Appl Environ Microbiol 72:4313–4322

Yokoyama E, Saitoh T, Maruyama S, Katsube Y (2005) The marked increase of *Listeria monocytogenes* isolation from contents of swine cecum. Comp Immunol Microbiol Infect Dis 28: 259–268

Chapter 6
Control of Foodborne Viruses at Retail

Jason Tetro

6.1 Introduction

Unlike bacteria, there are only a handful of viruses associated with foodborne outbreaks (Table 6.1). However, over the last decade, the role of viruses in outbreaks associated with foodborne illness has increased such that together, they represent a significant threat to global public health (FAO/WHO 2008). Moreover, there continues to be an ever growing list of emerging viral pathogens that could threaten the food supply. These include such well-known agents as the severe acute respiratory syndrome (SARS), foot and mouth disease virus (FMDV) and avian influenza, as well as the lesser known Aichi and Nipah viruses.

Estimating the necessity for control of viruses in retail can be difficult for several reasons. Most foodborne illnesses are either underreported or not reported at all leaving many gaps in our understanding of the impact of viruses in food (Fischer Walker et al. 2010; Mead et al. 1999; Newell et al. 2010). A large percentage of documented viral foodborne outbreaks are not associated with retail, but rather through away from home establishments (Matthews et al. 2012) such as restaurants, cruise ships, and healthcare facilities. Of those that do occur at home, outbreaks may be due not to the nature of the food at purchase, but as a result of contamination of the food source after the product has been purchased (Fein et al. 2011; Henley et al. 2012; Hoelzl et al. 2013). These factors in food safety suggest the current methods of microbiological control, which mainly are based on coliform bacterial identification and enumeration to assess fecal contamination, may not be sufficient.

Compiled information suggests that there is a need for better control of viruses in foods destined for the retail and RTE markets. A recent survey of foodborne out-

J. Tetro, B.Sc. (✉)
University of Guelph, 130 Rosedale Valley Road, Suite 103, Toronto, ON, Canada M4W 1P9
e-mail: jtetro@misciconsulting.com

J. Farber et al. (eds.), *Retail Food Safety*, Food Microbiology and Food Safety,
DOI 10.1007/978-1-4939-1550-7_6

Table 6.1 Known foodborne viruses and association with retail products

Virus	Mode of transmission	Incubation period (days)	Duration of illness (days)	Recorded retail foodborne outbreaks?	Current pathogen of concern at retail?
Adenovirus	Fecal–oral, contaminated water	3–10	10	Yes	Yes
Aichi virus	Fecal–oral, contaminated water	3–7	3–10	Yes	Yes
Astrovirus	Fecal–oral, contaminated water	2–3	3–4	Yes	Yes
Avian influenza	Fecal–oral, droplet, close contact with infected animals and birds	2–17	5–21 with proper treatment	Yes (live animal markets)	Yes
Caliciviruses	Fecal–oral, contaminated water	0.5–3	1–3	Yes	Yes
Coronavirus (SARS)	Fecal–oral, airborne	2–5	7–21	No	Yes
Coxsackievirus	Fecal–oral, contaminated water	3–10	3–7	Yes	No
Echovirus	Fecal–oral, contaminated water	3–10	3–7	Yes	No
Hepatitis A virus	Fecal–oral, contaminated water	5–10	14–21	Yes	Yes
Hepatitis E virus	Fecal–oral, contaminated water, infected animal meat	15–45	100–150	No	Yes
Nipah virus	Infected animals, contaminated fruit sap	4–18	5–30	Yes (infected date sap)	Yes
Parvovirus	Fecal–oral, contaminated water	1–2	5–10	No	No
Rotavirus	Fecal–oral, contaminated water	1–3	4–8	Yes	Yes
Tick borne encephalitis	Milk from infected animals	7–14	10–14	No	No

breaks in the USA revealed that regardless of the means of spread, over 40 % of the recorded outbreaks were due to virus infection (Centers for Disease Control and Prevention 2013). Globally, estimates suggest that viruses may account for between 8 and 68 % of the total number of foodborne infections (FAO/WHO 2008). A significant proportion of these cases are due to the continuing increase in food importation (Centers for Disease Control and Prevention 2013; FAO Trade and Markets Division 2012). Many of these countries do not have the capacity to incorporate food safety practices including hazard analysis and critical control point (HACCP), good hygiene practices (GHP), and adherence to the standards of the Codex

Alimentarius, in particular, Guidelines for the Validation of Food Safety Control Measures (Codex Alimentarius 2008). Yet, imported foods are actively sought by an increasing exotic appetite in the developed world. Without proper surveillance activity, many viral agents can move freely across borders without detection (Buisson et al. 2008; Jebara 2004).

6.2 Viruses in Food

The diverse nature of the viruses listed in Table 6.1 suggests that each possesses unique physical characteristics, causes a diverse array of symptoms, persists in the host and environment, and has a number of routes for spread. However, they all share common properties that are indicative of the necessary means for control:

1. They are abundant in nature.
2. They are common to several or all areas of the world.
3. They can easily be transferred either through contaminated water or through the fecal–oral route.

Adenoviruses: The adenoviruses are a group of double-stranded DNA viruses that are known pathogens of humans. Most documented cases are respiratory in nature, however, two particular strains, Ad40 and Ad41 have been implicated in gastroenteritis and foodborne transmission in many areas of the globe (Ahluwalia et al. 1994; Aminu et al. 2007; Brown 1990; Bryden et al. 1997; Dey et al. 2009; Grimwood et al. 1995; Herrmann et al. 1988; Johansson et al. 1994; Saderi et al. 2002; Shinozaki et al. 1991a; Tiemessen et al. 1989) particularly in children under 2 years of age (Shinozaki et al. 1991b; Uhnoo et al. 1984). The main source of these viruses is unsafe water, which can either contaminate fish or produce through irrigation. For example, Hansman et al. (2008) identified that 52 % of 33 packages of clams collected from Japanese markets were positive for adenoviruses. Similarly, Cheong et al. (2009) found the presence of adenoviruses on spinach, lettuce, and chicory; a result of irrigation with unsafe water. Based on laboratory studies of the persistence of these viruses on foods, there was no significant loss of infectivity after 1 week (Verhaelen et al. 2012). A similar study by Diez-Valcarce et al. (2012) showed that 36 % of the mussels sampled from three European countries had the presence of the gastrointestinal adenoviruses.

Aichi virus: First discovered in 1989 (Yamashita et al. 1991), this virus is a member of the Picornaviridae family in the Kobuvirus genus. Over the last two decades, the aichi viruses have demonstrated their significance as a foodborne pathogen worldwide (Goyer et al. 2008; Jonsson et al. 2012; Kaikkonen et al. 2010; Oh et al. 2006; Reuter et al. 2009; Ribes et al. 2010; Sdiri-Loulizi et al. 2009; Verma et al. 2011; Yang et al. 2009). The main sources of the virus are unsafe water and sewage (Alcala et al. 2010; Di Martino et al. 2013; Kitajima et al. 2011; Sdiri-Loulizi et al. 2010) and production of foods with such waters results in the potential for infection at the consumer level. The virus has been implicated in an outbreak associated with the consumption of oysters (Le Guyader et al. 2008) and has been linked to other incidences of gastroenteritis (Oh et al. 2006), although the food source was not determined. The virus is stable on produce (Fino and Kniel 2008a) and in shellfish (Sdiri-Loulizi et al. 2010).

Astroviruses: This group of viruses found in the Astroviridae family was first described in 1975 by Madeley and Cosgrove (1975). These viruses are significant pathogens of both humans and animals (Kurtz and Lee 1987) and have been identified in human outbreaks associated with foods (Le Guyader et al. 2008; Mead et al. 1999). The predominant route of infection is water (Abad et al. 1997) and the virus can persist on fomites for several days (Abad et al. 2001), suggesting that foodborne infections are due to improper food handling. Yet, there has also been evidence that astroviruses can contaminate shellfish (Hansman et al. 2008), suggesting a possible foodborne route at the retail level.

Hepatitis A virus: Also a member of the Picornaviridae family, HAV is a well-recognized cause of foodborne disease (Fiore 2004; Sanchez et al. 2007). The virus is abundant worldwide and present in many regions of the world including developed countries such as Italy (Campagna et al. 2012) and The Netherlands (Whelan et al. 2013). Studies in the laboratory have shown that HAV is highly stable in the environment (Siegl et al. 1984) and can easily be found in shellfish growing in contaminated waters (Diez-Valcarce et al. 2012). In agricultural settings, the virus can be internalized into produce such as spinach (Hirneisen and Kniel 2013), tomatoes (Carvalho et al. 2012), and strawberries (Niu et al. 1992). While there is ample evidence to suggest that the virus can easily be involved in retail as a result of improper food processing (Wang et al. 2013), there is also significant evidence showing that the virus can also be transferred through food handling (Tricco et al. 2006). The virus can transfer easily through environmental surfaces, known as fomites (Abad et al. 1994) including knives and graters (Wang et al. 2013), and can remain infective for several hours in acidic conditions (Scholz et al. 1989).

Hepatitis E virus: Initially described as a picornavirus in 1983 (Balayan et al. 1983), HEV has been found to represent a novel genus, Herpesvirus (Berke and Matson 2000). Since its discovery, the virus has grown to be a major cause of hepatitis in the developing world and its prevalence is growing in the developed world (Miyamura 2011). Transmission is generally mediated through water, however, foodborne outbreaks have occurred, primarily through the ingestion of improperly cooked meat products including swine, boar, poultry, venison, ovine, and beef products (Meng 2011). HEV has also been found in shellfish (Koizumi et al. 2004; Song et al. 2010), in pig livers (Berto et al. 2012; Bouwknegt et al. 2007), and in agricultural produce (Ceylan et al. 2003), but the risk associated with these two routes is significantly smaller than that of livestock and game meats.

Caliciviruses: The caliciviruses are a group of small viruses that are very stable in the environment and pose a significant threat for foodborne infection. The two major groups of caliciviruses known to cause foodborne infection are the sapoviruses and the noroviruses. While sapoviruses have been associated with foodborne outbreaks (Gallimore et al. 2005; Kobayashi et al. 2012; Usuku et al. 2008), noroviruses are the leading cause of gastroenteritis worldwide (Koo et al. 2010). The viruses were first discovered in 1972 (Kapikian et al. 1972) in an isolated case of pediatric diarrhea. Over the three decades that followed, the noroviruses were found to be globally abundant and identified as the cause of winter vomiting disease, stomach flu, and cruise ship illness. There have been over 900 documented cases of norovirus foodborne outbreaks (Matthews et al. 2012), many of which were determined to be due to retail and RTE purchases.

Rotaviruses: These viruses are part of the Reoviridae family. Studies to identify the presence of the virus in the food supply have revealed its presence in almost every aspect of the food continuum from shellfish (Benabbes et al. 2013; Bigoraj et al. 2012; Boxman 2010; Hansman et al. 2008; Woods and Burkhardt 2010) to livestock (Dalton et al. 2004; Mattison et al. 2007) to produce (Baert et al. 2011; Berger et al. 2010; Mattison et al. 2010; Serracca et al. 2012; Tuan et al. 2010) and fruits (Berger et al. 2010; Le Guyader et al. 2004; Martin-Latil et al. 2012; Strawn et al. 2011; Verhaelen et al. 2012). They have been recognized as a major cause of gastroenteritis, particularly in children (Parashar et al. 2003). There are five groups of rotavirus but only three are infectious to humans, Groups A–C. They are known to be highly stable in water, can survive for months in the environment (Fu et al. 1989), and for several hours in the air (Ijaz et al. 1985) and on human hands (Ansari et al. 1991). The majority of cases of infection are due to ingestion of contaminated water, however up to 1 % of foodborne infections are attributable to these viruses (Mead et al. 1999).

Emerging foodborne viruses: There have been several viruses that have caused concern with respect to foodborne illness due to the potential for infection from live or dead animals, a process known as zoonotic transmission. These include avian influenza, the Nipah viruses, and the coronaviruses, of which SARS is a member. In all three cases, they cause significant clinical infection and have high mortality rates. In addition, for all three viruses, interaction with live animals or foods associated with these animals at the market has led to human infection. In the case of Nipah virus, infection at retail has come from the sharing of raw date sap (Luby et al. 2006; Rahman et al. 2012), however the prevalence of these cases is low and isolated to areas where bats are common, such as Bangladesh (Luby and Gurley 2012).

6.3 Controlling Viruses in Food

The means to control viruses in retail foods in theory should not differ significantly from the methods used to control bacterial infections in these same products. However, there are several unique properties of many foodborne viruses that need to be viewed separately from bacteria. Therefore, no bacterial control studies can be extrapolated to the majority of these viruses.

Structurally, viruses are characterized into two major categories, enveloped and nonenveloped. Enveloped viruses possess an external layer made of both proteins and lipids. The lipids in the envelope can easily be broken down, particularly by soaps, rendering the virus unable to infect, a process known as inactivation (Klein 2004). In contrast, nonenveloped viruses have an external protein shell that can resist environmental stressors and many disinfectants (Maillard and Russell 1997; Sattar et al. 1989). In the context of foodborne viruses, the major contributors to infection, i.e., the astroviruses, Aichi virus, caliciviruses, HAV, and HEV, are all small and nonenveloped. The adenoviruses are also nonenveloped although somewhat larger in size, meaning controlling them may be somewhat easier (Maillard and Russell 1997). Only the rotaviruses and the emerging viruses, avian influenza, SARS, and Nipah are enveloped.

The survival and persistence of enveloped viruses in the food processing environment is fairly poor. Studies on rotaviruses showed that while the viruses have the ability to sustain infectivity over days in both raw and treated drinking water (Raphael et al. 1985; Sattar et al. 1984), the virus was rapidly reduced on fomites and hands in a matter of hours (Ansari et al. 1988). These data correlate well with the fact that foodborne infections due to rotavirus are limited to shellfish and raw produce irrigated with water from unsafe sources (Brassard et al. 2012; Le Guyader et al. 2008; Mattison et al. 2010; Vilarino et al. 2009). In contrast, the nonenveloped viruses can survive and spread throughout the entire food continuum from processing (Baert et al. 2008; Van Boxstael et al. 2013) to storage (Brandsma et al. 2012; Butot et al. 2008; Shieh et al. 2009; Sun et al. 2012; Verhaelen et al. 2012). Moreover, these viruses are well adapted to survive on hands (Greig et al. 2007; Richards 2001; Todd et al. 2009), increasing the potential for contamination both in processing as well as in preparation (Mokhtari and Jaykus 2009).

In determining risk factors associated with virus infections, the European Food Safety Authority (EFSA) published a risk assessment taking into account the survivability and transmissibility of viruses (EFSA Panel on Biological Hazards 2011). The breadth of the risks reveals that in order to properly control these viruses, there needs to be a wide-reaching set of control measures implemented in food processing and handling to ensure virus infections are reduced.

6.4 Viruses and Current Regulatory Mechanisms

Hazard analysis and critical control points (HACCP) and good hygiene practices (GHP) have been incorporated in many food industries and are generally known to be important in reducing the microbial risk to the consumer (FAO 1995; Panisello et al. 2000). These practices have been adopted in other environments, including retail, although there has yet to be one specific set of standards or guidelines to prevent retail virus infections (Little et al. 2003; Mortlock et al. 1999). The EFSA suggested (EFSA Panel on Biological Hazards 2011) that the use of HACCP to control viruses may not be sufficient to overcome the stability of viruses as well as their spread. In response, a 2008 joint meeting of the FAO and WHO (FAO/WHO 2008) suggested that regulation be focused on five high impact areas of concern involving specific combinations of viruses.

The virus–food combinations were determined based on (1) the number of documented cases and/or concerns of high impact public health threats; and (2) laboratory information focusing on virus survival in these food types. They are:

1. Noroviruses and HAV in bivalve molluscan shellfish, including oysters, clams, cockles, and mussels.
2. Noroviruses and HAV in fresh produce.
3. Noroviruses and HAV in prepared foods.
4. Rotaviruses in water used for food preparation.
5. Emerging viruses and their associated commodities including avian influenza, HEV, Nipah and others, as they are indicated.

In each case, there are subcategories that best characterize the potential for risk, as well as priority areas needed for a proper regulatory framework. They include (1) test development to identify these viruses throughout the food continuum; (2) in-depth assessment of exposure to these viruses not only at the consumer level but also at the worker and handler levels; and (3) an analysis of dose–response relationships.

While the EFSA developed these suggestions in 2008, there has been little progress made, due in part to hurdles occurring in the development of tests to identify viruses. While diagnostic tests continue to improve, there continues to be a large variation in testing results. The reasons for this have been excellently reviewed by Stals et al. (2012). In addition, while the detection of viruses in different food sources continues to improve, the applicability of these diagnostic tests has been less than favorable. All the viruses identified in these priority areas have relatively low dose responses and thus require a very low detection limit. This requires highly sensitive methods such as the diagnostic tool, polymerase chain reaction (PCR), which identifies the genetic material of a virus, and the more recently developed lab on a chip, in which not only the genetic material but other pieces of the virus including proteins can be detected (Yoon and Kim 2012). However, these are hindered by the requirement for a large sample size to best assess a food source. This challenge has yet to be overcome.

Another significant hurdle deals with the linking of quantitative analysis with qualitative risk assessment. Though genetic material may be found in a food source, there may be no actual link to a viable organism able to cause illness; the virus might already be dead. Thus, any current diagnostic test based on genetic material only gives you an indication of the potential risk associated with exposure to a food.

The determination of these five virus-food combinations has increased the understanding of virus transmission in the food continuum and provided keys to improvements in regulation. Using both data collected from the field as well as controlled experimental data using surrogates, such as the murine norovirus (MNV) and vaccine-strain poliovirus and/or bacteriophage MS2 for HAV (Deboosere et al.

2012; Richards 2012), a more comprehensive look at how these viruses spread by water, food users, and handlers as well as animals, follows.

Water contamination: The introduction of sewage, manure, and other biosolids into the watershed can contaminate water sources used in food production. Several studies have shown the capability of viruses to survive in sewage (Ehlers et al. 2005; Kokkinos et al. 2011b; Muniesa et al. 2009; Sattar and Westwood 1976, 1977, 1979; Wei et al. 2010) even after treatment (Myrmel et al. 2006; van den Berg et al. 2005; Villar et al. 2007) and the association with a risk for foodborne illness (Alcala et al. 2010; Ceballos et al. 2003; Ceylan et al. 2003; Cheong et al. 2009; Fiona Barker et al. 2013; Kokkinos et al. 2011a; Mathijs et al. 2012; Meng 2013; Steele and Odumeru 2004; Tierney et al. 1977; Ueki et al. 2005). The incorporation of management strategies to focus on the use of safe water has thus been identified as a necessary step in improving food safety (Godfree and Farrell 2005; Keraita et al. 2008; Westrell et al. 2004). Yet in many areas of the world, maintaining a safe supply of water can be difficult (Alcala et al. 2010; Ehlers et al. 2005; Kokkinos et al. 2011a), leaving regulatory officials facing a conundrum between the need for production and the maintenance of safety.

Food workers and handlers: Food workers and handlers are an important part of bringing foods to retail; however, these individuals also post a threat to the food, particularly when they themselves are infected with a foodborne virus. One study revealed that norovirus can reach as high as 10^{10} virus particles per gram of fecal matter (Atmar et al. 2008) while symptoms are being experienced. Lower levels can be found even before symptoms have begun (Gaulin et al. 1999) and for several weeks after symptoms have subsided (Gallimore et al. 2004). With the infectious dose of this particular virus being less than 100 particles (Teunis et al. 2008), the chance for contamination leading to infection is particularly high. Yet the most likely chance for contamination in this case occurs at the foodhandling stage, which is the last step before food products are provided to the consumer. As Michaels et al. (2004) and Mokhtari and Jaykus (2009) have both shown, food handlers represent the most likely reservoir leading to high levels of viral contamination and subsequent infections to the consumer.

Zoonotic transmission: While the most recent concerns with zoonotic transmission of pathogens such as avian influenza, SARS, and Nipah (Chmielewski and Swayne 2011; Guan et al. 2003; Smith et al. 2011) are due to close contact with live animals, the impact of animals on the contamination of the food supply cannot be understated. For example, the increase in HEV infections has been directly attributed to the zoonotic potential of the virus from swine (Banks et al. 2010; Berto et al. 2012; Bouwknegt et al. 2007; Casas et al. 2011; Di Bartolo et al. 2008; Fu et al. 2010; Leblanc et al. 2010; Pavio et al. 2010; Scobie and Dalton 2013). The presence of the virus not only in the liver of swine, but also their feces, suggests that this particular virus could cause infection either through the traditional fecal–oral route or through the bloodborne route during processing. In contrast, within the context of the viruses identified by the FAO/WHO, there is little evidence to demonstrate the likelihood of

HAV or rotavirus infection through a zoonotic route. Additionally, the noroviruses have shown potential, albeit no confirmed zoonotic route has been documented. Surveillance for noroviruses in animals has revealed that they can harbor human noroviruses (Mathijs et al. 2012; Mattison et al. 2007) and that without proper handling of animals could lead to transmission of the virus to humans, particularly farmers and food workers. Interestingly, Summa et al. (2012) have suggested that pet dogs may also serve as a route for infection. While this may not pose a risk for food processing, at the food handling level, where pets may be a part of a food service complement, a potential risk could be implied.

6.5 Control Measures

The achievements of HACCP and GHP implementation have aided in the increase of food safety but as seen earlier, there are gaps associated with these regulatory protocols in terms of preventing virus contamination of foods and subsequent foodborne infection. There have been a number of methods tested to inactivate viruses in the food continuum with an emphasis on retail. While each has demonstrated its potential to prevent infection of the consumer, there are still specific obstacles that need to be addressed. Moreover, in certain cases, there is little current feasibility for the incorporation of the methods at the retail stage; they are best used during prior steps of the food continuum.

Hand hygiene: The most effective and simplest means of controlling virus transmission is proper hand hygiene. In the context of food safety, the most effective means involves the use of soap for a minimum of 20 s followed by rinsing with water (Todd et al. 2010b). The use of other hand hygiene products, such as alcohol-based handrubs, may be effective against the majority of foodborne bacterial pathogens but the active ingredient, ethanol, is known to be ineffective against HAV and has limited efficacy against the noroviruses (Liu et al. 2010; Park et al. 2010; Sattar et al. 2011). While there is validity to the incorporation of alcohol-based handrubs in any food safety environment as a supplement to handwashing, these products cannot supplant regular handwashing.

The use of hand hygiene practices in the food continuum has been investigated (Michaels et al. 2004; Todd et al. 2010a, b) and there is an incorporation of hand hygiene in HACCP and GHP guidelines. Yet the use of hand hygiene measures at all stages of the food continuum continues to be an issue, particularly with compliance (Hoelzl et al. 2013; Strohbehn et al. 2004; Todd et al. 2010a). In 2008, for example, Strohbehn et al. (2008) conducted an assessment of foodservice workers in restaurants, childcare institutions, and facilities providing assisted living for the elderly and schools. In comparison to the Food Code requirements of handwashing, which ranged from 7 to 29 handwashing moments per hour, the results were disappointing. In the context of providing RTE foods, this result suggests that there is a significant risk posed to the consumer. Similar results have been seen in other retail markets such as butcheries, supermarkets, and delis (Tebbutt 2007).

In 1999, Armstrong (1999) developed an integrated hygiene program into food safety management called hygieomics. The program not only dealt with the implementation of hand hygiene into food production and processing practices, but also described means to cope with the problems associated with behaviour, which is a common concern in both the healthcare and food services sectors (Ferguson 2009; Gilling et al. 2001; Huis et al. 2012; Vindigni et al. 2011; Whitby et al. 2007). The process involved rules and compliance enforcement similar to HACCP, but also demanded an individual commitment to action and the development of a community that is engaged in safeguarding the food supply to achieve both personal and organizational confidence. Such efforts have been used in the health care field with significant success (Huis et al. 2012).

Another means to increase hand hygiene compliance in food workers and handlers is the use of appropriate and consistent training regimens. Hand hygiene training has been used extensively in the health care sector and results have been promising (Pincock et al. 2012). In food safety, training has been used but the results have been meager to disappointing (Averett et al. 2011; Chapman et al. 2010; Lillquist et al. 2005; York et al. 2009). Reasons for these poor results have been investigated (Green et al. 2005, 2006, 2007; Pragle et al. 2007) and a combination of factors including high workload, inappropriate staffing, lack of managerial support, and personal beliefs have been identified. The clear conclusion, therefore, is that a lack of adherence to hand hygiene is based on behavior, not lack of information.

The issues faced in the food industry are no different from those in the health care field where compliance rates for hand hygiene have never reached 100 %. While there has been no meaningful way to reach that goal, there has been a change in the direction of health care toward a 'patient-centric' viewpoint (Landers et al. 2012), whereby hand hygiene is a means to keep patient satisfaction high. This may be a very reasonable way to improve hand hygiene rates in the food industry as focusing on the satisfaction of those who are purchasing foods at retail will help maintain a high reputation and continued returns.

Washing and scrubbing: Vega et al. (2008) have demonstrated that viruses have the ability to attach to produce through electrostatic forces. Based on their analysis, the use of nonionic detergents as well as high levels of salt was sufficient to remove viruses from the surfaces of lettuce. This suggests that a salt solution of 1 N NaCl and agitation may be sufficient to remove the majority of viruses from fresh produce. Similarly, Wang et al. (2013) have shown that the simple action of scrubbing and peeling is sufficient to reduce up to 99 % of virus from the surfaces of produce. However, the likelihood of cross-contamination without proper hot water treatment in between items increases significantly. This potential for fomite transmission has been demonstrated for other food preparation activities such as cutting and grating (Wang et al. 2013).

Temperature: The use of temperature and pasteurization is an effective means to kill bacteria, however, viruses are significantly more resistant to such temperatures. Bozkurt et al. (2013) have shown that MNV is very temperature resistant, requiring over 10 min in some cases for a reduction of 1 log at 50 °C. Barnaud et al. (2012) found a similar requirement for inactivation of HEV in meat products. An internal temperature of 71 °C for 20 min was required to completely inactivate the virus. In a more comprehensive study, Tuladhar et al. (2012) investigated the thermal stability of viruses by measuring the time required to inactivate by 1 $\log_{10}$ (90 %). The results showed that 53 °C is inadequate to attain proper food safety for adenovirus, poliovirus, MNV, and adenovirus; the time required was well over 5 min and as long as 15 min for MNV-1. The results were significantly improved at 73 °C, with the required reduction being achieved in less than 2 min. Bertrand et al. (2012) reviewed the available literature and found similar observations for HAV and astroviruses. The data clearly show that higher temperatures than those used for bacteria are required to attain proper inactivation of viruses. Unfortunately, the use of temperatures above 73 °C in the food continuum can pose a problem in terms of maintaining the aesthetic and organoleptic properties of these foods.

Disinfection: The use of liquid chemical microbicides, more commonly referred to as disinfectants, in the food continuum can be used within a HACCP program including at retail. However, the actual application of these chemicals on food can be problematic due to potential changes in food quality, as well as the potential for improper rinsing leading to residues. Studies investigating the use of nonresidual disinfectants have been undertaken to reduce the levels of viruses on the surfaces of foods and also in waters used in the food continuum. Kahler et al. (2011) investigated the inactivation of viruses in the presence of monochloramine and found that there is a sufficient reduction of adenoviruses, coxsackieviruses, and MNV for use in food production and processing. In a similar manner, Su and D'Souza (2011) investigated the use of water containing 5 % trisodium phosphate (which has a similar activity to hypochlorite) on produce. They found the solution was sufficient to inactivate over 7 $\log_{10}$ of MNV after rinsing for 30 s. Fraisse et al. (2011) investigated the use of peroxyacetic acid against MNV and HAV and found that 100 ppm could reduce MNV on lettuce by 1 log with simple washing. An extended exposure of 2 min reduced the levels of MNV by over 99 %, whereas the reduction of HAV was only 0.7 $\log_{10}$.

Pressure: The use of high hydrostatic pressure (HPP) may be used in the processing and packaging stages of the food continuum to help prevent spread at retail. HPP has the ability to reduce the viral load of foods, including complex matrices, while maintaining food quality (Kingsley et al. 2004, 2013). Kingsley has reviewed the literature on the use of HPP and found that all but the Aichi viruses may be inactivated in 5 min by pressures ranging from 400 to 500 MPa (Kingsley 2013). However, there has yet to be a fully standardized protocol associated with HPP to ensure proper activity against all viruses. Upon finding a harmonized and standard protocol, HPP may see a rise in its use.

UV irradiation: Surface decontamination using ultraviolet (UV) irradiation continues to be investigated, although it has limited use in food processing and preparation. UV light has been known for over a decade to inactivate foodborne viruses (Nuanualsuwan et al. 2002) at levels over 0.1 J/cm^2. Fino and Kniel (2008b) found that UV light at a concentration of 0.24 J/cm^2 was effective at inactivating over 99 % of HAV, Aichi virus, and the human norovirus surrogate feline calicivirus (FCV) on experimentally contaminated lettuce and onions. The use of UV was not, however, applicable to strawberries due to shielding of the virus in the seed pockets as well as the three-dimensional nature of the surface allowing shadowing. Jean et al. (2011) investigated the use of pulsed-UV light to reduce MNV and HAV on inanimate surfaces. When exposed alone, a 2 s burst consisting of 1.27 J/cm^2 overall was enough to inactivate over 99 % of virus. However, when a complex mixture was used (comprising of 5 % fetal bovine serum), that level was reduced significantly. Thus, this method would likely be sufficient when surfaces are cleaned on a regular basis.

Ionizing irradiation: As an alternative to UV light, in some countries gamma irradiation is an accepted means of bacterial control in food processing and preparation. The use of 4 kGy has now been accepted by the FDA in the USA for use in ensuring food safety (U.S. Food and Drug Administration 2009). However, gamma irradiation is far less effective against foodborne viruses. At 4 kGy, Feng et al. (2011) have shown that inactivation of MNV is not sufficient to reduce the virus by more than 3 $\log_{10}$ on the surface of various produce. In a similar experiment, Espinosa et al. (2012) showed that 4 kGy was somewhat effective at reducing the levels of poliovirus by at least 1.5 $\log_{10}$ and satisfactory against rotavirus at levels of 3 $\log_{10}$. While there is significant promise for the use of irradiation, both the cost and the requirement for highly trained personnel suggest that this method is not applicable for retail but may be used in prior steps to ensure food safety.

6.6 Conclusion

Controlling virus infections at retail continues to be a significant challenge due to the fact that viruses can contaminate food at every level of the farm-to-fork continuum. The widespread nature of viruses in water poses a threat during production and their ease of transmission through the fecal–oral route can lead to inadvertent contamination during processing. Moreover, their relative stability and persistence renders many decontamination efforts useless.

There may be a direction to improving the safety of foods, but the path is iterative and highly systematic. There is little doubt that there needs to be a more integrated Food Safety Management System that spans the entire food continuum and harmonizes with the current practices of HACCP, GMP, and GHP. In Europe, the PathogenCombat project (Jakobsen 2010) aims to improve food safety through a combination of quantitative and qualitative risk assessment and subsequent framework development to develop Food Safety Management Systems specific to each food continuum.

PathogenCombat could potentially be effective not only due to the quantitative evaluations of risk, but also the inclusion of qualitative parameters including behavior and practice audits, as well as the ability for workers and handlers to register complaints (Jacxsens et al. 2010). This essentially holds any food production or service company to a higher standard of performance. For example, Sumner et al. (2011) examined the nature of food handlers' habits when suffering from vomiting or diarrheal illness. They found that over 11.9 % of these individuals actually worked during their sickness and did not adhere properly to food safety practices. No matter how effective technology might be to identify and inactivate viruses, the lack of adherence on the part of these workers is a risk to the food supply, including those who would purchase food at retail.

To fully combat foodborne viruses, the focus of food safety has to widen to incorporate a One-Heath approach such that it includes all stakeholders, not only microbiologists and inspectors. Much like what is occurring in the health care sector, there needs to be a full commitment from everyone involved in the food continuum to ensure that virus contamination is minimized. There may never be a means to entirely prevent virus contamination of food, yet a combination of quantitative and qualitative practices from farm to fork may leave not only these stakeholders, but also consumers confident that the food offered at retail is safe.

References

Abad FX, Pinto RM, Bosch A (1994) Survival of enteric viruses on environmental fomites. Appl Environ Microbiol 60:3704–3710

Abad FX, Pinto RM, Villena C et al (1997) Astrovirus survival in drinking water. Appl Environ Microbiol 63:3119–3122

Abad FX, Villena C, Guix S et al (2001) Potential role of fomites in the vehicular transmission of human astroviruses. Appl Environ Microbiol 67:3904–3907

Ahluwalia GS, Scott-Taylor TH, Klisko B et al (1994) Comparison of detection methods for adenovirus from enteric clinical specimens. Diagn Microbiol Infect Dis 18:161–166

Alcala A, Vizzi E, Rodriguez-Diaz J et al (2010) Molecular detection and characterization of Aichi viruses in sewage-polluted waters of Venezuela. Appl Environ Microbiol 76:4113–4115

Aminu M, Ahmad AA, Umoh JU et al (2007) Adenovirus infection in children with diarrhea disease in Northwestern Nigeria. Ann Afr Med 6:168–173

Ansari SA, Sattar SA, Springthorpe VS et al (1988) Rotavirus survival on human hands and transfer of infectious virus to animate and nonporous inanimate surfaces. J Clin Microbiol 26:1513–1518

Ansari SA, Springthorpe VS, Sattar SA (1991) Survival and vehicular spread of human rotaviruses: possible relation to seasonality of outbreaks. Rev Infect Dis 13:448–461

Armstrong GD (1999) Towards integrated hygiene and food safety management systems: the Hygieneomic approach. Int J Food Microbiol 50:19–24

Atmar RL, Opekun AR, Gilger MA et al (2008) Norwalk virus shedding after experimental human infection. Emerg Infect Dis 14:1553–1557

Averett E, Nazir N, Neuberger JS (2011) Evaluation of a local health department's food handler training program. J Environ Health 73:65–69

Baert L, Uyttendaele M, Vermeersch M et al (2008) Survival and transfer of murine norovirus 1, a surrogate for human noroviruses, during the production process of deep-frozen onions and spinach. J Food Prot 71:1590–1597

Baert L, Mattison K, Loisy-Hamon F et al (2011) Review: norovirus prevalence in Belgian, Canadian and French fresh produce: a threat to human health? Int J Food Microbiol 151: 261–269

Balayan MS, Andjaparidze AG, Savinskaya SS et al (1983) Evidence for a virus in non-A, non-B hepatitis transmitted via the fecal–oral route. Intervirology 20:23–31

Banks M, Martelli F, Grierson S et al (2010) Hepatitis E virus in retail pig liver. Vet Rec 166:29

Barnaud E, Rogee S, Garry P et al (2012) Thermal inactivation of infectious hepatitis E virus in experimentally contaminated food. Appl Environ Microbiol 78:5153–5159

Benabbes L, Ollivier J, Schaeffer J et al (2013) Norovirus and other human enteric viruses in Moroccan shellfish. Food Environ Virol 5:35–40

Berger CN, Sodha SV, Shaw RK et al (2010) Fresh fruit and vegetables as vehicles for the transmission of human pathogens. Environ Microbiol 12:2385–2397

Berke T, Matson DO (2000) Reclassification of the Caliciviridae into distinct genera and exclusion of hepatitis E virus from the family on the basis of comparative phylogenetic analysis. Arch Virol 145:1421–1436

Berto A, Martelli F, Grierson S et al (2012) Hepatitis e virus in pork food chain, United Kingdom, 2009–2010. Emerg Infect Dis 18:1358–1360

Bertrand I, Schijven JF, Sanchez G et al (2012) The impact of temperature on the inactivation of enteric viruses in food and water: a review. J Appl Microbiol 112:1059–1074

Bigoraj E, Chrobocińska M, Kwit E (2012) Norovirus contamination of bivalve molluscs as a cause of gastroenteritis. Med Weter 68:210–213

Bouwknegt M, Lodder-Verschoor F, van der Poel WH et al (2007) Hepatitis E virus RNA in commercial porcine livers in The Netherlands. J Food Prot 70:2889–2895

Boxman ILA (2010) Human enteric viruses occurrence in shellfish from european markets. Food Environ Virol 2:156–166

Bozkurt H, D'Souza DH, Davidson PM (2013) Determination of the thermal inactivation kinetics of the human norovirus surrogates, murine norovirus and feline calicivirus. J Food Prot 76: 79–84

Brandsma SR, Muehlhauser V, Jones TH (2012) Survival of murine norovirus and F-RNA coliphage MS2 on pork during storage and retail display. Int J Food Microbiol 159:193–197

Brassard J, Gagne MJ, Genereux M et al (2012) Detection of human food-borne and zoonotic viruses on irrigated, field-grown strawberries. Appl Environ Microbiol 78:3763–3766

Brown M (1990) Laboratory identification of adenoviruses associated with gastroenteritis in Canada from 1983 to 1986. J Clin Microbiol 28:1525–1529

Bryden AS, Curry A, Cotterill H et al (1997) Adenovirus-associated gastro-enteritis in the north-west of England: 1991–1994. Br J Biomed Sci 54:273–277

Buisson Y, Marie JL, Davoust B (2008) Ces maladies infectieuses importées par les aliments. Bull Soc Pathol Exot 101:343–347

Butot S, Putallaz T, Sanchez G (2008) Effects of sanitation, freezing and frozen storage on enteric viruses in berries and herbs. Int J Food Microbiol 126:30–35

Campagna M, Siddu A, Meloni A et al (2012) Changing pattern of hepatitis a virus epidemiology in an area of high endemicity. Hepat Mon 12:382–385

Carvalho C, Thomas H, Balogun K et al (2012) A possible outbreak of hepatitis A associated with semi-dried tomatoes, England, July–November 2011. Euro Surveill 17:6

Casas M, Cortés R, Pina S et al (2011) Longitudinal study of hepatitis E virus infection in Spanish farrow-to-finish swine herds. Vet Microbiol 148:27–34

Ceballos BS, Soares NE, Moraes MR et al (2003) Microbiological aspects of an urban river used for unrestricted irrigation in the semi-arid region of north-east Brazil. Water Sci Technol 47: 51–57

Centers for Disease Control and Prevention (2013) Surveillance for foodborne disease outbreaks—United States, 2009–2010. MMWR Morb Mortal Wkly Rep 62:41–47

Ceylan A, Ertem M, Ilcin E et al (2003) A special risk group for hepatitis E infection: Turkish agricultural workers who use untreated waste water for irrigation. Epidemiol Infect 131: 753–756

Chapman B, Eversley T, Fillion K et al (2010) Assessment of food safety practices of food service food handlers (risk assessment data): testing a communication intervention (evaluation of tools). J Food Prot 73:1101–1107

Cheong S, Lee C, Song SW et al (2009) Enteric viruses in raw vegetables and groundwater used for irrigation in South Korea. Appl Environ Microbiol 75:7745–7751
Chmielewski R, Swayne DE (2011) Avian influenza: public health and food safety concerns. Annu Rev Food Sci Technol 2:37–57
Codex Alimentarius (2008) Guideline for the validation of food safety control measures (CAC/GL 69-2008). Codex Alimentarius Commission, Rome
Dalton CB, Gregory J, Kirk MD et al (2004) Foodborne disease outbreaks in Australia, 1995 to 2000. Commun Dis Intell Q Rep 28:211–224
Deboosere N, Pinon A, Caudrelier Y et al (2012) Adhesion of human pathogenic enteric viruses and surrogate viruses to inert and vegetal food surfaces. Food Microbiol 32:48–56
Dey SK, Shimizu H, Phan TG et al (2009) Molecular epidemiology of adenovirus infection among infants and children with acute gastroenteritis in Dhaka City, Bangladesh. Infect Genet Evol 9:518–522
Di Bartolo I, Martelli F, Inglese N et al (2008) Widespread diffusion of genotype 3 hepatitis E virus among farming swine in Northern Italy. Vet Microbiol 132:47–55
Di Martino B, Di Progio F, Ceci C et al (2013) Molecular detection of Aichi virus in raw sewage in Italy. Arch Virol 158:2001–2005
Diez-Valcarce M, Kokkinos P, Söderberg K et al (2012) Occurrence of human enteric viruses in commercial mussels at retail level in three European countries. Food Environ Virol 4:73–80
EFSA Panel on Biological Hazards (2011) Scientific opinion on an update on the present knowledge on the occurrence and control of foodborne viruses. EFSA J 9:2190
Ehlers MM, Grabow WO, Pavlov DN (2005) Detection of enteroviruses in untreated and treated drinking water supplies in South Africa. Water Res 39:2253–2258
Espinosa AC, Jesudhasan P, Arredondo R et al (2012) Quantifying the reduction in potential health risks by determining the sensitivity of poliovirus type 1 chat strain and rotavirus SA-11 to electron beam irradiation of iceberg lettuce and spinach. Appl Environ Microbiol 78:988–993
FAO (1995) Report of the FAO expert technical meeting on the use of Hazard Analysis Critical Control Point (HACCP) principles in food control. FAO Food Nutr Pap 58:1–13
FAO Trade and Markets Division (2012) Food outlook: global market analysis. Food and Agriculture Organization of the United Nations, Rome
FAO/WHO (2008) Viruses in food: scientific advice to support risk management activities. World Health Organization, Geneva
Fein SB, Lando AM, Levy AS et al (2011) Trends in U.S. consumers' safe handling and consumption of food and their risk perceptions, 1988 through 2010. J Food Prot 74:1513–1523
Feng K, Divers E, Ma Y et al (2011) Inactivation of a human norovirus surrogate, human norovirus virus-like particles, and vesicular stomatitis virus by gamma irradiation. Appl Environ Microbiol 77:3507–3517
Ferguson JK (2009) Preventing healthcare-associated infection: risks, healthcare systems and behaviour. Intern Med J 39:574–581
Fino VR, Kniel KE (2008a) Comparative recovery of foodborne viruses from fresh produce. Foodborne Pathog Dis 5:819–825
Fino VR, Kniel KE (2008b) UV light inactivation of hepatitis A virus, Aichi virus, and feline calicivirus on strawberries, green onions, and lettuce. J Food Prot 71:908–913
Fiona Barker S, O'Toole J, Sinclair MI et al (2013) A probabilistic model of norovirus disease burden associated with greywater irrigation of home-produced lettuce in Melbourne, Australia. Water Res 47:1421–1432
Fiore AE (2004) Hepatitis A transmitted by food. Clin Infect Dis 38:705–715
Fischer Walker CL, Sack D, Black RE (2010) Etiology of diarrhea in older children, adolescents and adults: a systematic review. PLoS Negl Trop Dis 4:e768. doi:10.1371/journal.pntd.0000768
Fraisse A, Temmam S, Deboosere N et al (2011) Comparison of chlorine and peroxyacetic-based disinfectant to inactivate Feline calicivirus, Murine norovirus and Hepatitis A virus on lettuce. Int J Food Microbiol 151:98–104
Fu ZF, Hampson DJ, Blackmore DK (1989) Detection and survival of group A rotavirus in a piggery. Vet Rec 125:576–578

Fu H, Li L, Zhu Y et al (2010) Hepatitis E virus infection among animals and humans in Xinjiang, China: possibility of swine to human transmission of sporadic hepatitis E in an endemic area. Am J Trop Med Hyg 82:961–966

Gallimore CI, Cubitt D, du Plessis N et al (2004) Asymptomatic and symptomatic excretion of noroviruses during a hospital outbreak of gastroenteritis. J Clin Microbiol 42:2271–2274

Gallimore CI, Pipkin C, Shrimpton H et al (2005) Detection of multiple enteric virus strains within a foodborne outbreak of gastroenteritis: an indication of the source of contamination. Epidemiol Infect 133:41–47

Gaulin C, Frigon M, Poirier D et al (1999) Transmission of calicivirus by a foodhandler in the pre-symptomatic phase of illness. Epidemiol Infect 123:475–478

Gilling SJ, Taylor EA, Kane K et al (2001) Successful hazard analysis critical control point implementation in the United Kingdom: understanding the barriers through the use of a behavioral adherence model. J Food Prot 64:710–715

Godfree A, Farrell J (2005) Processes for managing pathogens. J Environ Qual 34:105–113

Goyer M, Aho LS, Bour JB et al (2008) Seroprevalence distribution of Aichi virus among a French population in 2006–2007. Arch Virol 153:1171–1174

Green L, Selman C, Banerjee A et al (2005) Food service workers' self-reported food preparation practices: an EHS-Net study. Int J Hyg Environ Health 208:27–35

Green LR, Selman CA, Radke V et al (2006) Food worker hand washing practices: an observation study. J Food Prot 69:2417–2423

Green LR, Radke V, Mason R et al (2007) Factors related to food worker hand hygiene practices. J Food Prot 70:661–666

Greig JD, Todd ECD, Bartleson CA et al (2007) Outbreaks where food workers have been implicated in the spread of foodborne disease. Part 1. Description of the problem, methods, and agents involved. J Food Prot 70:1752–1761

Grimwood K, Carzino R, Barnes GL et al (1995) Patients with enteric adenovirus gastroenteritis admitted to an Australian pediatric teaching hospital from 1981 to 1992. J Clin Microbiol 33:131–136

Guan Y, Zheng BJ, He YQ et al (2003) Isolation and characterization of viruses related to the SARS coronavirus from animals in Southern China. Science 302:276–278

Hansman GS, Oka T, Li TC et al (2008) Detection of human enteric viruses in Japanese clams. J Food Prot 71:1689–1695

Henley SC, Stein SE, Quinlan JJ (2012) Identification of unique food handling practices that could represent food safety risks for minority consumers. J Food Prot 75:2050–2054

Herrmann JE, Blacklow NR, Perron-Henry DM et al (1988) Incidence of enteric adenoviruses among children in Thailand and the significance of these viruses in gastroenteritis. J Clin Microbiol 26:1783–1786

Hirneisen KA, Kniel KE (2013) Comparative uptake of enteric viruses into spinach and green onions. Food Environ Virol 5:24–34

Hoelzl C, Mayerhofer U, Steininger M et al (2013) Observational trial of safe food handling behavior during food preparation using the example of Campylobacter spp. J Food Prot 76: 482–489

Huis A, van Achterberg T, de Bruin M et al (2012) A systematic review of hand hygiene improvement strategies: a behavioural approach. Implement Sci 7:92. doi:10.1186/1748-5908-7-92

Ijaz MK, Sattar SA, Johnson-Lussenburg CM et al (1985) Comparison of the airborne survival of calf rotavirus and poliovirus type 1 (Sabin) aerosolized as a mixture. Appl Environ Microbiol 49:289–293

Jacxsens L, Uyttendaele M, Devlieghere F et al (2010) Food safety performance indicators to benchmark food safety output of food safety management systems. Int J Food Microbiol 141:S180–S187

Jakobsen M (2010) Introduction to supplement issue PathogenCombat: reducing food borne disease in Europe—control and prevention of emerging pathogens at cellular and molecular level throughout the food chain. Int J Food Microbiol 141:S1–S3

Jean J, Morales-Rayas R, Anoman MN et al (2011) Inactivation of hepatitis A virus and norovirus surrogate in suspension and on food-contact surfaces using pulsed UV light (pulsed light inactivation of food-borne viruses). Food Microbiol 28:568–572
Jebara KB (2004) Surveillance, detection and response: managing emerging diseases at national and international levels. Rev Sci Tech 23:709–715
Johansson ME, Andersson MA, Thorner PA (1994) Adenoviruses isolated in the Stockholm area during 1987–1992: restriction endonuclease analysis and molecular epidemiology. Arch Virol 137:101–115
Jonsson N, Wahlstrom K, Svensson L et al (2012) Aichi virus infection in elderly people in Sweden. Arch Virol 157:1365–1369
Kahler AM, Cromeans TL, Roberts JM et al (2011) Source water quality effects on monochloramine inactivation of adenovirus, coxsackievirus, echovirus, and murine norovirus. Water Res 45:1745–1751
Kaikkonen S, Rasanen S, Ramet M et al (2010) Aichi virus infection in children with acute gastroenteritis in Finland. Epidemiol Infect 138:1166–1171
Kapikian AZ, Wyatt RG, Dolin R et al (1972) Visualization by immune electron microscopy of a 27-nm particle associated with acute infectious nonbacterial gastroenteritis. J Virol 10: 1075–1081
Keraita B, Drechsel P, Konradsen F (2008) Using on-farm sedimentation ponds to improve microbial quality of irrigation water in urban vegetable farming in Ghana. Water Sci Technol 57: 519–525
Kingsley DH (2013) High pressure processing and its application to the challenge of virus-contaminated foods. Food Environ Virol 5:1–12
Kingsley DH, Chen H, Hoover DG (2004) Inactivation of selected picornaviruses by high hydrostatic pressure. Virus Res 102:221–224
Kitajima M, Haramoto E, Phanuwan C et al (2011) Prevalence and genetic diversity of Aichi viruses in wastewater and river water in Japan. Appl Environ Microbiol 77:2184–2187
Klein G (2004) Verbreitung von Viren uber die Lebensmittelkette. Dtsch Tierarztl Wochenschr 111:312–314
Kobayashi S, Fujiwara N, Yasui Y et al (2012) A foodborne outbreak of sapovirus linked to catered box lunches in Japan. Arch Virol 157:1995–1997
Koizumi Y, Isoda N, Sato Y et al (2004) Infection of a Japanese patient by genotype 4 hepatitis e virus while traveling in Vietnam. J Clin Microbiol 42:3883–3885
Kokkinos P, Ziros P, Meri D et al (2011a) Environmental surveillance. An additional/alternative approach for virological surveillance in Greece? Int J Environ Res Public Health 8: 1914–1922
Kokkinos PA, Ziros PG, Mpalasopoulou A et al (2011b) Molecular detection of multiple viral targets in untreated urban sewage from Greece. Virol J 8:195
Koo HL, Ajami N, Atmar RL et al (2010) Noroviruses: the leading cause of gastroenteritis worldwide. Discov Med 10:61–70
Kurtz JB, Lee TW (1987) Astroviruses: human and animal. Ciba Found Symp 128:92–107
Landers T, Abusalem S, Coty MB et al (2012) Patient-centered hand hygiene: the next step in infection prevention. Am J Infect Control 40:S11–S17
Le Guyader FS, Mittelholzer C, Haugarreau L et al (2004) Detection of noroviruses in raspberries associated with a gastroenteritis outbreak. Int J Food Microbiol 97:179–186
Le Guyader FS, Le Saux JC, Ambert-Balay K et al (2008) Aichi virus, norovirus, astrovirus, enterovirus, and rotavirus involved in clinical cases from a French oyster-related gastroenteritis outbreak. J Clin Microbiol 46:4011–4017
Leblanc D, Poitras E, Gagne MJ et al (2010) Hepatitis E virus load in swine organs and tissues at slaughterhouse determined by real-time RT-PCR. Int J Food Microbiol 139:206–209
Lillquist DR, McCabe ML, Church KH (2005) A comparison of traditional handwashing training with active handwashing training in the food handler industry. J Environ Health 67:13–16
Little CL, Lock D, Barnes J et al (2003) Microbiological quality of food in relation to hazard analysis systems and food hygiene training in UK catering and retail premises. Commun Dis Public Health 6:250–258

Liu P, Yuen Y, Hsiao HM et al (2010) Effectiveness of liquid soap and hand sanitizer against Norwalk virus on contaminated hands. Appl Environ Microbiol 76:394–399
Luby SP, Gurley ES (2012) Epidemiology of henipavirus disease in humans. Curr Top Microbiol Immunol 359:25–40
Luby SP, Rahman M, Hossain MJ et al (2006) Foodborne transmission of Nipah virus, Bangladesh. Emerg Infect Dis 12:1888–1894
Madeley CR, Cosgrove BP (1975) Editorial: virus of infantile gastroenteritis. Br Med J 3: 555–556
Maillard JY, Russell AD (1997) Viricidal activity and mechanisms of action of biocides. Sci Prog 80:287–315
Martin-Latil S, Hennechart-Collette C, Guillier L et al (2012) Comparison of two extraction methods for the detection of hepatitis A virus in semi-dried tomatoes and murine norovirus as a process control by duplex RT-qPCR. Food Microbiol 31:246–253
Mathijs E, Stals A, Baert L et al (2012) A review of known and hypothetical transmission routes for noroviruses. Food Environ Virol 4:131–152
Matthews JE, Dickey BW, Miller RD et al (2012) The epidemiology of published norovirus outbreaks: a review of risk factors associated with attack rate and genogroup. Epidemiol Infect 140:1161–1172
Mattison K, Shukla A, Cook A et al (2007) Human noroviruses in swine and cattle. Emerg Infect Dis 13:1184–1188
Mattison K, Harlow J, Morton V et al (2010) Enteric viruses in ready-to-eat packaged leafy greens. Emerg Infect Dis 16:1815–1817
Mead PS, Slutsker L, Dietz V et al (1999) Food-related illness and death in the United States. Emerg Infect Dis 5:607–625
Meng XJ (2011) From barnyard to food table: the omnipresence of hepatitis E virus and risk for zoonotic infection and food safety. Virus Res 161:23–30
Meng XJ (2013) Zoonotic and foodborne transmission of hepatitis e virus. Semin Liver Dis 33: 41–49
Michaels BS, Keller C, Blevins M et al (2004) Prevention of food worker transmission of foodborne pathogens: risk assessment and evaluation of effective hygiene intervention strategies. Food Serv Technol 4:31–49
Miyamura T (2011) Hepatitis E virus infection in developed countries. Virus Res 161:40–46
Mokhtari A, Jaykus LA (2009) Quantitative exposure model for the transmission of norovirus in retail food preparation. Int J Food Microbiol 133:38–47
Mortlock MP, Peters AC, Griffith CJ (1999) Food hygiene and hazard analysis critical control point in the United Kingdom food industry: practices, perceptions, and attitudes. J Food Prot 62: 786–792
Muniesa M, Payan A, Moce-Llivina L et al (2009) Differential persistence of F-specific RNA phage subgroups hinders their use as single tracers for faecal source tracking in surface water. Water Res 43:1559–1564
Myrmel M, Berg EM, Grinde B et al (2006) Enteric viruses in inlet and outlet samples from sewage treatment plants. J Water Health 4:197–209
Newell DG, Koopmans M, Verhoef L et al (2010) Food-borne diseases—the challenges of 20 years ago still persist while new ones continue to emerge. Int J Food Microbiol 139:S3–S15
Niu MT, Polish LB, Robertson BH et al (1992) Multistate outbreak of hepatitis A associated with frozen strawberries. J Infect Dis 166:518–524
Nuanualsuwan S, Mariam T, Himathongkham S et al (2002) Ultraviolet inactivation of feline calicivirus, human enteric viruses and coliphages. Photochem Photobiol 76:406–410
Oh DY, Silva PA, Hauroeder B et al (2006) Molecular characterization of the first Aichi viruses isolated in Europe and in South America. Arch Virol 151:1199–1206
Panisello PJ, Rooney R, Quantick PC et al (2000) Application of foodborne disease outbreak data in the development and maintenance of HACCP systems. Int J Food Microbiol 59:221–234
Parashar UD, Hummelman EG, Bresee JS et al (2003) Global illness and deaths caused by rotavirus disease in children. Emerg Infect Dis 9:565–572

Park GW, Barclay L, Macinga D et al (2010) Comparative efficacy of seven hand sanitizers against murine norovirus, feline calicivirus, and GII.4 norovirus. J Food Prot 73:2232–2238
Pavio N, Meng XJ, Renou C (2010) Zoonotic hepatitis E: animal reservoirs and emerging risks. Vet Res 41:46
Pincock T, Bernstein P, Warthman S et al (2012) Bundling hand hygiene interventions and measurement to decrease health care-associated infections. Am J Infect Control 40:S18–S27
Pragle AS, Harding AK, Mack JC (2007) Food workers' perspectives on handwashing behaviors and barriers in the restaurant environment. J Environ Health 69:27–32
Rahman MA, Hossain MJ, Sultana S et al (2012) Date palm sap linked to Nipah virus outbreak in Bangladesh, 2008. Vector Borne Zoonotic Dis 12:65–72
Raphael RA, Sattar SA, Springthorpe VS (1985) Long-term survival of human rotavirus in raw and treated river water. Can J Microbiol 31:124–128
Reuter G, Boldizsar A, Papp G et al (2009) Detection of Aichi virus shedding in a child with enteric and extraintestinal symptoms in Hungary. Arch Virol 154:1529–1532
Ribes JM, Montava R, Tellez-Castillo CJ et al (2010) Seroprevalence of Aichi virus in a Spanish population from 2007 to 2008. Clin Vaccine Immunol 17:545–549
Richards GP (2001) Enteric virus contamination of foods through industrial practices: a primer on intervention strategies. J Ind Microbiol Biotechnol 27:117–125
Richards GP (2012) Critical review of norovirus surrogates in food safety research: rationale for considering volunteer studies. Food Environ Virol 4:6–13
Saderi H, Roustai MH, Sabahi F et al (2002) Incidence of enteric adenovirus gastroenteritis in Iranian children. J Clin Virol 24:1–5
Sanchez G, Bosch A, Pinto RM (2007) Hepatitis A virus detection in food: current and future prospects. Lett Appl Microbiol 45:1–5
Sattar SA, Westwood JC (1976) Comparison of four eluents in the recovery of indigenous viruses from raw sludge. Can J Microbiol 22:1586–1589
Sattar SA, Westwood JC (1977) Isolation of apparently wild strains of poliovirus type 1 from sewage in the Ottawa area. Can Med Assoc J 116:25–27
Sattar SA, Westwood JC (1979) Recovery of viruses from field samples of raw, digested, and lagoon-dried sludges. Bull World Health Organ 57:105–108
Sattar SA, Raphael RA, Springthorpe VS (1984) Rotavirus survival in conventionally treated drinking water. Can J Microbiol 30:653–656
Sattar SA, Springthorpe VS, Karim Y et al (1989) Chemical disinfection of non-porous inanimate surfaces experimentally contaminated with four human pathogenic viruses. Epidemiol Infect 102:493–505
Sattar SA, Ali M, Tetro JA (2011) In vivo comparison of two human norovirus surrogates for testing ethanol-based handrubs: the mouse chasing the cat! PLoS One 6:e17340. doi:10.1371/journal.pone.0017340
Scholz E, Heinricy U, Flehmig B (1989) Acid stability of hepatitis A virus. J Gen Virol 70: 2481–2485
Scobie L, Dalton HR (2013) Hepatitis E: Source and route of infection, clinical manifestations and new developments. J Viral Hepat 20:1–11
Sdiri-Loulizi K, Hassine M, Gharbi-Khelifi H et al (2009) Detection and genomic characterization of Aichi viruses in stool samples from children in Monastir, Tunisia. J Clin Microbiol 47:2275–2278
Sdiri-Loulizi K, Hassine M, Aouni Z et al (2010) First molecular detection of Aichi virus in sewage and shellfish samples in the Monastir region of Tunisia. Arch Virol 155:1509–1513
Serracca L, Rossini I, Battistini R et al (2012) Potential risk of norovirus infection due to the consumption of "ready to eat" food. Food Environ Virol 4:89–92
Shieh YC, Stewart DS, Laird DT (2009) Survival of hepatitis A virus in spinach during low temperature storage. J Food Prot 72:2390–2393
Shinozaki T, Araki K, Fujita Y et al (1991a) Epidemiology of enteric adenoviruses 40 and 41 in acute gastroenteritis in infants and young children in the Tokyo area. Scand J Infect Dis 23: 543–547

Shinozaki T, Fujita Y, Araki K et al (1991b) Clinical features of enteric adenovirus infection in infants. Acta Paediatr Jpn 33:623–627

Siegl G, Weitz M, Kronauer G (1984) Stability of hepatitis A virus. Intervirology 22:218–226

Smith TC, Harper AL, Nair R et al (2011) Emerging swine zoonoses. Vector Borne Zoonotic Dis 11:1225–1234

Song YJ, Jeong H, Kim YJ et al (2010) Analysis of complete genome sequences of swine hepatitis E virus and possible risk factors for transmission of HEV to humans in Korea. J Med Virol 82:583–591

Stals A, Baert L, Van CE (2012) Extraction of food-borne viruses from food samples: a review. Int J Food Microbiol 153:1–9

Steele M, Odumeru J (2004) Irrigation water as source of foodborne pathogens on fruit and vegetables. J Food Prot 67:2839–2849

Strawn LK, Schneider KR, Danyluk MD (2011) Microbial safety of tropical fruits. Crit Rev Food Sci Nutr 51:132–145

Strohbehn CH, Gilmore SA, Sneed J (2004) Food safety practices and HACCP implementation: perceptions of registered dietitians and dietary managers. J Am Diet Assoc 104:1692–1699

Strohbehn C, Sneed J, Paez P et al (2008) Hand washing frequencies and procedures used in retail food services. J Food Prot 71:1641–1650

Su X, D'Souza DH (2011) Trisodium phosphate for foodborne virus reduction on produce. Foodborne Pathog Dis 8:713–717

Summa M, von Bonsdorff CH, Maunula L (2012) Pet dogs—a transmission route for human noroviruses? J Clin Virol 53:244–247

Sumner S, Brown LG, Frick R et al (2011) Factors associated with food workers working while experiencing vomiting or diarrhea. J Food Prot 74:215–220

Sun Y, Laird DT, Shieh YC (2012) Temperature-dependent survival of hepatitis A virus during storage of contaminated onions. Appl Environ Microbiol 78:4976–4983

Tebbutt GM (2007) Does microbiological testing of foods and the food environment have a role in the control of foodborne disease in England and Wales? J Appl Microbiol 102:883–891

Teunis PF, Moe CL, Liu P et al (2008) Norwalk virus: how infectious is it? J Med Virol 80: 1468–1476

Tiemessen CT, Wegerhoff FO, Erasmus MJ et al (1989) Infection by enteric adenoviruses, rotaviruses, and other agents in a rural African environment. J Med Virol 28:176–182

Tierney JT, Sullivan R, Larkin EP (1977) Persistence of poliovirus 1 in soil and on vegetables grown in soil previously flooded with inoculated sewage sludge or effluent. Appl Environ Microbiol 33:109–113

Todd EC, Greig JD, Bartleson CA et al (2009) Outbreaks where food workers have been implicated in the spread of foodborne disease. Part 6. Transmission and survival of pathogens in the food processing and preparation environment. J Food Prot 72:202–219

Todd EC, Greig JD, Michaels BS et al (2010a) Outbreaks where food workers have been implicated in the spread of foodborne disease. Part 11. Use of antiseptics and sanitizers in community settings and issues of hand hygiene compliance in health care and food industries. J Food Prot 73:2306–2320

Todd EC, Michaels BS, Holah J et al (2010b) Outbreaks where food workers have been implicated in the spread of foodborne disease. Part 10. Alcohol-based antiseptics for hand disinfection and a comparison of their effectiveness with soaps. J Food Prot 73:2128–2140

Tricco AC, Pham B, Duval B et al (2006) A review of interventions triggered by hepatitis A infected food-handlers in Canada. BMC Health Serv Res 6:157

Tuan ZC, Hidayah MS, Chai LC et al (2010) The scenario of norovirus contamination in food and food handlers. J Microbiol Biotechnol 20:229–237

Tuladhar E, Bouwknegt M, Zwietering MH et al (2012) Thermal stability of structurally different viruses with proven or potential relevance to food safety. J Appl Microbiol 112:1050–1057

U.S. Food and Drug Administration (2009) Ionizing radiation for the treatment of food. Fed Reg 21:455–456

Ueki Y, Sano D, Watanabe T et al (2005) Norovirus pathway in water environment estimated by genetic analysis of strains from patients of gastroenteritis, sewage, treated wastewater, river water and oysters. Water Res 39:4271–4280
Uhnoo I, Wadell G, Svensson L et al (1984) Importance of enteric adenoviruses 40 and 41 in acute gastroenteritis in infants and young children. J Clin Microbiol 20:365–372
Usuku S, Kumazaki M, Kitamura K et al (2008) An outbreak of food-borne gastroenteritis due to sapovirus among junior high school students. Jpn J Infect Dis 61:438–441
Van Boxstael S, Habib I, Jacxsens L et al (2013) Food safety issues in fresh produce: bacterial pathogens, viruses and pesticide residues indicated as major concerns by stakeholders in the fresh produce chain. Food Control 32:190–197
van den Berg H, Lodder W, van der Poel W et al (2005) Genetic diversity of noroviruses in raw and treated sewage water. Res Microbiol 156:532–540
Vega E, Garland J, Pillai SD (2008) Electrostatic forces control nonspecific virus attachment to lettuce. J Food Prot 71:522–529
Verhaelen K, Bouwknegt M, Lodder-Verschoor F et al (2012) Persistence of human norovirus GII.4 and GI.4, murine norovirus, and human adenovirus on soft berries as compared with PBS at commonly applied storage conditions. Int J Food Microbiol 160:137–144
Verma H, Chitambar SD, Gopalkrishna V (2011) Circulation of Aichi virus genotype B strains in children with acute gastroenteritis in India. Epidemiol Infect 139:1687–1691
Vilarino ML, Le Guyader FS, Polo D et al (2009) Assessment of human enteric viruses in cultured and wild bivalve molluscs. Int Microbiol 12:145–151
Villar LM, de Paula VS, Diniz-Mendes L et al (2007) Molecular detection of hepatitis A virus in urban sewage in Rio de Janeiro, Brazil. Lett Appl Microbiol 45:168–173
Vindigni SM, Riley PL, Jhung M (2011) Systematic review: handwashing behaviour in low- to middle-income countries: outcome measures and behaviour maintenance. Trop Med Int Health 16:466–477
Wang Q, Erickson M, Ortega YR et al (2013) The fate of murine norovirus and hepatitis a virus during preparation of fresh produce by cutting and grating. Food Environ Virol 5:52–60
Wei J, Jin Y, Sims T et al (2010) Survival of murine norovirus and hepatitis A virus in different types of manure and biosolids. Foodborne Pathog Dis 7:901–906
Westrell T, Schonning C, Stenstrom TA et al (2004) QMRA (quantitative microbial risk assessment) and HACCP (hazard analysis and critical control points) for management of pathogens in wastewater and sewage sludge treatment and reuse. Water Sci Technol 50:23–30
Whelan J, Sonder G, van den Hoek A (2013) Declining incidence of hepatitis A in Amsterdam (The Netherlands), 1996–2011: second generation migrants still an important risk group for virus importation. Vaccine 31:1806–1811
Whitby M, Pessoa-Silva CL, McLaws ML et al (2007) Behavioural considerations for hand hygiene practices: the basic building blocks. J Hosp Infect 65:1–8
Woods JW, Burkhardt W III (2010) Occurrence of norovirus and hepatitis a virus in U.S. Oysters. Food Environ Virol 2:176–182
Yamashita T, Kobayashi S, Sakae K et al (1991) Isolation of cytopathic small round viruses with BS-C-1 cells from patients with gastroenteritis. J Infect Dis 164:954–957
Yang S, Zhang W, Shen Q et al (2009) Aichi virus strains in children with gastroenteritis, China. Emerg Infect Dis 15:1703–1705
Yoon JY, Kim B (2012) Lab-on-a-chip pathogen sensors for food safety. Sensors (Basel) 12:10713–10741
York VK, Brannon LA, Shanklin CW et al (2009) Foodservice employees benefit from interventions targeting barriers to food safety. J Am Diet Assoc 109:1576–1581

Chapter 7
An Overview of Retail Food Hygiene in Europe

Alec Kyriakides

7.1 Introduction

The grocery store has been the primary vehicle by which the consumer accesses their food for many years, and although there are huge variations in size and format of grocery store, the fundamental proposition remains universally simple; procuring a wide range of foods from a variety of sources, transporting them to an outlet and merchandising them in a compelling way to the customer. Retail stores throughout Europe vary in complexity of operation and include 'corner shops' offering predominantly ambient bought-in goods, specialist retailers such as delicatessens or charcuteries where much of the offer is prepared in-house and large retail outlets including supermarkets and hypermarkets, where these 'specialist' operations are combined under one outlet to provide a complete shopping offer. Although the food safety challenges differ depending on these circumstances, the fundamental principles of retail food hygiene are relatively simple and involve a small number of key hazards and their control;

Microbiological

- Temperature (cooking, cooling and refrigeration)
- Shelf life
- Hygiene (personal and environmental)
- Cross-contamination

A. Kyriakides (✉)
Sainsbury's Supermarkets Ltd, 33 Holborn, London EC1N 2HT, UK
e-mail: alec.kyriakides@sainsburys.co.uk

J. Farber et al. (eds.), *Retail Food Safety*, Food Microbiology and Food Safety,
DOI 10.1007/978-1-4939-1550-7_7

Chemical

- Cleaning compounds
- Allergens

Physical

- Foreign bodies
- Infestation

The value of the EU food chain (agriculture, manufacturing, wholesale and retail) has been estimated at over €3 trillion in 2010 (Anon. 2013a), comprising over 15 million operators and employing nearly 23 million people (10 % of EU employment). Food and drink retail had a value of €1 trillion, employing 6.4 million people in 849,000 businesses. Retail trade throughout the EU is categorised by a large number of small and medium-sized enterprises, although market share is concentrated in a small number of large national and multi-national retailers. The top three retailers in most EU countries account for 30–50 % of market share (Anon. 2013a). In the late twentieth century, there was a significant move toward non-specialised food retail and away from traditional specialised retailers such as those selling meat (butcher), bread (bakery), fruit and vegetables (greengrocer) and fish (fishmonger). In the UK, whereas over 80 % of sales in 2012 were accounted for by non-specialised food retailers, the number of such enterprises only marginally exceeded the number of specialised food retailers (Anon. 2013b). In the same period, growth was also dominated by the development of supermarkets (25–60,000 sq. ft.) and hypermarkets (>60,000 sq. ft.). While the trend in non-specialised food retail is a continuing feature of the market, there is somewhat of a renaissance in smaller retail outlets (<3,000 sq. ft.) that cater for local or convenience shopping.

In addition to retail through shops, be they large or small, there has been a resurgence in home delivery in recent years through the accessibility of online ordering, and this is becoming one of the fastest growing sectors of the industry with estimates for many EU countries being a doubling in sales between 2012 and 2016 (IGD 2013).

7.2 Legislation

The legislative framework in Europe is set by the European Parliament and Council of the European Union made up of representatives from all member states. Proposals for controls are usually prepared by the European Commission, and then approved by the Parliament and Council. Legislation is generally produced as either a Regulation that is directly enforceable in all member states with no modification, or as Directives that set the principles and allow broader interpretation at national level. All European regulations and directives have to then be adopted into national legislation within each member state. In many cases, flexibility is permitted for member states to adopt additional control measures in their own member state, above and beyond the directive, providing that it does not restrict the free trade of goods between European member states.

In terms of food safety in European food law, the broad principles are set out in Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002, laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety (Anon. 2002a) (Table 7.1). The Regulation establishes important principles in terms of food safety management at community and national level; it reiterates the goal of setting a high level of health protection for the Community and advocates a risk-based approach to setting food safety requirements. It also enshrines the precautionary principle, in circumstances where "risk to life or health exists but scientific uncertainty persists". The specific food safety requirement applicable to all food business operators is very simple; that "Food shall not be placed on the market if it is unsafe. Food shall be deemed to be unsafe if it is considered to be: (a) injurious to health; (b) unfit for human consumption."

In terms of retail, the European legislative definition is the "handling and/or processing of food and its storage at the point of sale or delivery to the final consumer, and includes distribution terminals, catering operations, factory canteens, institutional catering, restaurants and other similar food service operations, shops, supermarket distribution centres and wholesale outlets" (Anon. 2002a). In the context of this chapter, retail will focus on the conventional retail outlet, e.g., shops and supermarkets with some reference to distribution and storage together with home delivery.

Regulation (EC) No 178/2002 (Anon. 2002a) also requires traceability of food in a 'one up—one down' approach where each food business operator must be able to identify who they received goods from and who they supplied goods to, up to but not including the final consumer.

Detailed requirements for the management of food safety are legislated for in Regulation (EC) No 852/2004 of the European Parliament and of the Council of 29 April 2004 on the hygiene of foodstuffs (Anon. 2004a). It defines hygiene as "the measures and conditions necessary to control hazards and to ensure fitness for human consumption of a foodstuff taking into account its intended use". It mandates the adoption of HACCP principles in the management of food safety; "Food business operators shall put in place, implement and maintain a permanent procedure or procedures based on the HACCP principles". Importantly, it also recognises the need for flexibility for small businesses in this regard. There is no legislative requirement for food retail businesses to be approved, although the regulation does require that all food business operators are registered for traceability purposes. The regulation also details the general requirements expected of all food business operators, including all of the key areas impacting food safety and hygiene summarised as;

Table 7.1 Key European and United Kingdom Food Safety Legislation

Legislation	Summary	Reference
European Legislation		
Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety.	Defines the framework for food safety management at a European community level and sets in place the relevant bodies necessary to support risk assessment processes (European Food Safety Authority)	Anon. (2002a)
Regulation (EC) No 852/2004 of the European Parliament and of the Council of 29 April 2004 on the hygiene of foodstuffs.	General principles on the hygiene of foodstuffs	Anon. (2004a)
	Hazard analysis approach to food safety management	
	Registration of premises	
	Provision for the development of community and national guides to compliance	
	Specific requirements for premises, transport, equipment, waste, water, personal hygiene, packaging, heat treatment, training.	
Regulation (EC) No 853/2004 of the European Parliament and of the Council of 29 April 2004 laying down specific hygiene rules for food of animal origin.	Specific requirements on the hygiene of foods of animal origin	Anon. (2004b)
	Registration and approval of premises	
	Health/identification marking	
	Traceability	
	Specific requirements for slaughter, processing, transport and storage of the following products; meat of domestic ungulates, meat from poultry and lagomorphs, meat of farmed game, wild game meat, minced meat, meat preparations and mechanically separated meat, meat products, live bivalve molluscs, fishery products, raw milk and dairy products, eggs and egg products, frogs' legs and snails, rendered animal fats and greaves, treated stomachs, bladders and intestines, gelatine and collagen	
Regulation (EU) No 1169/2011 of the European Parliament and of the Council of 25 October 2011 on the provision of food information to consumers	Requirements on the mandatory information required to be given regarding food including name, ingredients, quantity, date coding, storage instructions, conditions of use, manufacturer, country of origin, nutrition declaration and allergens	Anon. (2011b)
Commission Regulation (EC) No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs	Specific requirements on the maximum levels of contaminants in foods including nitrate, mycotoxins, metals, 3-monochloropropane-1,2-diol (3-MCPD), dioxins and PCBs and polycyclic aromatic hydrocarbons (PAHs)	Anon. (2006b)

(continued)

Table 7.1 (continued)

Legislation	Summary	Reference
Regulation (EC) No 2073/2005 of 15 November 2005 on the microbiological criteria for foodstuffs	Specific requirements on the monitoring and maximum acceptable levels of microbial contaminants in foods including those relating to food safety; *Listeria monocytogenes*, *Salmonella* species, staphylococcal enterotoxins, *Enterobacter sakazakii*, *E. coli*, histamine and those relating to process hygiene.	Anon. (2005)
UK Legislation		
Food Safety Act Chapter 16	The general food safety framework defining the requirements for food business operators to produce and sell food that is safe and of the nature or substance or quality demanded by the purchaser together with associated definitions. Powers assigned for the enforcement of the requirements in the Act to relevant authorities. Provision for the production of a due diligence defence by a food business operator in the event of a food safety contravention being committed.	Anon. (1990)
The Food Hygiene (England) Regulations 2006, Statutory Instrument 2006 No 14	Specific requirements regarding the enforcement of the UK Food Safety Act and European Regulations (Regulation (EC) 852/2004 and 853/2004) including; Hygiene improvement notices, Hygiene prohibition orders, Hygiene emergency prohibition notices and orders, Remedial action notices and detention notices, Procurement and analysis of samples, Temperature control requirements and Restrictions on the sale of raw milk intended for direct human consumption.	Anon. (2013d)

- Food premises must be kept clean and in a good state of repair
- Layout, design and construction of the premises must allow for;
  - maintenance, cleaning and disinfection
  - protection against dirt, condensation and contact with toxic materials
  - operation of good hygienic practice including protection against contamination and infestation
  - appropriate temperature control (although not specifying the temperature), monitoring and where necessary recording
- Premises must have adequate provision for toilets with suitable ventilation (not opening into rooms handling food), wash hand basins (suitably located with hot and cold running water and with materials for washing and drying hands) and separate from those for washing food, ventilation and drainage to avoid risk of contamination of food, i.e., high-to-low care, storage of cleaning and disinfection materials in areas where food is not handled, adequate changing facilities and natural or artificial lighting.

More detailed legislative requirements are specified for those premises where foods are prepared, treated or processed that cover the hygienic aspects of walls, floors, ceilings, doors and windows, focussing on design and fabrication to prevent build up of contamination and suitability for cleaning and disinfection.

Considerations are also given in relation to conditions necessary for transportation of foods with particular emphasis on preventing cross-contamination. Other areas covered in the regulation include equipment, waste and water. On matters relating to people, the regulation does not require mandatory training, but instead requires that food handlers are supervised and instructed and/or trained in food hygiene matters commensurate with their work activity, and that those responsible for the development and maintenance of the HACCP-based food safety plan are suitably trained. It also importantly gives clear guidance on the exclusion of food handlers during periods of infection.

Each country is responsible for implementing relevant European legislation by transferring the requirements into their own legislative framework. In the UK, for example, this is undertaken through national regulations, and where permitted, additional national requirements can be introduced (Table 7.1). For example, while temperature controls are specified during the production and distribution (and in limited cases retail) of certain foods of animal origin in Regulation (EC) No 853/2004 laying down specific hygiene rules on the hygiene of foodstuffs (Anon. 2004b), no temperature control requirements are specified for chilled foods in Regulation (EC) No 178/2002 (Anon. 2002a), nor in Regulation (EC) No 852/2004 (Anon. 2004a), but the implementing UK regulation, is prescriptive in the requirement for perishable foods to be held at a maximum of 8 °C with specific provisions for limited time periods for such foods to be held outside of these temperatures. It similarly specifies hot holding temperatures of cooked foods (see Sect. 7.6).

In addition to the implementation of EU laws into national legislation, individual countries may have additional legislative requirements detailed in national law. For example, the UK has food law under the Food Safety Act 1990 and subsequent amendments (Anon. 1990). This Act makes it an offence to sell or offer food that fails to comply with food safety requirements which includes;

(1) If the food has been rendered injurious to health, (2) if it is unfit for consumption or (3) if it is so contaminated that it would be unreasonable to expect it to be used for human consumption.

7.3 Supplier Assurance

Food safety management in retail outlets requires a degree of management of raw material sources and suppliers, as many of the hazards and therefore risks originate well before the retail establishment. Some of the most serious food safety incidents in recent times occurred due to the supply, from the manufacturing sector, of contaminated products. For example, BSE in beef (Anon. 2000a), *Salmonella* spp. in

Table 7.2 Key components of a typical supplier assurance programme

Factor	Hazard
Supplier approval	In-house approval questionnaires
	Supplier vetting to in-house food safety, quality or other bespoke standards
	Third party certification to independent food safety management standard e.g. BRC Global Food Safety Standard/GFSI benchmarked standards and to other third party assurance standards e.g. GlobalGAP (www.globalgap.org), Red Tractor Assurance (http://assurance.redtractor.org.uk), Organic certification (www.soilassociation.org), etc.
Product approval	Specification detailing product composition, ingredient suppliers, nutritional composition, weights/number, labelling, packaging, hazards, controls, verification testing, etc.
Supplier management	Processes in place to verify the ongoing conformance of a supplier to the manufacturing standards agreed during supplier approval including key performance indicator tracking, routine and unannounced audits, ongoing certification requirements, etc.
Product management	Processes in place to verify ongoing conformance of a product to specifications agreed during product approval including surveillance testing, benchmarking, complaints monitoring, etc.

eggs (ACMSF 1993), dioxins in pork (FSAI 2008), Sudan 1 contamination of spices (FSA 2007) and many more food safety incidents occurred outside of the direct control of the retail establishment. The nature of supplier assurance programmes varies considerably and the degree to which a retail business can undertake them will often be dependent on their size and the complexity of their supply chain. The key elements of an effective raw material and supplier management programme are summarised in Table 7.2 and include supplier approval, supplier management, product approval and product management.

Assurance programmes should, as a minimum, be based on some form of risk assessment, with some considerations being;

- Size of supplier, e.g., small manufacturers, may have less sophisticated technical resources and therefore may require more focus
- Inherent risk of product, e.g., extended shelf life, chilled, ready-to-eat (RTE) foods
- Target population for the product, e.g., baby food
- Volume of production

Traceability is key to such assurance programmes—knowing where the product has come from and, if appropriate, who it is being supplied to. While the legislative requirement is only to maintain a record of a business's direct suppliers and direct business customers, most large scale retail businesses will have a sophisticated process for recording and managing suppliers throughout the entire supply chain, particularly for higher risk raw materials. In addition, this will include only contracting with suppliers who have certified food safety management processes in place such as the BRC Global Standard for Food Safety (BRC 2013) or other Global Food Safety Initiative (GFSI) benchmarked standards (http://www.mygfsi.com/), auditing suppliers to ensure they meet any additional specific requirements, holding detailed specifications defining the ingredients and conformance parameters, i.e., analytical checks and the routine monitoring of products at intake to ensure they are safe and fit for purpose prior to use, and ongoing monitoring of product and supplier key performance indicators, e.g., customer complaints.

7.4 Transportation and Distribution

Effective and efficient storage and distribution are a key part of any retail operation. Goods may be shipped over very large distances from different continents and may also be stored for long periods and the potential for food safety to be compromised during these stages is an important consideration, with suitable mitigation strategies being necessary. In the case of large retailers, this generally involves the delivery and consolidation of products in warehouses appropriate to the location of the retail outlets. Product suppliers deliver to these warehouses, usually in their own vehicles and the retailer then assembles orders for transportation in their own vehicles to their retail shops. In many cases, and especially for smaller retailers, the manufacturer may deliver direct to the store or there may be an intermediary distributor who supplies products to the retailer.

Distribution centres can vary widely in size and complexity with some modern day depots reaching 100,000 m^2 (>1 m sq. ft.). No matter what the size of the operation, the key principles for effective food safety management are essentially the same and focus particularly in the areas of temperature control, shelf life management, pest control and contamination (chemical, microbiological and physical).

The potential for foods to be contaminated during storage and transport presents a significant risk from a variety of microbiological, chemical and physical hazards, including pest infestation. In general, most foods being stored in depot or transported to stores are enclosed in packaging or may be in bags, boxes and containers. This presents an important barrier to contamination and packaging integrity is an important element in maintaining this barrier.

For environmental and sustainability reasons, products may be transported in open crates, although in most cases the product itself is usually in primary packaging to prevent damage or contamination. Occasionally, items may be distributed loose and open such as for some types of produce, but even in these instances the product is protected during transportation with protective sheets.

In addition, while larger retailers and distributors may have suitable facilities to keep cleaning chemicals, non-food items, raw and RTE foods separate, this is not necessarily the case for many smaller retailers where storage is more constrained.

The legislative requirements in the EU require that "at all stages of production, processing and distribution, food is to be protected against any contamination likely to render the food unfit for human consumption, injurious to health or contaminated in such a way that it would be unreasonable to expect it to be consumed in that state" (Anon. 2004a).

7.4.1 Chemical

7.4.1.1 Contamination

Although gross chemical contamination of products is not common, it is important to recognise that the co-transportation or storage of food and non-food items can result in taints being acquired by the food. This can be particularly prominent in low moisture and high-fat foods including bakery items, chocolate or even produce in crates (with perforated containers/punnets) if they are stored in close proximity to highly perfumed products including household, health and beauty products. Such taints can also arise from diesel fumes, poorly cured packaging, pallets or poorly cleaned crates. In general, such risks are well recognised and food and non-food items are usually stored separately and kept apart during transportation. Regulation (EU) 852/2004 (Anon. 2004a) requires that where different foodstuffs are transported at the same time or where non-foodstuffs are also transported in the same conveyance, there must be "effective separation of the products" and receptacles and containers cannot be used for carrying anything other than a foodstuff if there is a risk of contamination to the foodstuff.

7.4.2 Microbiological

7.4.2.1 Contamination

In general, the risks to foods during transportation and storage at depot are limited, as such products are generally packaged or covered in such a way as to protect against ingress of contamination sources or through cross-contamination from other sources. However, raw and RTE foods including raw and cooked meats are often stored in the same warehouse and also transported in the same vehicles. In such circumstances, it is normal practice to store products in different parts of the depot and to load deliveries onto separate containers or roll cages. Where it is not possible to employ separate storage areas or transport vehicles/containers, the practice of keeping raw products below RTE ones is operated together with the principle that the two should always be kept separate, i.e., through the use of secondary packaging such as a box or by placing the products in separate crates, thereby preventing the products coming into contact with each other. This is important because while it is generally recognised that the packaging presents a barrier to cross-contamination, surveys regularly demonstrate that microbial contamination can be present on the outside of raw food packaging (Harrison et al. 2001), due to either contamination of external surfaces in the factory or poor sealing resulting in leakage.

Regulation (EC) No 853/2004 (Anon. 2004b) laying down the specific hygiene rules on the hygiene of foodstuffs applicable to products of animal origin requires that “exposed meat must be stored and transported separately from packaged meat, unless stored or transported at different times or in such a way that the packaging material and the manner of storage or transport cannot be a source of contamination for the meat”. While this is clearly designed to protect the raw meat from contamination by other hazards, it is equally important to prevent the cross-contamination of raw meats to RTE foods.

7.4.2.2 Temperature Control

Effective refrigeration and chill chain maintenance during transport and storage is key both to the safety and quality of products. Whilst the focus of temperature control is usually applied to chilled, perishable foods due to their potential to succumb to microbial growth, it is also important to recognise that ambient products can also suffer from excessively high temperatures, which may impact on both microbial growth (thermophilic spore formers in some canned goods, moulds in bakery goods, etc.) and quality deterioration (oil rancidity, chocolate melting, etc.). Consequently, ensuring products are stored in a suitably controlled environment is absolutely essential.

In most cases, transported foods are under the direct control of the manufacturer or retailer, but in some instances, especially when shipping or air freighting products across countries or continents, the direct control is lost and becomes subject to a third party.

Product temperature should be monitored ideally during transport through the use of data loggers and all vehicles should have a means of measuring temperature on receipt at depot. Regulation (EC) No 852/2004 (Anon. 2004a) requires that conveyances and containers used for transporting foodstuffs should, where necessary, be capable of maintaining the foodstuffs at appropriate temperatures and to allow the temperatures to be monitored. It also requires foods that are capable of supporting the growth of pathogenic bacteria be kept at temperatures that will not result in a risk to health, which would apply during the storage periods in distribution. In addition, Regulation (EC) No 853/2004 (Anon. 2004b) details specific temperatures for the transportation and storage of certain foods, e.g., raw poultry meat where temperatures must not exceed 4 °C, raw offal (≤3 °C), minced meat (≤2 °C), meat preparations (≤4 °C), other meat (≤7 °C) and fresh fishery products, thawed unprocessed fishery products and cooked and chilled products from molluscs and crustaceans (temperatures approaching that of melting ice).

7.4.2.3 Shelf Life

The importance of shelf life management should not be overlooked particularly in the context of chilled, perishable foods. Most modern depots and distribution networks have sophisticated systems for managing stock flow within their respective networks. The key to this is inventory management linked to batch and coding information. Verification of shelf life usually occurs at handover points, i.e., delivery to depot and integrated systems manage the picking of stock in appropriate rotation. Where such systems are not in place and reliance is placed on manual systems, it is essential that shelf life management is a key driver of stock picking both for safety reasons and also for quality and sustainability, i.e., to avoid waste.

7.4.3 Physical

7.4.3.1 Infestation

Probably the greatest contamination risk during storage and transportation comes from infestation hazards including rodents, birds, insects and flies. Most depots by their very nature are prone to infestation due to being large, open spaces filled with foods, many of which may be held for long periods and with access points into the depot through large openings at either end (delivery and despatch loading bays). In terms of official legislation within Europe, Regulation (EC) No 852/2004 (Anon. 2004a) simply stipulates that "Adequate procedures are to be in place to control pests".

Each depot should have a pest control programme to reduce the potential for entry of pests, to reduce the likelihood of infestation once introduced, to monitor pest activity and to eradicate pests. Reducing the potential for entry starts with design and build of the facility including the use of elevated loading bays to reduce rodent access, strip curtains to minimise bird and flying insect entry and fully fitting loading bay doors, kept closed when not in use. It is also important to consider risks outside of the depot itself, therefore depots close to rivers and streams will have increased rodent risks, especially from rats and poorly maintained sewerage and drains which provide similar potential risk, and all these need to be taken into consideration to prevent entry. Managing the perimeter of the depot is essential in reducing pest activity with large clear, concreted borders being the gold standard in providing a less hospitable environment for pests.

Simple measures will significantly reduce the entry of many pests, but the entry of some is inevitable in such units and it is important that plans are in place to monitor and manage any infestation.

Once inside a depot, pests will only thrive if they have access to food, water and shelter. Therefore, simple measures such as effective clean as you go operations significantly diminish the availability of food and deprive the invader of nourishment. While stock rotation is simple good practice for supply chain management, it is also important in preventing harbourage points for insects and rodents in particular. Stock that is left for long periods, especially on low-lying pallets, usually accumulate debris including food and provide a potential home for rodents. Product, even if stored in bags, should be kept off the floor and ideally in crates or on pallets to allow for easy access to clean and also inspect. Cladding and piping including electrical housing used in depots also offers shelter for rodents and it is important that any potential ingress points are properly sealed and maintained to prevent these becoming long-term residences for the unwelcome visitors.

Electronic fly killers and rodent activity stations should be sited around the depot, the former at entrances and the latter close to floor and wall junctions where rodents prefer to travel.

While transport vehicles present less of a risk in terms of infestation, they do provide a means to introduce contamination from site-to-site as insects or rodents residing in contaminated foodstuffs will be disturbed during transport and may move onto other foodstuffs being carried or be transferred to the next depot or indeed store with the contaminated material or delivery. It is therefore important to ensure that evidence of infestation such as leaking or chewed bags is investigated upon picking at depot and on receipt at store.

The key food safety points for storage and transportation are summarised in Table 7.3.

Table 7.3 Key food safety points for transportation and storage

Factor	Hazard	Control
Chemical		
• Contamination	Contamination of food with chemicals or chemical taints, e.g., cleaning fluids, disinfectants, perfumes, etc.	Store foods and chemicals/non-food household products in separate storage areas and transport on separate roll cages/pallets/crates.
		Ensure products are not exposed to vehicle exhaust fumes.
Microbiological		
• Contamination	Cross-contamination of pathogens e.g. *Salmonella* spp., *E. coli*, *Campylobacter* spp., *Listeria monocytogenes* from raw to RTE foods directly or via contaminated/leaking packaging	Keep raw foods separate from ready to eat foods in storage and transportation. Where space is limited, ensure raw foods are always stored/transported below RTE foods and that they are physically separated by secondary packaging/crates.
• Temperature	Growth of surviving/contaminating microorganisms including spore-forming bacteria, e.g., *Clostridium botulinum*, *Bacillus* species and *Clostridium perfringens* and post-process contaminants, e.g., *Listeria monocytogenes*, *Staphylococcus aureus* due to temperature abuse during storage or transportation	Store chilled foods at 8 °C or less (ideally ≤5 °C) and frozen foods at ≤–18 °C. Monitoring of vehicle and cold store/freezer temperature (manual or automated) with defined contingency procedure for refrigeration failure. Transfer chilled and frozen foods from delivery vehicles to store freezers/cold stores and from freezers/cold stores to display cabinets quickly, e.g., within 30 min.

(continued)

Table 7.3 (continued)

Factor	Hazard	Control
• Shelf life	Growth of psychrotrophic pathogens e.g., *Listeria monocytogenes*, *Clostridium botulinum* in perishable chilled foods due to exceeding shelf life	Stock management systems in storage to monitor shelf life of incoming deliveries and rotation within depot.
Physical		
• Infestation	Contamination of food with insects and rodent/bird droppings	Design, fabrication and proofing of depot, e.g. concrete perimeter to deter external pests, elevated loading bays, strip curtains to prevent flying pests. Doors, walls and floors fully sealed to prevent nesting. Product stored on racking and pallets to allow easy access for cleaning. Clean as you go for spillages. Electronic fly killers at entrances, bait and activity monitors, sited in consultation with a pest control expert.

7.5 Receipt and in Store Storage

The delivery of goods to a store should be considered to represent an important food safety step. It provides an opportunity to ensure that major food safety controls have been in place during storage and transportation and that gross signs of contamination are not evident. Regulation (EC) No 852/2004 (Anon. 2004a) stipulates that "a food business operator is not to accept raw materials or ingredients, other than live animals, or any other material used in processing products, if they are known to be, or might reasonably be expected to be, contaminated with parasites, pathogenic microorganisms or toxic, decomposed or foreign substances to such an extent that, even after the food business operator had hygienically applied normal sorting and/or preparatory or processing procedures, the final product would be unfit for human consumption".

Therefore, all retail businesses should have provisions in place for incoming deliveries. They should be visually checked to ensure that received products are intact, i.e., no split bags, free from external contamination or signs of infestation, e.g., bird and rodent droppings and, where appropriate, the temperature of the delivery is within specified limits, i.e., for chilled foods. In the latter case, this may be through inspection of the vehicle air temperature gauge or by monitoring between pack temperatures. Such checks should be documented and, in the UK, this is important for the purposes of demonstrating due diligence as defined in the Food Safety Act (1990) (Anon. 1990).

Loading bays for retail outlets also offer similar pest control challenges as those detailed for depots, and similar mitigation strategies should be employed for management of such risks (see Sect. 7.4.3.1).

Storage rooms for incoming goods vary depending on the size and nature of the retail food business. Although storage rooms are only for short periods, they also offer significant opportunities to compromise the safety and quality of products with particular risks being presented in areas of temperature control, contamination and shelf life.

Large retail stores will have separate storage areas usually aligned to designated departments within the store, e.g., produce chiller, raw meat chiller, general foods chiller, freezer, ambient foods store, household, health and beauty (non food) store, general merchandise/electrical store, etc. In addition, departments within the store may have local storage facilities, e.g., bakery chiller, bakery ambient store, delicatessen chillers, etc.

Smaller retail outlets and specialised retailers, e.g., bakery, butchers, etc., do not have sufficient space or resources to operate such an array of storage areas and therefore tend to have stores for chilled, frozen or ambient goods.

It should also be recognised that storage areas are not just used for the food products in a retail establishment and materials likely to come into contact with food may also be stored for long periods including food service bags, plastic bowls, greaseproof paper, etc. Protecting these from contamination sources is as important as the food that they may be served from or packaged in.

7.5.1 Chemical

7.5.1.1 Contamination

The principle chemical hazards associated with gross contamination due to leakage of detergents and disinfectants used for sanitisation of the store or for sale have been detailed already (see Sect. 7.4.1.1) and equally apply in retail storage areas. Cleaning chemicals should not be stored in the same areas as food. Chemicals and highly scented products for resale, e.g., bleach, detergent powders/solutions, should be placed on separate racking or pallets to food products.

7.5.2 Microbiological

7.5.2.1 Cross-Contamination

Storage areas in a retail store offer significant potential microbiological cross-contamination risks. While most foods are received in some form of protective packaging, e.g., pre-packaged or in boxes, the potential exists to transfer contamination between raw and RTE product, if they are stored together. This may occur through direct contact, i.e., by placing them next to or on top of each other or indirectly through leakages of juices. Many storage areas are also used for storing opened and partly used products, i.e., delicatessen products such as olives, cheeses, cooked meats, etc. and in these circumstances the opened food product is highly vulnerable to cross-contamination too, if a RTE product, or as a vector of contamination, if a raw product.

An outbreak of salmonellosis caused by *Salmonella* Typhimurium DT170 resulting in 52 cases in Wales, UK was caused by cross-contamination in a storage area of a retail/wholesale outlet (Evans et al. 1999). Raw lamb carcasses were stored in the same cold store as poorly sealed cartons of yoghurt, which resulted in blood drip contaminating the yogurt. This was, in turn, used for garnishing take-away kebab meat.

Consequently raw and RTE products are generally stored in separate storage areas, or if not, they should be stored in separate parts of the storage area or with the raw product covered and on a shelf below the covered RTE product.

Regulation (EC) No 852/2004 (Anon. 2004a) of the European Parliament and of the Council of 29 April 2004 on the hygiene of foodstuffs requires that "raw materials and all ingredients stored in a food business are to be kept in appropriate conditions designed to prevent harmful deterioration and protect them from contamination".

The use of common storage areas by colleagues handling open raw and RTE products also needs to be considered in relation to the potential to transfer microbiological hazards. For example, colleagues working in the butchery area of a store may transfer microbiological contaminants to door handles that are subsequently used by colleagues working with open, RTE foods such as delicatessen counter colleagues. Such hazards can be eliminated by storing raw and RTE foods in separate cold stores or in ensuring that simple, good standards of hygiene are operated by colleagues, i.e., washing hands when exiting and entering food service counters.

7.5.2.2 Temperature Control

In general, all businesses will have storage areas dedicated for chilled, frozen and ambient goods. It is essential that chilled and frozen foods are moved quickly into their respective storage areas after delivery. In some cases, stock may be replenished straight into store cabinets, which is particularly common for overnight deliveries where stores are either closed or have few customers. In both cases, it is good practice to ensure stock is returned to chilled or frozen storage within 30 min, if not replenished or otherwise kept cold, to avoid elevation of temperature. This is especially important in countries where ambient temperature is high, where products are delivered in crates (as this offers little thermal protection) and also when replenishing directly into aisle cabinets as the latter are not designed to chill products, but merely to keep chilled products cold.

Storage rooms should be monitored constantly to ensure that appropriate temperatures are being maintained. In larger businesses, this will be done through automated, continuous temperature control devices fitted to the inside of the cold store at designated warm spots. Such devices are usually alarmed so that when temperatures rise beyond designated maximum values, a visible and audible alarm appears/sounds. These may also be linked to nominated engineers to alert them to refrigeration failures. In smaller businesses, temperature may be taken manually through the use of air probes or product temperature probes. It is good practice to keep records of temperature checks for the purposes of demonstrating due diligence.

Documented procedures should be in place to manage refrigeration failures in order to ensure that food safety is not compromised and stock is not unduly lost. As most temperature management systems tend to monitor air temperature, significant time usually exists between elevating air temperature and consequent product temperature increases in cold stores or freezers, providing doors are kept closed. Therefore, where temperature alarms sound, it is good practice to minimise the opening of chiller and freezer doors and where necessary, routine product temperature monitoring (between pack or in pack) should be employed to ensure products remain within defined limits. These limits will vary by establishment as the safety of many products is linked with shelf life and therefore while the legislative temperature limit may not be exceeded, the shelf life may have been set by an establishment based on the maintenance of lower temperatures within the distribution and retail chain.

EU requirements simply state that “raw materials, ingredients, intermediate products and finished products likely to support the reproduction of pathogenic micro-organisms or the formation of toxins are not to be kept at temperatures that might result in a risk to health. The cold chain is not to be interrupted. However, limited periods outside temperature control are permitted, to accommodate the practicalities of handling during preparation, transport, storage, display and service of food, provided that it does not result in a risk to health” [Regulation (EC) No 852/2004 (Anon. 2004a)]. In the UK, the maximum temperature for chilled, perishable foods is designated as 8 °C [Relevant Regulations for Scotland, Wales and Northern Ireland (Anon. 2013d)], although specific requirements are detailed in other legislation for poultry meat [Council Regulation (EC) No 1234/2007 establishing a common organisation of agricultural markets and on specific provisions for certain products (single CMO regulation)], (Anon. 2007a) that requires it is kept between –2 and 4 °C. In the UK, this can be elevated to 8 °C if the poultry meat is cut and handled in the retail establishment for direct sale to the customer, e.g., from the meat counter [The Poultrymeat (England) Regulations 2011 (Anon. 2011a)].

7.5.2.3 Shelf Life

Most foods have a minimum durability (shelf life) that results from chemical or microbial deterioration of the product. The speed with which this happens depends on the processing of the food, its physico-chemical properties and storage conditions. In the EU, foods must be marked with an indicator of the date of minimum durability which is defined as the “date until which the foodstuff retains its specific properties when properly stored” (Directive 2000/13/EC of the European Parliament and the Council of 20 March 2000 (Anon. 2000b) as repealed by Regulation (EU) No 1169/2011 of the European Parliament and the Council of 25 October 2011 (Anon. 2011b)). For foods that from a microbiological perspective are highly perishable and will therefore constitute an immediate health risk after a short period, the words “use by” (or equivalent member state term) must precede the date code, i.e., use by 25 DEC. All other foods must be coded with the terms “best before or best before end”.

This does not extend to foods prepared on retail premises and sold to the consumer e.g., from service counters such as the delicatessen.

Stock rotation is a key part of managing the safety, quality and indeed the commercial success of a retail operation. Selling food beyond its use by date is illegal and good management of stock and associated stock rotation is key to this. It is normal practice to manage stock inventory in both large and small stores to ensure reconciliation of goods, although this can vary between basic manual systems through to sophisticated computer-based systems.

7.5.3 Physical

7.5.3.1 Infestation

The main pest infestation risks are presented to ambient areas of retail storage as neither the chillers nor freezers present hospitable environments for most pests. The key controls have already been outlined for distribution storage areas (see Sect. 7.4.3.1) and these equally apply in retail storage; storing product off the floor on pallets or roll cages to allow easy access for cleaning; removing spillages quickly to prevent access to food; maintaining fabrication of floors, walls, cabling and other harbourage points to ensure they are sealed and no access is provided for pests to set up ‘home’; rotating stock.

It is also useful to monitor pest activity using appropriately sited electronic fly killers, rodent traps, monitors, etc. The services of third party pest control contractors is important in designing pest control and monitoring programmes, but it is important to recognise that the management of infestation is essentially through the routine adoption of good hygiene and manufacturing practice by the food business operator and not through the delegation to the pest contractor.

The key food safety points for receipt and in store storage are summarised in Table 7.4.

Table 7.4 Key food safety points for receipt and in store storage

Factor	Hazard	Control
Chemical		
• Contamination	Contamination of food with chemicals or chemical taints, e.g., cleaning fluids, disinfectants, perfumes, etc.	Store foods and chemicals/non-food household products in separate storage areas or on separate racking within the storage area.
Microbiological		
• Contamination	Cross-contamination of pathogens, e.g., *Salmonella* spp., *E. coli*, *Campylobacter* spp., *Listeria monocytogenes* from raw to RTE foods directly or via contaminated/leaking packaging	Keep raw foods and RTE foods in separate storage facilities, e.g., raw meat chiller, provisions chiller. Where space is limited, ensure raw foods are always stored below RTE foods, i.e., on different shelving and that they are covered and in secondary packaging/crates. Colleague hygiene, i.e., hand washing to prevent common areas of the store becoming cross-contamination hazards, e.g., chiller door handles, etc.
• Temperature	Growth of surviving/contaminating microorganisms including spore-forming bacteria, e.g., *Clostridium botulinum*, *Bacillus* species and *Clostridium perfringens* and post-process contaminants e.g., *Listeria monocytogenes*, *Staphylococcus aureus* due to temperature abuse during storage	Incoming temperature checks of delivery vehicles. Store chilled foods at ≤8 °C (ideally ≤5 °C) and frozen foods at ≤ -18 °C. Monitoring of cold store/freezer temperature (manual or automated) with defined contingency procedure for refrigeration failure. Transfer chilled and frozen foods from delivery vehicles to freezers/cold stores and from freezers/cold stores to display cabinets quickly, e.g., within 30 min.
• Shelf life	Growth of psychrotrophic pathogens, e.g., *Listeria monocytogenes*, *Clostridium botulinum* in perishable chilled foods due to exceeding shelf life	Stock rotation and code checking procedures.
Physical		
• Infestation	Contamination of food with insects and rodent/bird droppings	Check incoming goods for evidence of pest activity/infestation, e.g., chewed bags, etc. Design, fabrication and proofing of store e.g. doors, walls and floors fully sealed to prevent nesting. Loading bay doors kept closed when not in use. Product stored on racking and pallets to allow easy access for cleaning. Clean as you go for spillages. Electronic fly killers at entrances, bait and activity monitors, sited in consultation with a pest control expert.

7.6 In Store Prepared Foods and Service Counters

Large supermarkets operate a variety of service counters where food may be prepared in store and served to the customer on request. Such counters include salad bars, olive bars, in store bakery counters, pizza counters, meat, fish and poultry counters, delicatessens and many more. Essentially such counters are versions of standalone shops that still exist in most countries specialising in each of these commodity areas, e.g. butchers (UK), boucherie (France), Metzgerie (Germany); bakers (UK), boulangerie (France), Bäckerei (Germany), panificio (Italy); delicatessen (UK), charcuterie (France), Feinkost (Germany), salumeria (Italy), etc.

These shops or parts of a store represent the highest risk areas as they usually bring the store colleague and sometimes the customer into direct contact with foods, many of which will be RTE.

The key challenge in these areas of the store is undoubtedly microbiological posed by cross-contamination hazards, temperature control and shelf life, together with potential allergen contamination due to the open and extensive handling associated with these foods. Some in store operations also present significant challenges regarding the control of physical hazards, i.e., bakery.

Delicatessen counter—The delicatessen counter serves the widest variety of RTE food, from cooked sliced meats, cheeses, dips, air dried or fermented meats and sandwiches among many others. Most delicatessens consist of a refrigerated counter often covered with a glass or plastic screen. Products are served by counter staff who may slice or decant product to order (Fig. 7.1). Products are merchandised on display plates or bowls in the well of the counter and refrigerated air is

Fig. 7.1 Delicatessen counter with cooked meat slicer in background

circulated over the product in an ‘air curtain’ usually via a grill vent at one end of the counter (air off). The air passes back through the cabinet condensers (air on) where it is re-chilled and then back onto the product. Delicatessen counters will have an array of equipment including slicers, knives, cutting boards, serving bowls, packaging, weighing scales, etc.

Salad bar—The salad bar offers a wide variety of cut and sliced salads and vegetables, many of which may be dressed with pH-controlled dressings. Salad bars are generally refrigerated, but they are more often open and designed for self-service by the customer. Salad bars also serve a variety of prepared fruit products. As they are self-serve, salad bars may be located next to manned service counters or located in other parts of a supermarket, often situated adjacent to the produce aisle or near take home aisles to cater for meal time trade, i.e., lunch. Products for the salad bar may be prepared in store or are often purchased in bulk, ready prepared where the product is either decanted into the display bowls or where the bowl is replaced completely.

Meat and fish counter—Counters for the display of store prepared meat, poultry and fish products, whether in a supermarket or in specialist butchers or fishmongers, essentially operate in a similar way to the delicatessen counter. They are usually chilled with circulated, cold air although fish counters may use ice with or without air circulation. Many counters are completely open, although some may have screens similar to many delicatessen counters. In addition, meat and fish counters often feature misters that circulate a fine mist of water over the products to prevent dehydration and maintain optimal visual quality (Figs. 7.2 and 7.3). Meat and fish counters are usually separated although often co-manned and some, although predominantly displaying raw product, may also co-display raw and RTE product.

Fig. 7.2 Fish counter with ice bed and chilled air circulation

Fig. 7.3 Meat counter with misting

This is more common in specialist retailers, i.e., butchers and fishmongers. In supermarkets, RTE fish and meat products are often prepared and served from the delicatessen counter.

Bakery—The in-store bakery (Fig. 7.4) or bakers shop has historically presented minimal safety risks due to the baking process and ambient stability of bread and bread products. The main risk in these operations are from physical hazards, especially from equipment used in the weighing, mixing, proving and baking stages together with pest infestation from ingredient storage areas. Many bakeries prepare cream either manually or more often using benchtop cream machines that can additionally present significant potential microbiological risk due to poor cleaning and cross-contamination. Many bakeries do not have chilled serving counters and this presents additional microbiological risks for perishable products. Bakeries also handle a wide range of allergens including nuts, egg, sesame seeds, etc. and therefore cross-contamination of these hazards also needs significant attention.

Hot food counter—Many stores cook products such as bulk meats, cooked chicken, etc., on the premises and therefore may handle raw and cooked meats in the same areas. Such products are usually cooked in conventional or rotisserie ovens. In some cases, these may be served hot from a temperature-controlled cabinet (Fig. 7.5), although some may chill the product for sale on the delicatessen or cooked meat counter. Significant potential microbiological risks are presented in these operations.

Fig. 7.4 Bakery counter with in-store baked product in background

Fig. 7.5 Hot food counter with in-store cooked products

7.6.1 Chemical

7.6.1.1 Contamination

Cleaning chemicals will be in use in all open food handling areas of the store as a consequence of the need to regularly clean and disinfect surfaces used for the handling and preparation of RTE foods, e.g. cutting boards, slicers, knives, etc. Disinfectants will often be present in trigger spray bottles for ready use in the relevant departments. Regulation (EC) 852/2004 (Anon. 2004a) requires that "Cleaning agents and disinfectants are not to be stored in areas where food is handled" and it is important that the chemicals do not themselves contaminate the open product. Therefore, clear labelling to highlight the presence of chemicals and storage away from food are simple but important measures to prevent such contamination.

Bulk chemicals should be stored in areas away from the main food handling areas, ideally in dedicated cupboards. Detergents and disinfectants used for routine cleaning and disinfection in a store should be kept in small volumes, i.e., trigger spray bottles, clearly labelled and, when not in use, stored in areas where they will not present a risk to foods if leakage were to occur, i.e., on a hand wash basin.

Some pieces of equipment are also subject to more extensive cleaning regimes such as cream machines used in the bakery where cleaning compounds and disinfectants will be circulated within the equipment to effect a full clean. Such circumstances present a risk to subsequent product, if procedures for rinsing the chemicals out of the machinery are not conducted effectively prior to the use for cream/food production. Clear cleaning instructions and visual checks with appropriate sign off are important to prevent contamination with cleaning compounds.

7.6.1.2 Allergens

The management of allergens in retail establishments has become a key part of food safety management programmes in recent years due to the significant increase in diagnosed allergy and intolerance to a variety of foods and food ingredients. Allergic reactions to foods can vary from mild intolerance through to severe life-threatening anaphylaxis, and therefore control of allergens is critical. Allergy to foods differs quite markedly in different countries and continents, which makes the consistent management of risk across the EU more difficult. For example, whilst allergy to celery is particularly high in France, it is conversely quite rare in the UK. The legislative framework for the declaration and management of allergens in the EU has therefore taken account of the key allergens of clinical significance in all EU countries and applied a consolidated approach (Anon. 2000b as amended by Directive 2003/89/EC (Anon. 2003) and Directive 2006/142/EC (Anon. 2006a) and repealed by Regulation (EU) 1169/2011 (Anon. 2011b)). The list of legislated allergens in the EU is shown in Table 7.5. Labelling of pre-packaged foods with the defined allergens is mandatory throughout the EU if the allergen is used as an ingredient (at any level, except for sulphur dioxide, see Table 7.5), with certain exceptions if

Table 7.5 List of allergens that must be declared on food products in the EU (Anon. 2003, 2006a, 2011b)

Allergen
Cereals containing gluten; wheat, rye, barley, oats, spelt, kamut or their hybridised strains
Crustaceans
Eggs
Fish
Peanuts
Soybeans
Milk
Nuts (almonds, hazelnuts, walnuts, cashews, pecan nuts, Brazil nuts, pistachio nuts, macadamia or Queensland nuts)
Celery
Mustard
Sesame seeds
Sulphur dioxide and sulphites at concentrations of more than 10 mg/kg or 10 mg/L
Lupin
Molluscs

the allergen is not present in the final product (Anon. 2007b). It is also a mandatory requirement for foods sold loose in a retail store to be labelled with the allergen or for the customer to have ready access to information relating to the presence of allergens, for example, through the provision of product information guides behind food service counters.

Measures can be implemented in stores to reduce the risk of cross-contamination with allergens during the preparation, display and serving of foods. Prior to the measures to prevent allergen cross-contamination in store, it is important that the component foods bought into the store for preparation, assembly, slicing, etc. are themselves not already an allergen risk. This should be declared on the label in accordance with EU regulations and should form part of the product specification agreed as part of supplier and product assurance programmes (see Sect. 7.3). The main risk of cross-contamination in the store occurs during the preparation, display and serving of the food. The key to preventing allergen cross-contamination is the use of separate utensils, surfaces/cutting boards, display containers, tongs/slicers and any other food contact surfaces for allergen-containing and non-allergen-containing products. This can also be achieved by preparing non-allergen-containing products first, after a full clean and prior to the preparation of allergen-containing products. However, in many cases, preparation of products may be necessary throughout the day, i.e., to order and therefore it is not possible to operate this type of 'scheduled' segregation.

In addition to cross-contamination risks from allergens, the potential for the use of the wrong ingredient is also a significant potential risk. This can be exacerbated when a large number of products are prepared. The key to controlling these hazards are clearly defined recipe sheets for the preparation of products, together with clear labelling of the components/ingredients.

In many cases, however, despite implementing measures to reduce the risk of cross-contamination, the sheer number of allergens being handled in food service counters makes effective control too difficult. Combined with the significant risk that the presence of an undeclared allergen presents to an allergic customer, this often results in the display of generic advice that all foods may contain all allergens and that customers should avoid purchasing products from such counters if they have specific food allergies.

7.6.2 Microbiological

7.6.2.1 Contamination

One of the most significant risks to foods prepared in store or served from open food counters comes from contamination from microbiological hazards. Contamination can arise from a number of key sources or vectors including people, products, equipment and environment.

Although microbiological contamination can present a risk to all open food products, the focus in this section is on RTE foods rather than raw foods. However, cross-contamination risks also apply to some raw foods, i.e., from chicken to fish where contamination in the chicken, usually at high levels with pathogens such as *Campylobacter* spp. (Bell and Kyriakides 2009), can pass to the fish, which is ordinarily free from or contains very low levels of the pathogen. As fish tends to be more lightly cooked by the consumer, increasing enteric pathogen loading through poor control of raw foods is an important consideration. Therefore, procedures to prevent cross-contamination between raw foods such as meat and fish through segregation in display cabinets, handling with separate utensils and weighing using separate scales or into designated packaging are equally applicable in a retail environment for these foods.

People

Training—A key factor impacting on food safety is usually the food handler themselves. In general, they can be a contamination source and/or a vector of pathogenic microorganisms to food. The specific requirement for training and qualification of food handlers varies in different EU member states, but there is no defined qualification required in European food law for individuals preparing food. Regulation (EC) 852/2004 (Anon. 2004a) requires that "food handlers are supervised and instructed and/or trained in food hygiene matters commensurate with their work activity" and that those responsible for the development and maintenance of hazard analysis-based procedures "have received adequate training in the application of the HACCP principles"; the latter applying principally to the food business operator rather than the food handler.

Notwithstanding the legal requirement referred to above, the first principle in food safety for food businesses is that all employees are suitably trained in food hygiene and the basic precautions necessary to avoid the contamination of food with microbiological, chemical, and physical hazards. Most food business operators would require all colleagues working in a food retail environment to be trained in basic food hygiene and accredited courses are available for such undertakings, although in most large retailers this would be undertaken in house. For individuals whose work involves the handling and preparation of food, more extensive training and qualification in food safety and hygiene is also commonly undertaken, which in the UK is certified by accreditation bodies to a level referred to as level 2 (award in food safety), which is recognised as a National Occupational Standard. For those supervising others, a further food safety qualification can be gained (Level 3 Award in Supervising Food Safety).

In addition to training individuals to understand food safety principles, the importance of ongoing reinforcement of positive and unacceptable food safety behaviours is a key component of the long-term delivery of food safety and hygiene—ignoring a food handler who does not wash their hands or who does not adequately clean equipment ultimately is tacit recognition to that individual that their behaviour is tolerable. Management commitment to food safety and hygiene is therefore critical at all levels in a business to ensure that good practice is recognised and rewarded and that bad practice is addressed.

Training records should be kept for all individuals and, in the UK, would form an important component of any due diligence defence in the event of a food safety incident.

Infectious disease control—The basic principles of operating adequate standards of personal hygiene and exclusion from handling food when suffering from an infectious disease are widely recognised minimum standards, also specified in Regulation (EC) 852/2004 (Anon. 2004a); "Every person working in a food-handling area is to maintain a high degree of personal cleanliness and is to wear suitable, clean and, where necessary, protective clothing. No person suffering from, or being a carrier of a disease likely to be transmitted through food or afflicted, for example, with infected wounds, skin infections, sores or diarrhoea is to be permitted to handle food or enter any food-handling area in any capacity if there is any likelihood of direct or indirect contamination. Any person so affected and employed in a food business and who is likely to come into contact with food is to report immediately the illness or symptoms, and if possible their causes, to the food business operator."

Specific national guidelines have been developed to assist food business operators in managing infectious diseases in food handlers (FSA 2009; Anon. 2004c) (Table 7.6).

It is important when developing infectious disease management procedures to ensure that they cover both the risk of contamination to product and also the risk of spreading infection to other workers. In addition, consideration needs to be taken not just of the food handler, but also of a food handler's contact with individuals outside of work who may themselves be suffering from infectious disease.

Table 7.6 Guidance on infectious disease control (adapted from FSA 2009)

Organism	Advice
General	
Symptoms of infectious disease (vomiting, diarrhoea, skin infections) must be reported immediately	
Individuals handling food or working where open foods are present should be excluded from working in these areas for a minimum of 48 h from when the last symptoms stopped naturally	
Salmonella Typhi and *Salmonella* Paratyphi A, B or C	Exclusion of infected individuals and those in contact with infected individuals, e.g., household contacts. Due to the potential for long-term carriage, exclusion may be extensive to ensure clearance through stool testing
Verocytotoxin producing *Escherichia coli* (VTEC)	Exclude until two consecutive negative stool samples, the second sample being taken at least 48 h after the symptoms have stopped naturally. Exclude food handlers who have household contacts infected with VTEC and undertake microbiological stool clearance as above
Norovirus	Exclusion from entire food business until 48 h after the last symptoms due to potential for spread to other colleagues. Exclude individuals who have come into contact with other individuals who have norovirus infection for at least 24 h
Hepatitis A	Exclusion for a period of at least 7 days after onset of symptoms
Skin infection	Ensure the infected or damaged area is completely covered using a waterproof dressing
Entamoeba histolytica	One negative stool sample a week after treatment
Shigella dysenteriae, *flexneri* and *boydii*	Two consecutive negative stool samples taken at intervals of at least 48 h
Threadworm	Exclude from direct handling open ready to eat foods until treated
Taenia solium	Two negative stool tests at 1 and 2 weeks post-treatment
Vibrio cholerae O1 and O139	Two consecutive negative stool samples taken at intervals of at least 24 h

In general, most businesses operate a procedure of excluding individuals with suspected or confirmed infectious disease from handling food for a period of at least 48 h following the last onset of any symptoms. Certain infectious diseases present greater risk of spread via food, usually because of their severity or low infectious dose and therefore such infections merit longer periods of exclusion together with stool testing to establish clearance (Table 7.6).

Although stool testing can be useful in monitoring the carrier state of those workers who have recently suffered foodborne disease, it is important to recognise that such testing has limited significance in relation to routine management of infectious disease risks in individuals who have not or are not suffering infectious disease, since a single test may fail to detect a pathogen in a stool sample. The main risk presented by organisms causing infectious disease is usually within the timeframes of the disease itself and outside of these times, when exclusion from handling food would be merited, it is the operation of high standards of personal hygiene that represents the best barrier to the spread of such infectious agents.

Quite possibly the most effective control of infectious disease is rigorous compliance to hand washing; prior to handling foods, after using toilets, after handling raw foods or making contact with environmental contamination sources, e.g., cleaning utensils, bins, etc. Although most food handlers could be expected to know how to wash hands, it is also important that training is given for effective hand washing, including the importance of wetting hands, applying soap, scrubbing hands and nails and then rinsing and drying fully. Handwashing instructions located at wash hand basins can be useful prompts to food handlers in the correct procedure for this simple, but most important of tasks. Hand washing is often supplemented with the use of an additional hand sanitiser (alcohol or quaternary ammonium compound), and although some businesses use antibacterial soap, the key hygiene step is the washing and drying itself irrespective of the use of an antibacterial agent.

The use of gloves for handling food varies between businesses and remains of debatable food safety significance. Whether used or not, it is essential that this is not used as a substitute for hand washing.

A large number of foodborne disease outbreaks have been attributed to poor infectious disease control (Graves et al. 1998; Olsen et al. 2001; Barrabeig et al. 2010).

Food handlers should wear appropriate protective clothing, which should be dedicated as much as possible to the area of the business they are working in, i.e., delicatessen counter or bakery. Clothing should be clean and laundered regularly to prevent the clothing itself becoming a risk of contamination to product. Regulation (EC) 852/2004 (Anon. 2004a) states that "Every person working in a food-handling area is to maintain a high degree of personal cleanliness and is to wear suitable, clean and, where necessary, protective clothing". Practices within retail operations for protective clothing can vary significantly, but it is good practice for those handling food to have outer garments such as aprons dedicated for use in any particular counter operation e.g., delicatessen, bakery, etc. The use of colour coding of clothing can also be helpful to quickly identify any colleagues in inappropriate areas of the store. Such protective clothing should be regularly changed and laundered, this being dependent on the degree of soiling that occurs during normal operation. Such laundering should ensure that clothing is both cleaned and disinfected, this normally being achieved through high temperature washing (>70 °C) and drying (>100 °C) together with separation of dirty and clean laundry.

Product

Cross-contamination—Products can themselves be a source of contamination to other products or indeed to equipment that may in turn become a vehicle of cross-contamination to other products. It is therefore important to recognise the relative risks presented by different products and to ensure that appropriate controls are in place to manage them in a retail environment. As previously noted, Regulation (EC) 852/2004 (Anon. 2004a) requires that "at all stages of production, processing and distribution, food is to be protected against any contamination likely to render the food unfit for human consumption, injurious to health or contaminated in such a way that it would be unreasonable to expect it to be consumed in that state". The obvious greatest risk in retail exists between the handling of open raw and RTE foods, and it is essential that practices in a retail environment minimise the opportunities for such products to come into contact directly or indirectly. Physical separation is the most effective means to manage this risk and raw food counters such as for meat and fish are usually kept separate from those for RTE foods such as delicatessen, salad bar and bakeries. It is also important to consider the cross-contamination risk that the 'back of store' storage areas present to food handlers working in these areas. For example, if the main cold store is used to store materials for all counters, then food handlers from each of these departments in the store will access the same area and may themselves contaminate common touch points such as handles, doors, etc. Clearly, the best control is to remove the risk entirely by having dedicated storage areas for raw and RTE products. However, in smaller operations this may not be feasible, and therefore the main control should actually be with colleague hygiene practices in washing hands and changing protective clothing, e.g., aprons prior to leaving and upon entering the relevant food service operation.

However, even where perceived raw and RTE foods are kept separate, other microbiological risks exist in food service areas such as the delicatessen. For example, one of the key risks in a delicatessen is from the contamination of chilled, perishable foods such as sliced meats and soft cheeses with *Listeria monocytogenes*. While the majority of foods sold on the delicatessen will be cooked or pasteurised, some products such as dried or fermented meats are essentially raw and their safety and stability relies on the prior conditions during their manufacture. However, many such products can be contaminated with *L. monocytogenes* at very low levels, but where the organism cannot grow (Bell and Kyriakides 2005). Therefore, the product itself presents little risk to the customer, but it could present a source of *L. monocytogenes* to the delicatessen counter and therefore to other products susceptible to its growth. In these situations, some businesses employ separate slicers for cooked and 'uncooked' meat products to maintain a degree of separation between the products. This may equally apply to other products such as raw milk, mould-ripened soft cheeses and appropriate controls should be considered.

In addition to cross-contamination risks presented by raw and RTE foods, it is important to recognise other contamination sources particularly where used on open RTE foods. Examples include ice used for the fish counter that may come into direct contact with foods and is often generated by local ice machines in retail stores. Such equipment must be suitably maintained and cleaned to ensure the ice does not become a source of contamination to any foods on the fish counter. Regulation (EC) 852/2004 (Anon. 2004a) requires that "ice which comes into contact with food or which may contaminate food is to be made from potable water or, when used to chill whole fishery products, clean water. It is to be made, handled and stored under conditions that protect it from contamination".

It is also quite common practice for garnishes to be used for decorating delicatessen counters and whether this uses fresh herbs or, as often the case, plastic imitation herbs, it is essential that these are suitably cleaned and disinfected before use.

Process controls—In many store operations, processes are employed to eliminate microbial hazards or to reduce them to acceptable levels, e.g., cooking of chicken or bulk meats or washing of produce. In such circumstances, it is essential that appropriate procedures are in place to ensure the process is consistently applied, taking into account factors that may contribute to variation which can be more difficult to control in a retail environment. Cooking processes are described later under 'Temperature', but one additional key process to note is washing of produce. Produce used for salad bars may be prepared in store or in many cases may be bought in, having already been cut and washed at a manufacturing facility. In both cases, one of the key controls is effective washing of produce. The objective of washing is to remove physical debris from the product such as soil and also to achieve some microbial reduction. It is therefore normal practice to remove the outer leaves of salads that are often most heavily soiled and then to cut and then wash the remaining leaves. Regulation (EC) 852/2004 (Anon. 2004a) requires that "adequate provision is to be made, where necessary, for washing food. Every sink or other such facility provided for the washing of food is to have an adequate supply of hot and/or cold potable water". In a retail environment, produce is washed either in free flowing water or soaked in a disinfectant solution, usually chlorine.

Such processes achieve a minimal reduction in microbial contamination, with most achieving approximately a $1-\log_{10}$ reduction (Zhang and Farber 1996). Notwithstanding the minimal reductions achieved, it is important that suitably clean water is used for washing produce and that appropriate levels of disinfectants are dispensed and applied. Ensuring that colleagues have clear instructions on how to make up specified concentrations of the relevant disinfectants is critical to ensuring the efficacy of the wash. Commonly applied regimes for disinfection with chlorine range from 50 to 100 ppm chlorine with a contact time of 2–5 min.

Equipment and Environment

A key enabler to the operation of effective food safety and hygiene is the provision of the correct tools to do the job. No matter how much training or how detailed a procedure is for an individual, if the equipment or environment is unfit or unavailable for a key food safety intervention, then it is negligent of the food business operator. Outbreaks of foodborne disease have implicated the lack of suitable equipment. For example, in the outbreak of *E. coli* O157 in Wales in 2006 that resulted in 157 cases and the death of a 5 year old boy, the official investigation report identified that the use of a vacuum-packing machine for both raw and cooked product may have lead to cross-contamination of the pathogen from raw to cooked product (Pennington 2009).

Each food service counter or operation has key equipment that must be appropriately used and suitably cleaned and maintained to prevent it from becoming a focal point for contamination to foods. The nature of these operations also means this can include both simple utensils such as knives and serving dishes to more complex machinery like cream machines and bakery mixers. A typical store with a delicatessen, bakery and salad bar will have a selection of the following:

Meat slicers, cheeseboards/wires, bread slicer, cutting boards, preparation utensils (knives, stirrers, sieves, measuring jugs, etc.), cream machine, mixing bowls, display cabinet (salad bar, delicatessen counter, cream cake display unit), serving utensils (spoons, plates, bowls, etc.), weighing scales and packaging (film, wrap, trays, bowls, bags, greaseproof paper).

The key principle to avoid cross-contamination, be that microbiological or indeed from allergens, is to use dedicated equipment for each counter in the store preparing and serving open, RTE food. Such equipment should also be colour-coded to ensure that it is simple for food handlers and also managers to identify that the correct equipment is being used in any particular area to avoid cross-contamination. It also follows that such areas of a store should have dedicated cleaning and disinfection areas for equipment.

In some smaller stores, it may not be feasible to have separate equipment for all areas and the normal good hygienic practice applies in ensuring that any shared equipment is appropriately cleaned and disinfected between use.

Cleaning and disinfection is a critical component of any food safety management programme. Open foods prepared and served from food service counters in stores frequently come into contact with equipment used variously to store, prepare, slice, cut, display or serve the product. Such equipment can readily be a source of microbiological contamination, usually representing a vector of contaminants from people or the environment, although the equipment itself can become a reservoir of contamination itself. Cleaning and disinfection is therefore key to preventing cross-contamination to foods with either pathogenic or spoilage microorganisms. The requirement to ensure equipment is hygienic is legislated for in Regulation (EC) 852/2004 (Anon. 2004a) whereby "All articles, fittings and equipment with which food comes into contact are to be effectively cleaned and, where necessary, disinfected. Cleaning and disinfection are to take place at a frequency sufficient to avoid any risk of contamination".

Cleaning and disinfection may be through manual means or through the use of dishwashers. In addition, cleaning may need to occur both throughout the day on slicers, for example, as well as at the end of a production shift, e.g., cream machines.

The purpose of cleaning and disinfection is clearly to ensure equipment and surfaces are suitably cleaned of residual food product and also contaminating microorganisms, be they spoilage or potentially pathogenic. Consequently, it is essential that an appropriate cleaning schedule is established for each area of the store. Surfaces that are subject to ongoing handling of product and that are not chilled, i.e., cutting boards, slicers, preparation surfaces and utensils should be subject to clean as you go operations using the principle of removing or rinsing food debris away, washing with a detergent, rinsing and then applying a disinfectant. In some cases, a combined detergent/disinfectant may be used. Other equipment such as display bowls and serving cabinets that are under refrigeration are usually subject to a daily clean and a deep clean when emptied. The importance of stripping down equipment for a full deep clean is essential for more complex equipment such as cream machines and even display cabinets, i.e., delicatessen counters, as the build up of food debris and potential microbial contaminants may be in areas not readily visible, i.e., in pipe-work in cream machines, under the base plate of a delicatessen counter, etc.

It is important that as part of any cleaning schedule, the recommended concentrations of chemicals are used and that they are applied in accordance with validated sanitisation regimes. It is usual for such sanitisation regimes to be recommended by specialist hygiene companies, usually those supplying the chemicals to the retail establishment.

Food handlers tasked with cleaning and disinfection should be appropriately trained and signed off as competent.

The use of rapid tests to assess post-cleaning efficacy has become popular in recent years, including swab checks that detect traces of protein, sugars or adenosine tri-phosphate (present in food and microorganisms). These can usefully support the implementation of an effective cleaning and disinfection regime, but it is important that they don't in themselves become the means by which an individual judges whether cleaning is sufficient.

Cleaning records should be kept to demonstrate that specified schedules of cleaning are being adhered to.

7.6.2.2 Temperature

The key issues relating to temperature on food service counters fall into three categories; display, cooking and cooling. Cooking and cooling only apply to those operations where product is cooked in store or on the counter, some of which may be served hot and others cooled and sold from the chill counter.

Display

The temperature control requirements for food on service counters do not differ from any other part of the store where temperatures must be maintained in accordance with defined limits for quality or safety reasons. However, the completely open nature of the display cabinets for many of these operations can make maintaining chill temperature more difficult. In most cabinets, chilled air is circulated from condensers underneath the cabinet, through grills at the back of the unit and blown over the top and around products in the cabinet, producing an ‘air-curtain’ that maintains product temperature. Like any chill, display cabinet, they are only designed to maintain temperature and not to chill warm products, hence any prepared products where temperatures elevate must be cooled before they are placed in the cabinet. The entire principle of maintaining chill temperatures in these cabinets relies on air being able to circulate around product and the product remaining below the ‘air curtain’. It is essential that in such cabinets, products are not stacked too high or overcrowded with product, which can often be a temptation as retail appeal often relies on abundant displays. Hence, the use of clear merchandising guides for store colleagues and the presence of load lines in cabinets can ensure maximum efficiency of these display units. Some display cabinets, e.g., fish counters, are sometimes not refrigerated but rely instead on physical contact with ice. In these cases, effective temperature control relies on direct contact between product and ice and avoiding the stacking of product is key to maintaining chill temperatures. Regular icing of product is also important to ensure chill temperatures are maintained.

The effective operation of chilled display cabinets is essential and most refrigeration cabinets in modern stores are monitored automatically through ‘air on’ or ‘air off’ temperature, which ensures that the cabinet temperatures are within set specifications. These normally alarm within the store to alert colleagues to any defect. In general, alarms are set to indicate a failure of a unit, but do not indicate the temperature of the product. Therefore, any alarms should be followed up with monitoring of actual product and where equipment cannot be rectified quickly, product should be moved to an alternative cabinet or to the storage chiller.

Regulation (EC) 2004 (Anon. 2004a) has a general requirement in relation to temperature control which states that “raw materials, ingredients, intermediate products and finished products likely to support the reproduction of pathogenic micro-organisms or the formation of toxins are not to be kept at temperatures that might result in a risk to health”, although it also recognises that practical necessity requires flexibility to operate outside of chilled conditions for short periods during delivery and replenishment, and therefore also states that “the cold chain is not to be interrupted. However, limited periods outside temperature control are permitted, to accommodate the practicalities of handling during preparation, transport, storage, display and service of food, provided that it does not result in a risk to health”.

In the UK, that chilled foods must be kept at a maximum of 8 °C or below during display, although most businesses store chilled foods at a much lower temperature (5 °C or less) to maximise the chilled shelf life of the product. Periods of time are allowed for foods to exceed 8 °C, but this must not compromise the safety of the product. Specifically, the Regulation requires that “any person who keeps any food which is likely to support the growth of pathogenic micro–organisms or the formation of toxins … at or in food premises at a temperature above 8 °C commits an offence”. Certain exceptions to this requirement are specified, including foods that are then cooked or reheated for service or on display for sale and need to be kept at or above 63 °C in order to control the growth of pathogenic microorganisms or the formation of toxins. In addition, if it can be demonstrated through scientific means that holding at temperatures above 8 °C will be safe or is specified by the manufacturer’s instructions, then this also is permitted. Other reasons for upward variation from the 8 °C maximum include where the food was for service or on display for sale, had not previously been kept for service or on display for sale at a temperature above 8 °C, and had been kept for service or on display for sale for a period of less than 4 h.

Although most focus is on maintaining chill temperature, a variety of foods are displayed on counters at ambient temperatures including fermented and dry-cured meats, e.g., salami, Parma ham, etc. The safe storage of these products at ambient temperature is dependent on the conditions applied during their manufacture and it is important to establish that these are safe and stable prior to storing under such conditions.

Some products sold on open food counters may carry additional risk to certain groups and in a similar way to the use of labelling to advise customers of potential allergen cross-contamination risks; this may also be necessary for microbiological safety. Therefore, for products such as mould-ripened soft cheeses made from unpasteurised or pasteurised milk, where the presence and growth of *L. monocytogenes* may be a risk particularly to certain vulnerable groups such as expectant mothers and the general advice is that such groups should not consume these products (Anon. 2013c), the use of labelling on the counter is important to indicate the nature of the cheese, i.e., unpasteurised or pasteurised and to reiterate such advice.

Cooking

A number of cooking operations are undertaken in store for products to be served on the delicatessen counter including bulk cured and uncured meats, e.g., ham, or from hot food counters, e.g., chicken rotisserie. As with any cooking operation, the critical control is the time and temperature achieved throughout the product. Most businesses tend to use previously defined processing times and temperatures for ovens to generate a safe cook and then apply some temperature monitoring at the end point to ensure minimum temperatures have been achieved. While the general approach of post-cooking temperature monitoring is an important check of the process, it must be recognised that the prior cooking validation to generate the correct process times and temperatures is the key element for achieving consistent safety.

Cooking validation is designed to ensure that the cooking process is established using worst-case operating parameters including;

- maximum piece size
- minimum ingoing temperature
- maximum oven fill
- cold spot analysis
- minimum process temperature
- minimum process time

Processes established in this way and then subsequently managed to ensure that these parameters are not exceeded can then be usefully supplemented with post-cooking verification using temperature probing.

There are no minimum cooking times and temperatures set in EU or UK regulations for cooking of raw foods. In the UK, raw meats are cooked in accordance with guidance originally developed for the cooking of prepared ready meals to achieve a 6-log reduction in *L. monocytogenes*, subsequently also used as the reference process for the cooking of burgers (Anon. 1998); this requires that all parts of the food are cooked to a minimum of 70 °C for 2 min or an equivalent combination. The *z*-value and therefore time/temperature combinations of thermal equivalents were recently reviewed (ACMSF 2007).

In the UK, allow cooked foods to be sold hot, providing they are kept at 63 °C or above. Alternatively, they can be sold below 63 °C, providing the food is sold within a maximum of 2 h or within a period of time that “a well-founded scientific assessment of the safety of the food at temperatures below 63 °C has concluded that there is no risk to health”.

Temperature probes are used extensively in food retail to monitor both chilled and cooked products, and it is therefore essential that such probes are suitably calibrated and the calibration routinely checked. Checking of calibration should be undertaken on a daily basis using ice water.

Cooling

In general, cooked foods that are intended to be sold at chill temperatures can be chilled quickly if they are relatively small in size/thickness. However, bulk meats provide a more difficult challenge. It is not possible to cool such products safely without some form of additional cooling, i.e., chilled air or immersion in water/ice. Regulation (EC) 852/2004 (Anon. 2004a) requires that “where foodstuffs are to be held or served at chilled temperatures, they are to be cooled as quickly as possible following the heat-processing stage, or final preparation stage if no heat process is applied, to a temperature which does not result in a risk to health”. No prescribed rate of cooling is required in EU legislation, although the general principle of ensuring the food is safe to eat remains. The main hazards in relation to the cooling of cooked, RTE foods, i.e., bulk meats, are the organisms capable of surviving the cooking process, i.e. spore formers, and that can then subsequently grow rapidly during the cooling of the product. *Clostridium perfringens*, *Bacillus cereus* and other spore forming bacteria, often present in raw materials, survive conventional pasteurisation, i.e., 70 °C for 2 min and can subsequently germinate and grow in the final product during cooling. *C. perfringens* grow at a remarkably fast rate at warm temperature and therefore holding the product hot or cooling it rapidly are essential controls regarding this and other similar hazards. Several studies have been conducted to assess the growth of *C. perfringens* in cooked meats in order to establish safe cooling regimes and specific guidance has been adopted in the UK. Gaze et al. (1998) recommended the following maximum cooling regimes for meats to prevent the germination and growth of *C. perfringens* during the cooling of uncured meats;

2.5 h to 50 °C, 6 h from 50 to 12 °C and 1.5 h to cool from 12 to 5 °C. This could be extended by 0.75 h, 1.5 h and 0.25 h, respectively, for cooked, cured meat.

Additional, practical guidance based on research commissioned by the Meat and Livestock Commission has been used for many years by butchers' shops in the UK to cool meats safely (BRC 2009). This recommends different approaches for several types of cooked meat and cooked meat products with cooling in water or air. In summary;

– Large bulk meat joints (up to 9.5 kg in watertight bags)—water cooling in iced potable water with regular stirring will achieve <12 °C in 6 h and <5 °C in 10 h. After an initial period of ambient cooling (<90 min), the recommended amount of crushed ice needed to reduce a cooked meat joint from 70 °C to 5 °C is 0.8 kg per kg of meat and to achieve cooling from 100 to 5 °C, 1.2 kg per kg meat.

– Small meat joints (10 cm/4 in. diameter)—for smaller joints of meat, the thickness of the joint is more important in relation to the rate of cooling and joints of 10 cm diameter can be cooled in a forced air circulation refrigerator/cold room operating at approximately 0 °C, to <5 °C within 10 h. A combination of water chilling and air cooling is also recommended in certain circumstances.
– Meat pies—air-cooling is the only practical approach for cooling meat pies and similar products, although this is more readily achievable as most pies are relatively thin. In a cold room/chiller operating at 0 °C, a pie of 4–5 cm thickness can be cooled from 70 to 5 °C within 4 h.

In all cases, it is important to consider the number of products being cooled at any one time, fluctuations in chiller temperature at the start and during cooling, and the use of a thermometer to verify cooling is recommended to ensure cooling is achieved within safe limits.

Blast chillers are now more commonly available and these are preferable for cooling product.

7.6.2.3 Shelf Life

The shelf life of many foods is critical to the safety of the product and foods opened and sold from the counter introduce a level of complexity that must be carefully managed to ensure safety is not compromised. Shelf life is generally defined by the maximum time the product will retain its optimum organoleptic characteristics, i.e., quality and remain safe to consume. Quality may be limited by visual deterioration caused by drying, wilting, emulsion breakdown, enzyme activity or microbial growth, whereas safety is usually limited by the presence and growth of pathogenic microorganisms. Products are therefore assigned an indicator of durability which, in the EU, is either a 'best before' date where quality is the key determining factor, or a 'use by' date where the product will become unsafe if consumed after the date. The majority of chilled foods are assigned 'use by' dates, whereas most ambient foods are given 'best before' dates. In the context of in-store prepared foods, products are usually bought in as pre-packaged goods in a bulk form, if not prepared on site.

Consequently, they will already have an allocated maximum shelf-life that must not be exceeded for either safety or quality reasons. However, these bulk foods will be opened and used as ingredients, e.g., cream, or further prepared/sliced, e.g., cooked meats and cheeses or simply served, e.g., dressed salads, olives, etc. The subsequent shelf life allocated to prepare/display the product on the counter needs to be taken into consideration in relation to the total allocated shelf life, as the combined shelf life should never exceed the original maximum shelf life unless some form of additional control is introduced by the process, i.e., cooking, drying, etc. In many cases, the opening of the bulk product may introduce contaminants or break-controlled gas mixtures, i.e., in bulk gas packed products that will result in earlier deterioration of the product. Consequently, products are normally allocated a maximum shelf life after opening the product, which is considerably shorter than the original maximum shelf life if left in the original bulk packaging. This is common to fish, meat and poultry products, i.e., highly perishable.

A further complication is added by the fact that products sold from the counter must also take into account the shelf life allocated to the customer to indicate the maximum time before which they should consume the product.

Procedures must be clear to food handlers in the store where shelf life is varied after opening bulk packs or preparing product and this must be simple to interpret and calculate. This is normally accomplished through on pack labelling or product information manuals informing the food handler of the maximum shelf life after opening, i.e., use within *x* days of opening. Best practice is then to transfer this new maximum shelf life onto the counter ticket that is placed next to the product on display. In general, most chilled, perishable foods sold opened from the counter are allocated display shelf lives from 2 to 7 days with a further 1–2 days customer shelf life.

7.6.3 Physical

7.6.3.1 Foreign Body

In-store operations are more prone to physical contamination hazards due to the nature of open and extensively handled foods. The contamination risks can extend beyond those from store operations as customers may also introduce an additional hazard to open food service counters, e.g., salad bars.

A variety of utensils, serving bowls, mixers, etc., are used on service counters and in some cases quite complex machinery, i.e., automated baking ovens in bakeries that offer significant potential for foreign body introduction. Foreign body risks due to equipment falling into mixers, pieces falling off poorly maintained equipment or broken serving utensils or plates/bowls can generally be reduced by good management and maintenance. Glass should not be used in such food operations, but it is common for metal, hard plastic and ceramics to be used. Less obvious foreign body hazards also exist, particularly cleaning cloths, display/price labels and broken knife blades. Key controls include the use of utensil inventories, reporting breakages immediately for investigation and planned preventative maintenance/replacement of worn or damaged utensils or equipment.

Hair is probably one of the biggest causes of physical contamination of product and while it can also introduce microbiological hazards, the main risk is physical due to visual unacceptability of hair in the product, indicative of poor hygiene control in the facility. Normal good practice is to tie all hair up and to cover it fully with a hairnet, cap or hat.

Jewellery also poses a risk to food and it is normal practice for all jewellery to be removed prior to handling food with the exception of a plain single band wedding ring.

False nails must not be used when handling food and similarly nails should not be painted, as both present a potential contamination risk.

7.6.3.2 Infestation

The potential for contamination with pests has been addressed in more detail in previous sections (see Sect. 7.3), but it is important that equipment and environments used for in-store operations are managed to reduce contamination risks. For example, equipment can become harbourage points for pests, offering them protection and warmth and certain equipment attracts specific pests, i.e., fruit flies on salad bars. The use of electronic fly killers, pest activity monitors allied with removal of food and water sources is key to control of pest infestation risks in these counters.

The key food safety points for in-store prepared food and service counters are summarised in Table 7.7.

Table 7.7 Key food safety points for in-store prepared food and service counters

Factor	Hazard	Control
Chemical		
• Contamination	Contamination of food with chemicals used for cleaning and disinfection of equipment and surfaces	Store bulk chemicals in dedicated, separate storage areas from food. Clearly label any in-use chemicals, e.g., trigger spray bottles. Clear procedures and appropriate training for use of cleaning chemicals.
• Allergens	Cross-contamination of allergens, e.g., peanut, nuts, sesame, wheat, etc. during the storage, preparation, display and serving from allergen-containing foods/ ingredients to non-allergen-containing foods	Use separate storage areas, display equipment, serving utensils and surfaces for the preparation of foods with allergens and those where allergens are not present. Ensure recipes for non-allergen-containing foods are clear and similar allergen-containing ingredients cannot be mistakenly used. Ensure effective cleaning of any shared utensils, surfaces or equipment.
		Provide suitable allergen warnings to customers where controls are not possible.

(continued)

Table 7.7 (continued)

Factor	Hazard	Control
Microbiological		
• Contamination	Cross-contamination of pathogens e.g. *Salmonella* spp., *E. coli*, *Campylobacter* spp., *Listeria monocytogenes*, *Staphylococcus aureus* from raw to RTE foods, from infected individuals or from environmental sources, e.g., equipment and utensils	Separation of raw and ready to eat counters, equipment, preparation areas and associated staff. Separate handling of 'uncooked' RTE foods e.g. fermented meats, raw milk cheeses, from other ready to eat foods capable of supporting growth of pathogens, e.g., *Listeria monocytogenes*
		Equipment suitable for the job and capable of being cleaned and disinfected. Simple, clearly documented cleaning procedures visible to colleagues. Clean as you go and deep clean regimes established for all equipment and demonstrated to be adequate for the purposes used, i.e., daily strip clean of cream machine, clean as you go for slicers with end of day full strip clean, etc.
		Cleaning efficacy checks using visual inspection and rapid hygiene monitors e.g. ATP, protein, sugars.
		Protective clothing that is clean and hygienically laundered.
		Training of food handlers in food hygiene practices to a minimum of Level 2 in Food Safety.
		Infectious disease control—excluding individuals until at least 48 h symptom free.
		Colleague hygiene, i.e., hand washing.
• Temperature	Survival of enteric pathogens due to undercooking of in-store prepared foods	Cooking validation to generate cooking procedure for in-store cooked products, e.g., cooked chicken and bulk meats to ensure a minimum cook to 70 °C for 2 min or equivalent
	Growth of contaminating or surviving microorganisms including spore-forming bacteria, e.g. *Clostridium botulinum*, *Bacillus* species and *Clostridium perfringens* and post-process contaminants, e.g., *Listeria monocytogenes*, *Staphylococcus aureus* due to temperature abuse during storage or inadequate cooling of in-store prepared foods	Temperature monitoring of cabinets using automated sensors or manual temperature checks and associated action plan in the event of refrigeration failure.
		Adhering to maximum loading of counters, i.e., not overfilling, not interrupting 'air flow' and regular icing of fish on counters.
		Cool in-store prepared foods to <5 °C in 6 h maximum (longer for bulk meats; see text) using forced air or water cooling.

(continued)

Table 7.7 (continued)

Factor	Hazard	Control
• Shelf life	Growth of psychrotrophic pathogens, e.g., *Listeria monocytogenes*, *Clostridium botulinum* in perishable chilled foods due to exceeding shelf life	Shelf life allocation to in-store prepared product taking account of open counter life and customer shelf life to ensure the maximum safe shelf life is not exceeded.
Physical		
• Foreign body	Contamination of food with foreign objects from colleagues preparing foods, e.g. nails, jewellery, hair or broken/damaged equipment and utensils	Colleague hygiene, i.e. hand washing and prevention of physical contamination hazards e.g. covering hair, removal of jewellery, no false nails, no nail varnish, etc.
		Physical hazard control through equipment maintenance, utensil registers, training of colleagues to report broken utensils/equipment promptly

7.7 Pre-packaged Food (Fresh, Chilled and Frozen)

A large proportion of a supermarket's sales comes from fresh, chilled and frozen foods including meat, fish, poultry, produce, prepared meals and dairy products. A key characteristic of these foods, with the exception of some produce lines, is their reliance on cold temperature to maximise shelf life. While some of these foods, again predominantly produce lines, may be sold open and loose, the vast majority are sold as pre-packaged units in boxes, flow wraps, cartons or some other form of container that is usually hermetically sealed. The key hazards to these products tend to include microbiological ones associated with contamination, shelf life and temperature abuse together with physical hazards predominantly affecting open, loose foods.

7.7.1 Microbiological

7.7.1.1 Contamination

For pre-packaged foods, the product should not in general be exposed to any further contamination risks as it is enclosed. However, it is important to recognise that the outside of the packaging can become contaminated if procedures are not employed to minimise contact between RTE and raw foods. Therefore, it is normal practice in most stores to keep raw and RTE foods displayed on separate shelves in a chiller or freezer cabinet or, if stored in the same cabinet, the normal principles apply of keeping raw food displayed in the well of the cabinet with RTE foods on higher shelves or separated by physical divides in the cabinet to prevent any direct contact.

No legislation exists in relation to the storage of raw and ready to eat pre-packaged food with specific regard to the potential for cross- contamination to the packaging, although the general principles of Regulation (EC) 852/2004 (Anon. 2004a) would apply; "at all stages of production, processing and distribution, food is to be protected against any contamination likely to render the food unfit for human consumption, injurious to health or contaminated in such a way that it would be unreasonable to expect it to be consumed in that state". In addition, following a number of major outbreaks caused by *E. coli* O157 in the UK (Pennington 1997, 2009), national guidance has been published with regard to the specific control of this hazard (FSA 2014).

It is equally important that shelves do not themselves become reservoirs of contamination and routine cleaning and disinfection should be undertaken as part of 'clean as you go' procedures for chiller cabinets. This is particularly important in cabinets where blood spillage from raw products may occur due to poor or damaged packaging, i.e., beef, lamb, pork, chicken cabinets. While the products may themselves be contaminated with microbial pathogens, it is important to minimise the presence of such pathogens on the outside of packaging, as these will in turn be handled by customers, placed with other foods in trolleys/baskets/bags and onto conveyor belts. Hence, minimising external contamination is important in a retail context.

7.7.1.2 Temperature Control

The maintenance of effective chilled and frozen temperatures is key to maintaining both the quality and safety of chilled and frozen products. Legislative requirements for temperature control have already been described, and it is important that set temperatures are maintained in the chiller and freezer cabinets. Monitoring of cabinet temperatures is conducted automatically in large supermarket operations linked to alarm systems if failures occur. In smaller operations, temperature checks are conducted manually. Automated systems tend to monitor the air temperature of the cabinet and therefore set points can be managed to ensure that any alarm is triggered before product temperature increases beyond a critical level. Where manual temperature checks are undertaken, it is equally important to ensure that action levels are set to trigger remedial action before critical levels are exceeded.

It goes without saying that records of temperature checks whether automated or manual should be kept for due diligence purposes.

In addition to ensuring that cabinets operate effectively, the key to ensuring effective product temperature control is also the ranging/replenishment of the cabinet and the design/maintenance. Cabinets vary markedly in design and may be vertical or horizontal, open fronted or with a door and inside each of them they may have physical divides for different ranges or promotional signage. It is essential that any equipment is operated within the design constraints of the unit, i.e., products should not block vents, be above load lines, impede air flow and circulation, etc. Appropriate defrost cycles need to be in operation to prevent ice build up and the potential for product temperature fluctuation during these cycles must be accounted for. In large businesses, the freezer and chiller units are often operated from a refrigeration pack feeding a large number of units and whether large or small, the ability of the refrigeration units to operate under worst case conditions needs to be established, i.e., warm summer months.

Procedures need to be in place to account for chiller breakdowns and this should ensure that critical temperature limits are not exceeded through the use of in-pack or between pack temperature monitoring.

Some foods are more vulnerable to temperature abuse than others and special precautions may be necessary to draw colleagues' attention to these when storing, merchandising or displaying such products. Probably the most vulnerable commodity are raw scombroid fish such as tuna, mackerel, sardines, etc., due to the risk of histamine formation by contaminating microorganisms. Under conditions of mild temperature abuse, growth and decarboxylation of amino acids such as histidine can result in excessive levels of histamine presence in the fish that will not be subsequently destroyed when cooked. EU limits have been set for the maximum amount of histamine in fish products (Anon. 2005), recognising this hazard and the key to control is hygiene (in the processing of the fish) and then strict temperature control thereafter. Most outbreaks of scombrotoxin poisoning (caused by high levels of histamine and other amines) implicate poor temperature control at any stage from fishing, processing, transportation, retail or in the home.

7.7.1.3 Shelf Life

The importance of shelf life in controlling microbiological hazards has already been described for open foods (see Sect. 7.6) and similar risks are present whether the food is open and sold from a counter in the store or if sold pre-packaged. The shelf life of frozen products tends to be limited by quality deterioration including drying due to moisture loss or chemical breakdown. Consequently, such products are usually marked with a 'best before' date to indicate that their durability is limited by quality. This equally applies to many chilled, perishable foods such as yogurts, hard cheeses, fats (butter), juices, etc., where the shelf life is often not dictated by microbial safety; consequently they are also labelled with a 'best before' date.

Many fresh and chilled foods are, however, capable of supporting the growth of microbial pathogens that may be occasionally present and, if allowed to grow beyond the allocated shelf life may be unsafe to consume. Directive 2000/13/EC (Anon. 2000b) and Regulation (EU) No 1169/2011 (Anon. 2011b) require that "In the case of foodstuffs which, from the microbiological point of view, are highly perishable and are therefore likely after a short period to constitute an immediate danger to human health, the date of minimum durability shall be replaced by the 'use by' date". Consequently these foods are labelled with a 'use by' date and it is important that these are labelled appropriately and used as indicated by the consumer.

There are no EU or national requirements regarding the maximum shelf life of a food, merely the criteria against which a food business operator must label the food's durability, as already described. Therefore, it is left to the business operator, i.e., manufacturer or retailer to establish the safe shelf life of the product taking account of potential contaminants and their subsequent ability to grow in the product.

Foods such as cooked meats, soft, ripened cheeses, prepared produce and similar perishable products may occasionally be contaminated with low levels of pathogenic microorganisms such as *L. monocytogenes*, and the EU has set strict criteria for the levels of the organism that are acceptable at any point in the shelf life of a RTE food (Anon. 2005). Under most circumstances, levels of the organism must not be present above 100 cfu per g and the detection of the organism above these levels in a RTE food must result in it being recalled from the market and consumer, i.e., a public recall. This also applies if the organism is found to be present at any level in a food if it is capable of growing to levels above 100 per g within the allocated shelf life. Absence of evidence, i.e., challenge test data to demonstrate that it cannot grow to unsafe levels within the products shelf life will require the product to be recalled from the market. Consequently, the shelf life of foods vulnerable to the presence of organisms such as *L. monocytogenes* must be set taking account of the likelihood of its presence and the potential for subsequent growth. Due to the potential risk associated with exceeding the shelf life of these products, a 'use by' date is applied to indicate their durability.

Similarly, vacuum packed cooked, chilled foods such as cooked meats, fish, vegetables, etc. may be occasionally contaminated with spores of *Clostridium botulinum* capable of growth under refrigeration conditions, i.e., psychrotrophic *C. botulinum* (including a variety of non-proteolytic types). Although the organism has been reported to grow in foods at temperatures approaching 3 °C, many retail chill chains do not operate at such low temperatures and some products may therefore be susceptible to growth of the organism even under normal 'good' temperature control conditions. In the UK, guidance exists on the maximum shelf life that should be given to these foods when stored under chilled conditions, i.e., 10 days (ACMSF 1992; FSA 2008). A longer shelf life can be applied if controlling factors exist in the product capable of preventing growth of non-proteolytic *C. botulinum* or if a challenge tests have demonstrated safety.

Given that the shelf life and therefore durability coding of the product defines the safe shelf life, it is clear that managing products to ensure that they are sold and consumed within their safe shelf life is key to safety. Stock rotation is therefore clearly critical to the safety of the product and code-checking procedures are a key part of a retail store process to ensure that product of shortest shelf life is being sold first and that products approaching their 'use by' date are 'reduced' in price to encourage purchase or/are removed from sale. It is an offence to sell products beyond their 'use by' date and Regulation (EU) 1169/2011 (Anon. 2011b) states that "After the 'use by' date a food shall be deemed to be unsafe".

The key food safety points for pre-packaged food (fresh, chilled and frozen) are summarised in Table 7.8.

Table 7.8 Key food safety points for pre-packaged food (fresh, chilled and frozen)

Factor	Hazard	Control
Microbiological		
• Contamination	Cross-contamination of enteric pathogens, e.g., *Salmonella* spp., *E. coli*, *Campylobacter* spp. from raw to RTE foods, via packaging and contaminated display cabinets, i.e., blood drip	Display of raw and RTE products in separate chillers or with raw products on separate shelves, below ready to eat products.
		Clean as you go procedures for shelves, e.g., blood drip from meat packs, etc.
• Temperature	Growth of surviving microorganisms including spore-forming bacteria, e.g., *Clostridium botulinum*, *Bacillus* species and *Clostridium perfringens* and post-process contaminants, e.g., *Listeria monocytogenes*, *Staphylococcus aureus* and histamine decarboxylating bacteria due to temperature abuse during storage	Temperature monitoring of cabinets using automated sensors or manual temperature checks and associated action plan in the event of refrigeration failure.
		Adhering to maximum loading of cabinets, i.e., not overfilling and not interrupting ‘air flow’.
• Shelf life	Growth of psychrotrophic pathogens, e.g., *Listeria monocytogenes*, *Clostridium botulinum* in perishable chilled foods due to exceeding shelf life	Stock rotation of products to ensure products are not sold outside of their shelf life.

7.8 Grocery Food

The grocery aisle of most stores sell ambient, long shelf life (>3 months) products including canned, dried, pickled and otherwise shelf stable commodities.

7.8.1 Microbiological

There is little microbiological risk associated with these products in relation to the grocery store management as risks are predominantly controlled by the manufacturing processes in the factory, e.g., canning prior to receipt in the store. However, two key operational issues are important, impacting on cross-contamination and shelf life.

7.8.1.1 Cross-Contamination

Many grocery products are low-acid, high moisture, ambient stable products and their safety depends on maintaining sterility from processing through to opening by the consumer, e.g., canned salmon, bottled vegetables, etc. The storage and, particularly, merchandising of these products often results in them being subject to physical stress through being knocked, dropped, stacked, etc. Consequently, cans may become dented, jars can be cracked and lids can be loosened. In such circumstances, critical parts of the hermetically sealed container can be breached leading to potential ingress of microbiological contaminants including spoilage organisms and potential pathogens. It is essential that procedures are in place in-store firstly to minimise the damage to such products through training, use of shelf ready packaging, etc. and also to remove from sale any damaged stock. Normal good practice is to exclude products where the tamper evident seal is breached, e.g., pop-up lids or where damage has occurred to a vulnerable region of the can or jar, lids, seals and seams.

7.8.1.2 Shelf Life

The durability of ambient stable foods is usually dictated by organoleptic deterioration and not microbiological. While microorganisms may grow in some products, e.g., bread, modified atmosphere packaged products, etc., these would generally be as a result of a microflora that either has little impact on the product or, in some cases, may contribute to microbial spoilage, e.g., moulds, spore formers, etc. The shelf life would be set to take account of these factors and therefore the key issue for the retailer is to ensure good stock rotation to ensure that products are sold within their allocated shelf lives. Most grocery items would consequently be labelled with a 'best before' date (Directive 2000/13/EC (Anon. 2000b), Regulation (EC) 1169/2011, Anon. 2011b) that indicates it is not unsafe to eat after the date but that it may not be organoleptically at its 'best'. Although not microbiological, shelf life of certain grocery foods such as canned fruit is limited by the slow migration of metals such as tin into the product and legal limits exist in the EU controlling the maximum amount of such metals in products, i.e., 200 mg/kg tin in canned foods, 100 mg/kg tin in canned beverages, fruit juices and vegetable juices, etc. (Anon. 2006b). Consequently, the management of some of these long shelf life products is important, albeit safety is not usually compromised immediately after the end of shelf life and so products are labelled with a 'best before' date.

7.8.2 Physical

7.8.2.1 Foreign Body

In addition to the potential microbiological risk presented by damage caused to cans, jars and other foods in containers during storage and replenishment, the same practices can impact on the presence of physical hazards entering the product. While severe damage of this nature tends to result in catastrophic failure, i.e., glass breakage, less visible damage can occur if damage is less pronounced and can thereby present a safety risk to the customer. For example, glass bottles and jars that are knocked together during transit and replenishment can lead to internal fractures, particularly of the internal lid, that is already under some stress as a consequence of the torque applied during sealing. While it is not possible to identify such occurrences, the focus has to be on training of colleagues to handle and merchandise the products in such a way as to minimise the bottles knocking against each other or on shelves.

Similarly, many retail operations may merchandise products on pallets leading to the presence of potential wooden foreign body risks from splintering wood to products packed in paper or plastic film. While it is best practice to merchandise such products on metal or hard plastic roll cages or pallets or indeed on shelves themselves, the use of cardboard liners on the base of pallets will reduce such risks.

7.8.2.2 Infestation

The grocery aisles are generally the slowest sales area of the store with lower stock rotation frequency due to long shelf lives of product. Consequently, they offer greater potential for pest infestation, particularly if spillages occur due to product damage. Split packs of sugar, flour and other commodities that result in food debris falling under fixture can attract ground or aerial pests. The presence of obstructions to effective cleaning such as kick plates at the floor level makes it impossible to remove debris without removing stock and dismantling the floor level shelving. Design of fixtures to allow ready access to cleaning and removal of food debris together with scheduled cleaning of these areas is important in preventing infestation. The merchandising of products that are readily attacked by rodents, e.g., paper bags of petfood, etc., can also encourage infestation.

The key food safety points for grocery foods are summarised in Table 7.9.

Table 7.9 Key food safety points for grocery foods

Factor	Hazard	Control
Microbiological		
• Contamination	Contamination of pathogens, e.g., *Clostridium botulinum* to low acid, ambient stable foods due to container damage	Removal of damaged products that may compromise sterility, i.e., seal, lid, seam damage to cans or jars.
Physical		
• Foreign body	Contamination of food with foreign objects due to damage during transit and replenishment, i.e., internal glass fractures	Replenishment techniques to avoid product damage, e.g., internal glass breakage of jars.
• Infestation	Contamination of food with insects and rodent droppings	Clean as you go and deep clean regimes for display cabinets to discourage infestation especially under base plates.

7.9 Home Delivery

The home delivery or online grocery market has experienced significant growth in the last decade, brought about predominantly by the Internet and digital platforms. Historically, home delivery was undertaken by local delivery boys who would travel short distances to take shopping to individual customers. These days, delivery vehicles equipped with ambient, chilled and frozen storage capability transport grocery orders to multiple customers over much larger distances (10+ miles away). Online grocery sales have grown at a rate well over 10 % per annum for the last decade and this growth is expected to continue for the foreseeable future, driven by consumer demand, although it will remain a relatively small proportion of overall retail sales (1–5 %). The main challenges presented by home delivery include temperature control and cross-contamination (microbiological and chemical).

7.9.1 Chemical

7.9.1.1 Contamination

The principle chemical contamination risks arise from either strongly scented household cleaners or from leakages from containers such as bleaches and other disinfectants. While it is good practice to ensure these items are placed in dedicated carrier bags, it is also normal practice to place such carrier bags in separate crates for transport in the delivery vehicle to ensure any spillages do not reach any foodstuffs being delivered. Crates are usually designed so that they do not have holes in the base to ensure any spillages, if they occur, are also contained.

7.9.2 Microbiological

7.9.2.1 Contamination

Home deliveries of groceries include all of the same foods as those available in the store and so include both pre-packed and loose foods that may be raw or RTE. In addition, they will include household cleaning chemicals, detergents, bleaches, etc. Therefore, transportation of such products needs to take account of both microbiological and chemical cross-contamination risks.

In general, most foods whether originally loose or pre-packed will be contained within some form of packaging during delivery. For example, loose fruit such as apples or pears or produce, e.g., lettuce, will be placed in bags during picking at the store or from a dark store and then placed into a carrier bag. It is good practice to ensure that raw foods are separated from RTE foods and, in general, this is achieved by placing them in separate carrier bags even if they are already pre-packed or placed in a primary bag for weighing. This ensures that microbial pathogens that may be present on the outside of packaging or loose, in store packaged products, e.g., chicken or meat from the meat counter, do not transfer contamination to RTE products directly or via packaging.

7.9.2.2 Temperature Control

In many ways, home delivery probably ensures greater control of temperature than that achieved by the average customer and so, if conducted appropriately, actually improves the safety of product. Modern delivery vehicles have temperature-controlled compartments where chilled and frozen foods are stored and these are designed to keep food at the designated temperature. Due to the inability to operate multiple temperatures, products are generally distributed at temperatures required for the most perishable foodstuff. As vehicles may be on the road making deliveries for several hours, it is important to ensure temperature is monitored and modern vehicles have temperature gauges to monitor temperature which can be supplemented with manual temperature checks where necessary. Temperature control is most important during the warm, summer months and it is normal for vehicles to have strip curtains to avoid temperature loss during unloading. For operational reasons, it is normal to check the customer is able to take receipt of the delivery before unloading, but this is also important for temperature control reasons. Unloading and receipt are normally undertaken within a matter of a few minutes and this does not generally present any food safety challenges.

The key food safety points for home delivery are summarised in Table 7.10.

Table 7.10 Key food safety points for home delivery

Factor	Hazard	Control
Chemical		
• Contamination	Contamination of food with chemicals or chemical taints, e.g. cleaning fluids, disinfectants, perfumes, etc.	Transport foods and chemicals/ non-food household products in separate bags/crates.
Microbiological		
• Contamination	Cross-contamination of pathogens, e.g., *Salmonella* spp., *E. coli*, *Campylobacter* spp., *Listeria monocytogenes* from raw to RTE foods directly or via contaminated/ leaking packaging.	Pack raw foods and ready to eat foods in separate bags and crates.
• Temperature	Growth of surviving microorganisms including spore-forming bacteria, e.g., *Clostridium botulinum*, *Bacillus* species and *Clostridium perfringens* and post-process contaminants, e.g., *Listeria monocytogenes*, *Staphylococcus aureus* due to temperature abuse during transportation.	Monitoring of vehicle and cold store/freezer temperature (manual or automated) with defined contingency procedure for refrigeration failure. Transfer chilled and frozen foods from delivery vehicles to customers quickly, e.g., within 30 min.

7.10 The Future

The retail landscape continues to evolve and the store of the future will undoubtedly introduce additional challenges for food safety control. Recent increases in Internet shopping and home delivery, rather than quelling the development of the retail store, have actually been accompanied by more sophisticated in-store operations. These operations often aim to bring the manufacturing or local store experience into the larger stores with associated increases in complexity of operation. Likewise, the rapid growth in smaller convenience retail stores has changed the 'corner' shop from a predominantly grocery store to one offering a wide range of fresh, chilled products together with some food service operations.

Notwithstanding the undoubted changes that the retail environment will experience in years to come, the same hazards outlined in this chapter will remain. It is merely the processes and procedures for the control of these hazards that will need to adapt to the changing environment in which they will be exposed.

References

ACMSF (1992) Report on vacuum packaging and associated processes. Advisory Committee on the Microbiological Safety of Food. Her Majesty's Stationery Office, London. http://www.food.gov.uk/multimedia/pdfs/acmsfvacpackreport.pdf. Accessed 31 Dec 2013

ACMSF (1993) *Salmonella* in eggs. Advisory Committee on the Microbiological Safety of Food. Her Majesty's Stationery Office, London. http://acmsf.food.gov.uk/acmsfreps/acmsfreports. Accessed 29 Dec 2013

ACMSF (2007) Report on the safe cooking of burgers. Advisory Committee on the Microbiological Safety of Food, Food Standards Agency, London. http://www.food.gov.uk/multimedia/pdfs/acmsfburgers0807.pdf. Accessed 31 Dec 2013

Anon. (1990) Food Safety Act Chapter 16 (1990) The Stationery Office Ltd, London. http://www.legislation.gov.uk/ukpga/1990/16. Accessed 29 Dec 2013

Anon. (1998) Department of Health. Revised guidance on the safe cooking of burgers, Department of Health press release 31 July 1998, reference number 98/316

Anon. (2000a) The BSE enquiry findings and conclusions. The Stationery Office Ltd, London

Anon. (2000b) Directive 2000/13/EC of the European Parliament and the Council of 20 March 2000 on the approximation of the laws of the Member States relating to the labelling, presentation and advertising of foodstuffs. Official Journal of the European Union L109/29, 6 May 2000. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:2000L0013:20110120:EN:PDF. Accessed 31 Dec 2013

Anon. (2002a) Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety. Official Journal of the European Union L31/1, 1 February 2002. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2002:031:0001:0001:EN:PDF. Accessed 29 Dec 2013

Anon. (2003) Directive 2003/89/EC of the European Parliament and of the Council of 10 November 2003 amending Directive 2000/13/EC as regards indication of the ingredients present in foodstuffs. Official Journal of the European Union L308/15, 25 November 2003. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:308:0015:0018:EN:PDF. Accessed 31 Dec 2013

Anon. (2004a) Regulation (EC) No 852/2004 of the European Parliament and of the Council of 29 April 2004 on the hygiene of foodstuffs. Official Journal of the European Union L226/3, 25 June 2004. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:139:0001:0054:en:PDF. Accessed 29 Dec 2013

Anon. (2004b) Regulation (EC) No 853/2004 of the European Parliament and of the Council of 29 April 2004 laying down specific hygiene rules for food of animal origin. Official Journal of the European Union L226/22, 25 June 2004. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:139:0055:0055:EN:PDF. Accessed 29 Dec 2013

Anon. (2004c) Preventing person-to-person spread following gastrointestinal infections: guidelines for public health physicians and environmental health officers. Commun Dis Public Health 7(4):362–384. http://webarchive.nationalarchives.gov.uk/+/http://www.hpa.org.uk/cdph/issues/CDPHVol7/no4/guidelines2_4_04.pdf. Accessed 31 Dec 2013

Anon. (2005) Regulation (EC) No 2073/2005 of 15 November 2005 on the microbiological criteria for foodstuffs. Official Journal of the European Union L338/1, 22 December 2005. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2005:338:0001:0026:EN:PDF. Accessed 31 Dec 2013

Anon. (2006a) Commission Directive 2006/142/EC of 22 December 2006. Amending Annex IIIa of Directive 2000/13/EC of the European Parliament and of the Council listing the ingredients which must under all circumstances appear on the labelling of foodstuffs. Official Journal of the European Union L226/3, 25 June 2004. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:368:0110:0111:EN:PDF. Accessed 31 Dec 2013

Anon. (2006b) Commission Regulation (EC) No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs. Official Journal of the European Union. L364/3, 20 December 2006. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:364:0005:0024:EN:PDF. Accessed 31 Dec 2013

Anon. (2007a) Council Regulation (EC) No 1234/2007 establishing a common organisation of agricultural markets and on specific provisions for certain products (single CMO regulation) amended by Regulation (EC) 1047/2009 of 19 October 2009. Official Journal of the European Union L299/1, 22 October 2007. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:2007R1234:20100501:EN:PDF. Accessed 31 Dec 2013

Anon. (2007b) Commission Directive 2007/68/EC of 27 November 2007 amending Annex IIIa to Directive 2000/13/EC of the European Parliament and of the Council as regards certain food ingredients. Official Journal of the European Union L310/11, 28 November 2007. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:310:0011:0014:EN:PDF. Accessed 31 Dec 2013

Anon. (2011a) The Poultrymeat (England) Regulations 2011. The Stationery Office, London. http://www.legislation.gov.uk/uksi/2011/452/pdfs/uksi_20110452_en.pdf. Accessed 31 Dec 2013

Anon. (2011b) Regulation (EU) No 1169/2011 of the European Parliament and of the Council of 25 October 2011 on the provision of food information to consumers, amending Regulations (EC) No 1924/2006 and (EC) No 1925/2006 of the European Parliament and of the Council, and repealing Commission Directive 87/250/EEC, Council Directive 90/496/EEC, Commission Directive 1999/10/EC, Directive 2000/13/EC of the European Parliament and of the Council, Commission Directives 2002/67/EC and 2008/5/EC and Commission Regulation (EC) No 608/2004. Official Journal of the European Union L304/18, 22 November 2011. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:304:0018:0063:EN:PDF. Accessed 31 Dec 2013

Anon. (2013a) Data & trends of the European food & drink industry 2012. FoodDrinkEurope. http://www.fooddrinkeurope.eu/uploads/publications_documents/Data__Trends_(interactive).pdf. Accessed 29 Dec 2013

Anon. (2013b) Count of enterprises in the United Kingdom by selected UK SIC2007 Class (4 digit) and turnover size band. The United Kingdom Office for National Statistics. http://www.ons.gov.uk/ons. Accessed 29 Dec 2013

Anon. (2013c) Listeriosis. NHS Choices. http://www.nhs.uk/Conditions/Listeriosis/Pages/Introduction.aspx. Accessed 31 Dec 2013

Anon. (2013d) The Food Safety and Hygiene (England) Regulations 2013. http://www.legislation.gov.uk/uksi/2013/2996/made/data.pdf. Accessed 9 Aug 2014

Barrabeig I, Rovira A, Buesa J et al (2010) Foodborne norovirus outbreak: the role of an asymptomatic food handler. BMC Infect Dis 10:269. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3161355/pdf/1471-2334-10-269.pdf. Accessed 31 Dec 2013

Bell C, Kyriakides A (2005) *Listeria*—a practical approach to the organism and its control in foods, 2nd edn. Blackwell, Oxford

Bell C, Kyriakides A (2009) *Campylobacter*—a practical approach to the organism and its control in foods. Wiley-Blackwell, Chichester

BRC (2009) Food industry guide to good hygiene practice. British Retail Consortium, The Stationery Office, London

BRC (2013) Global standard for food safety. The Stationery Office, London. http://www.brcglobalstandards.com. Accessed 29 Dec 2013

Evans MR, Salmon RL, Nehaul L et al (1999) An outbreak of *Salmonella typhimurium* DT170 associated with kebab meat and yogurt relish. Epidemiol Infect 122(3):377–383

FSA (2007) Report of the Sudan I review panel. Food Standards Agency, London. http://www.food.gov.uk/multimedia/pdfs/sudanreview.pdf. Accessed 29 Dec 2013

FSA (2008) Food Standards Agency guidance on the safety and shelf-life of vacuum and modified atmosphere packed chilled foods with respect to non-proteolytic *Clostridium botulinum*. Food Standards Agency, London. http://www.food.gov.uk/multimedia/pdfs/publication/vacpacguide.pdf. Accessed 31 Dec 2013

FSA (2009) Food handlers—Fitness to work. Regulatory guidance and best practice advice for food business operators. Food Standards Agency, London. http://www.food.gov.uk/multimedia/pdfs/publication/foodhandlersireland1009.pdf. Accessed 31 Dec 2013

FSA (2014) E. coli O157 control of cross-contamination. Guidance for food business operators and local authorities. Food Standards Agency, London. http://multimedia.food.gov.uk/multimedia/pdfs/guidance/ecoli-control-cross-contamination-guidance.pdf. Accessed 9 Aug 2014

FSAI (2008) Dioxins in pork and bacon products. Food Safety Authority of Ireland. http://www.fsai.ie/news_centre/news/dioxins_in_pork_and_bacon_products.html. Accessed 29 Dec 2013

Gaze JE, Shaw R, Archer J (1998) Identification and prevention of hazards associated with slow cooling of hams and other large cooked meats and meat products. Review No 8. Campden & Chorleywood Food Research Association

Graves TK, Bradkey KK, Crutcher JM (1998) Outbreak of *Campylobacter* enteritis associated with cross-contamination of food—Oklahoma 1996. Morb Mortal Wkly Rep 47(07):129–131

Harrison WA, Griffith CJ, Tennant D et al (2001) Incidence of *Campylobacter* and *Salmonella* isolated from retail chicken and associated packaging in South Wales. Lett Appl Microbiol 33:450–454. http://webarchive.nationalarchives.gov.uk/20060715141954/bseinquiry.gov.uk/. Accessed 29 Dec 2013

IGD (2013) Online grocery retailing in France and Germany to double by 2016. Institute for Grocery Distribution. http://www.igd.com/Media/IGD-news-and-press-releases/Online-Grocery-Retailing-in-France-and-Germany-to-Double-by-2016/. Accessed 29 Dec 2013

Olsen SJ, Hansen GR, Bartlett L et al (2001) An outbreak of *Campylobacter jejuni* infections associated with food handler contamination: the use of pulse field gel electrophoresis. J Infect Dis 183:164–167. http://wales.gov.uk/ecolidocs/3008707/reporten.pdf?lang=en. Accessed 31 Dec 2013

Pennington H (1997) The Pennington Group: report on the circumstances leading to the 1996 outbreak of infection with *E. coli* O157 in central Scotland, the implications for food safety and the lessons to be learned. The Stationery Office Ltd, Edinburgh

Pennington H (2009) The public inquiry into the September 2005 outbreak of *E. coli* O157 in South Wales. The Stationery Office Ltd, London

Zhang S, Farber JM (1996) The effects of various disinfectants against *Listeria monocytogenes* on fresh-cut vegetables. Food Microbiol 13:311–321

Chapter 8
Retail HACCP-Based Systems

Jackie Crichton

8.1 Introduction

Hazard Analysis Critical Control Point (HACCP) is an internationally recognized, science-based approach to food safety that may be applied to all food sectors, from farm to retail. The HACCP approach is endorsed by the CODEX Alimentarius Commission *General Principles of Food Hygiene* and has been used by various regulatory departments and agencies, as well as by industry sectors, in the development of food safety programs.

HACCP is a proactive and preventive approach to the identification and management of food safety hazards.

There are seven principles to HACCP:

1. Hazard Analysis (biological/microbiological; chemical, including allergen; physical)
2. Identification of Critical Control Points (CCPs)
3. Establishment of Critical Limits (for each CCP)
4. Monitoring Procedures (for each CCP)
5. Establishment of Corrective Actions (for use when deviations occur)
6. Establishment of Verification Procedures (to ensure that procedures are effective and that monitoring and corrective actions are performed as per company standard operating procedures, known as SOPs)
7. Record Keeping

J. Crichton (✉)
Consultant, 3062 – 9th Conc N., Pakenham, ON, Canada K0A 2X0
e-mail: mail@jackiecrichton.ca

J. Farber et al. (eds.), *Retail Food Safety*, Food Microbiology and Food Safety,
DOI 10.1007/978-1-4939-1550-7_8

Detailed information in regard to HACCP and the seven principles is available from a number of sources including but not limited to the Canadian Food Inspection Agency—Hazard Analysis Critical Control Point (HACCP); the Canadian Food Inspection Agency—Food Safety Enhancement Program—Hazard Analysis Critical Control Points; the United States Department of Agriculture—National Food Service Management Institute—*HACCP-based Standard Operating Procedures* (*SOPs*); the United States Food and Drug Administration: A Manual for the Use of HACCP Principles for Operators of Food Service and Retail Establishments; the United States Food and Drug Administration: Retail & Food Service HACCP—HACCP & Managerial Control of Risk Factors; the United States Food and Drug Administration: FDA Food Code: Annex 4—Management of Food Safety Practices—Achieving Active Managerial Control of Foodborne Illness Risk Factors; the United States Food and Drug Administration: *HACCP Principles & Application Guidelines* (1997).

8.2 Retail HACCP-Based Systems

A HACCP-based approach has typically been applied at the on-farm and retail levels. The Canadian Food Inspection Agency—Food Safety Recognition Program provides a recognition framework that supports national, auditable, industry-led, HACCP-based food safety programs such as CanadaGAP—Food safety for fresh fruits and vegetables (on-farm).

HACCP-based, retail food safety programs have been developed by industry associations such as the Retail Council of Canada (previously the Canadian Council of Grocery Distributors) jointly with the Canadian Federation of Independent Grocers and also by the Food Marketing Institute (2003a, b) in the USA. Generally, retail HACCP-based programs will include a prerequisites section, sometimes referred to as Good Retail Practices (GRPs), and a section that includes SOPs. The lines between GRPs and SOPs may become blurred and the terms are sometimes used interchangeably. Having said this, GRPs are typically general in nature (e.g., define general practices, conditions, or requirements that are conducive to the production of safe food) while SOPs provide detailed process or product specific procedures. The process or product specific procedures outlined in a given SOP may address Critical Control Points (i.e., CCPs including critical limit(s), monitoring, and validation requirements) as well as Control Points (i.e., CPs including limit(s), monitoring, and validation requirements). In some instances SOPs may be imbedded in or linked to GRPs. Table 8.1 provides an example of the content of a GRP and a SOP. Regardless of the format or terminology used, what is most important is that the potential food safety hazards are identified and the practices or procedures to manage such hazards are documented, implemented, monitored, and verified.

Table 8.1 Example good retail practice (GRP) and standard operating procedure (SOP)

Good retail practice—preparation
Food is prepared in a manner that:
– Minimizes the risk of biological, chemical (including allergen), or physical contamination
– Minimizes the risk of temperature abuse
– Minimizes the potential for contamination or cross-contamination
– Adheres to applicable company standard operating procedures and recipes
– Complies with the requirements of the regulatory authority having jurisdiction
SOPs: (List all SOPs falling under this GRP: e.g., cooking; washing/cutting of produce; assembly; hand washing)

Date of coming into effect:		Name of writer:	
Date of previous version:		Signature of writer:	

Standard operating procedure—Hand washing	
Company:	(Insert company name)
Department:	All departments
Responsibility:	All employees
Materials:	Potable hot and cold (warm) running water; hand soap in dispenser; single use towel in dispenser; waste container
Frequency:	Ongoing (as needed)
Instructions:	All employees are trained to:
	– Wash their hands whenever they are of may be contaminated from any source. This includes but is not limited to before starting work; when entering a preparation area; after any absence from a preparation area; when switching tasks (e.g., before and after handling raw product or known allergens; when switching from one product to another); before putting on or changing gloves; after using/before leaving the restroom; after touching their hair or face; after handling garbage or recycling; etc.
	– Wash their hands using the following procedure:
	1. Turn on taps
	2. Wet hands to wrist or beyond with warm water
	3. Apply (name of the soap) from dispenser
	4. Lather for (specify the time) seconds, including palms, back of hands, between fingers
	5. Rinse off soap with warm running water
	6. Dry hands using a single use towel
	7. Turn off taps using single use towel
	8. Dispose of towel in container provided
Monitoring:	(Specify the name or position of the trained, designated employee) monitors for compliance with this SOP. Any noncompliance with this SOP is documented noting the name of the non-compliant employee and the date of the noncompliance

(continued)

Table 8.1 (continued)

Corrective action:	The non-compliant employee is re-trained in this SOP. The date of retraining is recorded
Verification:	(Specify the name or position of the trained, designated employee, or designate) verifies compliance with the requirements set out in this SOP on a (specify the frequency, e.g., annual) basis

Date of coming into effect:		Name of writer:	
Date of previous version:		Signature of writer:	

8.2.1 Hazard Analysis: Biological, Chemical (Including Allergen), Physical

Hazard analysis involves the identification of potential food safety hazards, sometimes referred to as risks, and how such potential hazards will be managed. The potential hazards that are identified may be addressed by way of prerequisite programs, sometimes referred to as GRPs, and/or SOPs.

The development of HACCP-based programs for use at retail starts with a generic hazard analysis that may be applied across multiple retail locations. The approach taken is generally process based (e.g., receiving, storage, preparation, display, checkout).

Potential hazards are grouped under three headings:

- Biological (e.g., microbiological/microbial—bacterial, viral, parasitic)
- Chemical (e.g., microbial toxins, allergens, non-food chemicals, improperly used chemicals)
- Physical (e.g., pits, metal, glass, wood, jewelry, wound coverings)

Table 8.2 provides a checklist to assist in the identification of processes that occur within a store and whether such processes are to be addressed from a total store, individual department, or product specific basis. The table can also be used as a checklist for the development of GRPs or SOPs (i.e., if the process occurs then a GRP or SOP is needed to address it).

8.2.2 Identification of CCPs

CCPs are points where an action can be taken to prevent, eliminate, or reduce a food safety hazard to an acceptable level. CCPs typically involve a "kill step" such as cooking.

Hazard analyses that have been conducted for retail have generally identified the following CCPs:

Table 8.2 Total store—good retail practices (GRPs)/standard operating procedures (SOPs) checklist

Good retail practices (GRPs)/standard operating procedures (SOPs)	Total store/department/product:		
	Total store	**Department specific**	**Product specific**
1. Store Location and Design			
– Site Selection			
– Store/Department Design			
– Renovation			
– Water Source			
– Other			
2. Sourcing and Procurement			
– Food/Ingredients			
– Packaging			
– Equipment			
– Chemicals			
– Other			
3. Temperature Control			
– Refrigerated			
– Frozen			
– Reheating (from fully cooked)			
– Cooking/Baking			
– Chilling/Cooling			
– Other			
4. Product Rotation			
5. Allergen Control			
6. Cleaning and Sanitizing			
– Housekeeping			
– Cleaning and Sanitizing			
7. Personnel			
– Practices/Hygiene (e.g., hand washing, glove use, hair containment)			
– Illness/Injury (e.g., reporting, bodily fluid spills, wound coverings)			
– Other			
8. Visitors/3rd Party Service Providers/Contractors			
9. Equipment			
– Maintenance/Repair			
– Broken Glass			
– Other			
10. Pest Control			

(continued)

Table 8.2 (continued)

Good retail practices (GRPs)/standard operating procedures (SOPs)	Total store/department/product:		
	Total store	**Department specific**	**Product specific**
11. Waste Management			
– Garbage			
– Recycling			
– Reclamation			
– Return to store (Packaging)			
– Other			
12. Crisis Management			
– Water Advisories/Boil Water Orders			
– Water Outages			
– Floods			
– Power Outages			
– Foodborne Illness Complaints			
– Infestation			
– Other			
13. Audit/Verification			
– Self Audit			
– 3rd Party Audit			
– Other			
14. Receiving			
– General			
– Ambient			
– Refrigerated			
– Frozen			
– Live (e.g., fish, seafood)			
– Other			
15. Storage			
– General			
– Ambient			
– Refrigerated			
– Frozen			
– Live (e.g., fish, seafood)			
– Other			
16. Preparation			
– General			
– Thaw and Sell			
– Portioning only (raw)			
– Portioning only (ready-to-eat)			
– Cut Fruit (in-store)			
– Juice (in-store)			

(continued)

Table 8.2 (continued)

Good retail practices (GRPs)/standard operating procedures (SOPs)	Total store/department/product:		
	Total store	**Department specific**	**Product specific**
– Portioning and assembly/mixing only (no reheating, cooking or baking)			
– Reheating (from fully cooked)			
– Cooking/Baking			
– Curing/Smoking			
– Chilling/Cooling			
– Ice Production (e.g., use in store, for sale to consumers)			
– Water Production (for sale to consumers)			
– Other			
17. Packaging			
18. Labelling/Product Information			
– On-package			
– Service case tag			
– Signage			
– Other			
19. Display			
– General			
(a) Service			
– Ambient			
– Refrigerated			
– Frozen			
– Hot			
(b) Self-serve Packaged			
– Ambient			
– Refrigerated			
– Frozen			
– Hot			
(c) Self-serve Bulk			
– Ambient			
– Refrigerated			
– Frozen			
– Hot			
(d) Self-serve Salad Bar/Buffet			
– Ambient			
– Refrigerated			
– Frozen			
– Hot			

(continued)

Table 8.2 (continued)

Good retail practices (GRPs)/standard operating procedures (SOPs)	Total store/department/product:		
	Total store	**Department specific**	**Product specific**
(e) Product Sampling (e.g., staffed, unstaffed)			
– Ambient			
– Refrigerated			
– Frozen			
– Hot			
(f) Other			
20. Checkout/Front End			
21. Product Returns/Consumer Complaints			
22. Product Recalls (including withdrawals)			
23. Training/Certification			
– Management			
– Non-management			
24. Other			
25. Other			

Note: This table is provided as an example

- Cooking/reheating
- Hot hold/hot display
- Chemical concentration if using a chemical wash for produce
- Nitrate/nitrite concentration if curing/smoking product at retail

This is not to say that there are not other points that need to be controlled. Such other points may be referred to as Control Points (CPs) rather than CCPs and include but are not limited to receiving, storage, maintenance of temperature (refrigerated, frozen); rotation; allergen control; cleaning and sanitizing; personnel practices.

8.2.3 Establishment of Critical Limits (For Each CCP)

Critical limits (CLs) are established for each CCP. CLs are the limits at which a hazard does not compromise food safety (e.g., the internal temperature that a product being cooked or reheated must reach and in some instances the time that the product must be at that temperature. See Canadian Food Inspection System Implementation Group—*Food Retail and Food Services Code 2004* Appendix B).

Limits may also apply to CPs. These may include but are not limited to maintenance of temperature (refrigerated, frozen); water temperature; and concentration of chemicals used for cleaning and sanitizing.

8.2.4 Monitoring Procedures (For Each CCP)

Monitoring is necessary to ensure that CCPs are met and within critical limits (e.g., the internal temperature of each batch of product that is being cooked or reheated is taken and recorded; the internal temperature of product that is held or display hot is taken and recorded at a set frequency).

Monitoring may also apply to CPs (e.g., the temperature of refrigerated or frozen product is taken and recorded at an established frequency; the concentration of sanitizer solution is taken and recorded at a set frequency).

8.2.5 Establishment of Corrective Actions (For Use When Deviations Occur)

In conjunction with the development of SOPs and monitoring, it is imperative that corrective actions be established for each CCP. Corrective actions are to be taken and recorded when a deviation occurs (e.g., when the internal temperature of a product that is being cooked or reheated is taken and has not reached the critical limit, the product is cooked/reheated to the appropriate end temperature and if appropriate held at that temperature for the appropriate time; when the internal temperature of a product held or displayed hot falls below 60°C it is discarded).

Corrective actions should also be established for CPs (e.g., corrective actions to be taken when a refrigerated product is found to be above 4°C; when sanitizer strength is too high or too low).

8.2.6 Establishment of Verification Procedures

Verification procedures are established to ensure that procedures are effective and that monitoring and corrective actions are performed as per company SOPs (i.e., for CCPs critical limits are met and deviations are acted on; for CPs limits are met and deviations are acted on). Verification is performed by someone other than the person(s) who is/are performing the monitoring process (e.g., department employee responsible for cooking monitors and records internal product temperature along with any necessary corrective action(s) and the department manager verifies that this has been done correctly by the employee).

8.2.7 Record Keeping

Records are maintained as proof that applicable limits have been met, whether for CCPs or CPs, and that corrective actions have been taken when appropriate, as per company SOPs.

Such records may be of value in the event of consumer complaints, foodborne illness investigations, or other interactions with government inspectors.

8.3 Good Retail Practices and Standard Operating Procedures

GRPs and SOPs are written based on, or in conjunction, with the Hazard Analysis. An example GRP and an example SOP are provided in Table 8.1.

8.4 Preventive Control Plans

PCP is a relatively new term that has been introduced by a number of governments. See Canadian Food Inspection Agency—Guide to Food Safety and Canadian Food Inspection Agency—Improved Food Inspection Model—*Proposed Draft RDIMS # 3349307 Section 4.2*.

The *Improved Food Inspection Model—Proposed Draft* lists the following elements as part of a PCP:

- Physical structure and maintenance
- Equipment design and maintenance
- Employee hygiene and training
- Sanitation and pest control
- Product/process control
- Transportation and storage
- Traceability and recall
- Company verification process

PCPs have been described, by some, as a HACCP or HACCP-based approach to food safety plus additional documentation to demonstrate compliance with all applicable regulations (e.g., labelling, standards of identity, grade).

8.5 Training

Management commitment is key to the successful implementation of HACCP-based programs and PCPs at retail. This includes a commitment to ongoing training of employees, both at the management and non-management level. All employees should be trained to fulfill the requirements of their job function. At a minimum, training should include training in the SOPs that an employee is responsible to carry out at store level. It is recommended that employees also be trained, and in some instances certified, in safe food handling practices. A company's SOPs provide details in regard to "what" and "how" something is to be done while safe food handling courses provide the "why" (e.g., some of the science) behind the "what" (e.g., the potentially far-reaching consequences of not adhering to SOPs). Additional information on Training is provided in Chap. 10.

8.6 Conclusion

HACCP and HACCP-based approaches to food safety have been implemented internationally and are applicable to all food sectors, including the retail sector.

There are numerous generic, HACCP-based food safety programs available for implementation at retail. Such programs are adaptable to specific retail company or retail location use.

Examples of readily accessible programs and additional information on HACCP and HACCP-based programs are provided in the references section of this chapter.

Training is key in the successful implementation of HACCP-based retail food safety systems and the delivery of safe food to consumers.

References

CanadaGAP—Food safety for fresh fruits and vegetables (on-farm). http://www.canadagap.ca

Canadian Food Inspection Agency—Food Safety Enhancement Program. Hazard analysis critical control points. http://www.inspection.gc.ca/food/fsep-haccp/eng/1299855874288/1299859914238

Canadian Food Inspection Agency—Food Safety Recognition Program. http://www.inspection.gc.ca/food/fsep-haccp/food-safety-recognition-program/eng/1299860970026/1299861042890

Canadian Food Inspection Agency—Guide to Food Safety. http://www.inspection.gc.ca/food/non-federally-registered/safe-food-production/guide/eng/1352824546303/1352824822033

Canadian Food Inspection Agency—Hazard Analysis Critical Control Point. http://www.inspection.gc.ca/about-the-cfia/newsroom/food-safety-system/haccp/eng/1346306502207/1346306685922

Canadian Food Inspection Agency—Improved Food Inspection Model—Proposed Draft RDIMS # 3349307. http://www.inspection.gc.ca/dam/dam-aboutcfia-sujetacia/STAGING/text-texte/acco_modernization_modeldraft_1344008567583_eng.pdf

Canadian Food Inspection System Implementation Group. Food retail and food services code 2004. http://epe.lac-bac.gc.ca/100/206/301/cfia-acia/2011-09-21/cfis.agr.ca/english/indexe.shtml; http://epe.lac-bac.gc.ca/100/206/301/cfia-acia/2011-09-21/cfis.agr.ca/english/regcode/frfsrc-amendmts/codeang-2004.pdf

CODEX Alimentarius—General Principles of Food Hygiene. www.codexalimentarius.org/input/download/standards/23/CXP_001e.pdf

Food Marketing Institute (FMI) (2003a) A total food safety management guide. A model program for category: raw sold as ready to eat product: fresh-cut produce

Food Marketing Institute (FMI) (2003b) A total food safety management guide. A model program for category: raw, sold ready to cook product: ground beef

Retail Council of Canada—Grocery Division. Food safety and labelling. http://www.retailcouncil.org/grocery/food.asp

United States Department of Agriculture—National Food Service Management Institute. HACCP-based Standard Operating Procedures (SOPs) http://sop.nfsmi.org/HACCPBasedSOPs.php

United States Food and Drug Administration—A manual for the use of HACCP principles for operators of food service and retail establishments. http://www.fda.gov/Food/GuidanceRegulation/HACCP/ucm2006811.htm

United States Food and Drug Administration: FDA Food Code 2009: Annex 4—Management of food safety practices. Achieving active managerial control of foodborne illness risk factors. http://www.fda.gov/Food/GuidanceRegulation/RetailFoodProtection/FoodCode/ucm188363.htm

United States Food and Drug Administration. HACCP Principles and Application Guidelines (1997) http://www.fda.gov/Food/GuidanceRegulation/HACCP/ucm2006801.htm

United States Food and Drug Administration: Retail & Food Service HACCP—HACCP & Managerial Control of Risk Factors. http://www.fda.gov/Food/GuidanceRegulation/HACCP/ucm2006810.htm

Chapter 9
Sanitation and Sanitation Issues at Retail

Thomas Ford and Amy Opper

9.1 Sanitizing and Cook Steps are the Only Kill Step at the Retail Level

Food safety at retail is intimately tied to the ability to effectively sanitize the equipment and surfaces within the store environment. The food production, handling, and merchandizing operations conducted in a typical grocery store really only provide two opportunities to eliminate or reduce microbial contaminants: cooking and sanitizing. Foods prepared within the store that receive a cook step, such as rotisserie chicken, take a product that is potentially harboring a pathogen, and eliminate that pathogen from the food rendering it safe for consumption. Applying an effective sanitizer to a properly cleaned surface reduces pathogens in the retail food environment to a safe level. A retailer must align their thinking and their support of the cleaning and sanitation program, as they do the cooking process of their products that are manufactured at the retail level. These steps are critical because the risks are right within the retail departments themselves.

9.2 The Right Procedures

Using the *right procedure* really means following the Standard Sanitation Operating Procedure (SSOP), which is a written and active document. The SSOP procedures are specific for each piece of equipment or area to be cleaned, and are written so they can be understood and executed by the store level associate. SSOPs should be validated microbiologically under the anticipated soil type and level expected during use.

T. Ford, M.P.H. (✉) • A. Opper, R.E.H.S.
Food Safety, Ecolab, 7900 McCloud Rd., Suite 200 Greensboro, NC 27409, USA
e-mail: Tom.ford@ecolab.com; Amy.opper@ecolab.com

J. Farber et al. (eds.), *Retail Food Safety*, Food Microbiology and Food Safety,
DOI 10.1007/978-1-4939-1550-7_9

An SSOP should be created for each piece of equipment and surface within the department, therefore a department would have a full portfolio of SSOPs, as well as a corresponding schedule of when each SSOP should be executed. The frequencies of SSOP execution may be based on the regulatory standard by which the facility is governed (such as the Food Code in the US) as well as the retailers' experience and/or production load. For instance, some items, such as utensils, might be cleaned on an as needed basis. Others, such as food contact surfaces used at ambient temperatures (a deli slicer), may be on a wash, rinse, sanitize frequency of every 4 h. Other areas and surfaces may be on daily, weekly, or even monthly cycles. Every surface or piece of equipment should be evaluated by the retailer as to its use and food safety risk and placed on a SSOP cycle as necessary.

Once an SSOP is created, it should be evaluated to ensure it is effective for the device or surface before it is put into use. This would ideally mean an evaluation in a laboratory setting, using the typical soil the retail environment would encounter. The evaluation should identify points and locations where soil may build up or create harborage points where microbes may accumulate. The SSOP should be written and evaluated to address the removal of the likely soil to be encountered, but also determine if there is a potential for the soil to accumulate or be driven into areas where it will subsequently be difficult to remove. Additionally, the procedure should be evaluated to assure it is effective at a microbiological level. The purpose of a cleaning and sanitizing step is to reduce microbes from the item being cleaned and sanitized, and therefore laboratory testing is an appropriate way to evaluate the effectiveness of the SSOP.

When testing the effectiveness of an SSOP, equipment should undergo a challenge study, where a soil and pathogen (such as *E. coli*) matrix is applied to the equipment, the SSOP is executed as written, and the equipment surface is swabbed to determine if the microbes have been removed. It may be necessary for the retailer to work with the equipment manufacturer to redesign or reconfigure the equipment to assure the SSOP is effective both from a soil removal standpoint, but also from a microbiological perspective. Finally, the SSOP should be evaluated from a standpoint that it can and will be executed by the store level associate on the scheduled frequency.

9.3 The Right Tools

The cleaning and sanitizing procedure, especially for equipment, may require the use of tools. These may be tools to disassemble the equipment to facilitate cleaning, but also tools to be used in the execution of the SSOP itself. The appropriate cleaning tools should be listed as a part of the SSOP and be available for use by the associates in the store at all times.

Tools required to disassemble equipment should be easily accessible to the associate designated to conduct the procedure and may have to be washed, rinsed, and sanitized themselves prior to or after use. Tools for cleaning (such as brushes, squeegees, brooms, etc.) need to be constructed of materials that are impervious, durable, and conducive for the food environment. They should be washed, rinsed, and sanitized prior to use and removed from use when they are no longer in a condition that facilitates the execution of the SSOP such as when they become broken, damaged, not able to be easily cleaned, etc.

Tight areas and gaps may require a brush or other item to adequately access them for cleaning. Cleaning tools such as brushes should be specific to the task and procedure, ideally of the size, shape, bristle length, etc., to achieve the removal of soil from the surface. They should only be used for the procedure they are designated for and not taken to other areas, departments, or used for other tasks that may cause them to become contaminated.

9.4 The Right Chemistry

Soil conditions, facilities, and the human factor should be considered when determining what chemistries should be used for cleaning and sanitizing.

The chemistry should match the soil found in the department. Soils are department specific, such as fats and proteins in a meat department; carbohydrates in a bakery department; and carbohydrates, fats, and proteins in a deli department. Every attempt should be made to work with a chemical provider to provide cleaning components that do not require personal protective equipment (PPE) and should be safe to use in their diluted form. Store associates have multiple activities to perform daily; they are not specifically cleaning and sanitation specialists. Therefore, the retailer should make the effort to procure cleaning and sanitizing agents that are both safe *and* effective for use.

Regulatory agencies may specify the type of sanitizers that are allowed in a jurisdiction. The 2009 Food Code, for instance, states three categories of sanitizers that are allowed: quaternary ammonium, chlorine, and iodine. Once again, the retailer should work with a reputable cleaning and sanitizing company to identify which cleaning and sanitizing products work best in the specific department and conditions to be encountered. Sanitizers should be registered as effective with an appropriate government agency (such as the Environmental Protection Agency in the US). Registration will prescribe how and where the product should be used and what pathogens it is registered as effective against. The retailer should identify if there are specific pathogens of concern to them, and ideally, they should seek out sanitizers that have that registration.

Using the sanitizer as directed on the label is key. The label is a legal document and if the product is not used in accordance with the label directions, the registration can be jeopardized. Using a sanitizer at a level above that which is stated on the label should never be attempted.

9.5 The Right Person

Perhaps the most important component, and the one with most variables associated with it, is the associate who conducts the cleaning step. As we have described earlier in this chapter, there certainly is a science behind cleaning and sanitizing, but the science ultimately has to be applied by a person.

A large-scale production facility is comprised of materials to be cleaned that are extremely durable and typically employs dedicated cleaning crews. Having such specialized equipment and cleaning crews allows for the ability to use more aggressive chemistries. A grocery store, on the other hand, uses a wide range of materials, has a crew that performs every task in the department (food production, customer service, and cleaning and sanitation), and therefore the chemistries used must be safe for a multiplicity of surfaces, soils, and most often, do not require the use of PPE.

For all of these reasons, the role played by the associate is critical to the cleaning and sanitation process. In order for the process to be effective, the retailer must be able to select the right person to perform the tasks, the person has to be properly trained, all obstacles to successfully completing the process have to be identified and removed, and the procedure has to be executed correctly and evaluated in order to determine if it has been successful.

9.6 Identifying the Right Person

As was stated, the grocery store associate is not tasked with cleaning and sanitation as their sole responsibility. In fact, from an operational standpoint, one can state that the departmental associate's top two priorities are the serving of the customer and the production/merchandizing of the food sold in the department. Sanitation then must be built into the daily tasks of the associate, both between serving the customer and making of the food, but also as scheduled by the SSOP. Therefore, an important step a retailer must take is identifying the SSOP tasks that should be conducted, and aligning them with the most appropriate associate within the department.

Factors that should be considered in identifying the right person for the individual SSOP are the SSOP itself, the expected customer flow throughout the day, and the training and skill set of the associate. As we have discussed, in the USA, the SSOPs are based on the Food Code requirements, the EPA requirements, and times of day when major cleaning tasks can be executed. For instance, in the deli department, food contact surfaces such as a slicer must be cleaned every 4 h throughout the day, therefore a deli worker working the daytime shift must be trained to fully wash, rinse, and sanitize the slicer. In contrast, a deli worker that is closing the department might be trained on closing SSOPs such as cleaning the fryers, floors, walls, ceilings, and other more invasive procedures that can be conducted when there is no food preparation being conducted.

9.7 Training the Associate

Perhaps the most important step in the cleaning and sanitation process is the training of the associate. The task of cleaning and sanitizing can only be successfully completed if the associate is motivated to conduct cleaning and sanitation in an effective and consistent manner. Therefore, a training program must incorporate a motivation component. An associate will conduct a process because he or she is told to, but will conduct it more effectively and consistently if they *want* to.

9.7.1 Setting the Associate Up for Success

Several obstacles can become inadvertently set in front of the store level associates that may hinder them from being able to successfully clean and sanitize the departments they are assigned to tend. It is the role of management to set up the associates for success, as opposed to making their tasks more difficult. A new product or menu item that is produced on a piece of equipment that is difficult to disassemble or has portions that are inaccessible can limit the chance of success for the associate to adequately clean the equipment. Even pieces of equipment that do come apart, but have components that are simply too large to fit into a three compartment sink, provide challenges that store level associate should not be forced to overcome. Just because management has driven a program down to the store level without fully exploring all the tasks the store personnel will have to comply with, it should not result in a compromised sanitation program.

Chains that are most successful in their sanitation programs have done the best at exploring all the aspects and challenges created when implementing new products and food programs. They have fully identified the SSOP, how it will be conducted and by whom within the department, and how and where the equipment and utensils will be cleaned. Lastly, but certainly an important factor, is that management has assessed the labor requirements for the production and cleaning and sanitation portions of these new programs and assigned the labor to cover these two aspects of the program. If management has not done their homework and fully vetted the financial benefit as well as the labor and manufacturing costs of the program, they will certainly be setting up the associate for failure.

The merchandising teams that create the menus and how those items are stored, prepared and held for sale are key players in allowing the store teams to be successful in cleaning and sanitizing, and therefore creating safe food.

9.8 Execution of the Procedure

Thus far, this chapter has covered a lot of information and discussed much around the topic of cleaning and sanitation. Now we will cover the actual execution of the cleaning and sanitizing steps, which all revolve around the Three Step Method, whereas each step in the process is equally as important as the other and must be followed in the proper order every time it is executed.

The Three Step Method is the action of washing, rinsing, and sanitizing a surface. Bacteria are killed if they are exposed to an adequate concentration of sanitizer for the proper amount of contact time. This cannot happen effectively in a retail environment until the first two steps have taken place. First, the soil must be removed. This is typically done by removing any large debris and then using a detergent to remove the visible soils. The next necessary step is rinsing. Fresh water should be used to rinse away the soil that has been captured by the action of the detergent. Rinsing is also important in another regard, in that the chemistry of the detergent may impact the ability of the sanitizing agent to be effective against the microbes it has been designed to destroy.

Once the soil has been broken down, bound into a solution and rinsed away, a sanitation step can occur. Application of a sanitizing compound, at a strength/concentration and for a contact time that is listed on its label, is the reduction step that was described earlier in this chapter. This reduction step, the last of the three steps, is the key to cleaning and sanitizing at retail and therefore food safety.

9.9 Measurement of the Effectiveness

Too often, the cleaning and sanitation process is left off or forgotten entirely when stores are measuring the success of their business. Often times, associates are not held accountable for a task due to a lack of oversight verifying that the task has been conducted. Management, who has provided the resources (labor dollars, cost of tools and products, training costs) should expect some sort of assurance that their investment has provided the return they expected.

Observation is the most common and cost-effective method to measure the effectiveness and successful completion of the cleaning and sanitation step. The person observing could be a member of the store management team or even an empowered associate, who provides a review of the areas and equipment that were supposed to be cleaned and sanitized. Through observation of the areas, they will be able to note whether they appear to have been cleaned and sanitized correctly. This observation can also come from a third-party provider.

An extremely effective check and balance program that can be efficiently put in place is one in which store level associates are responsible for daily cleaning and sanitation verification possibly with the use of a logging system. Logging daily cleaning activities can assure that the items and surfaces individual associates have been assigned to clean have actually been achieved. A third-party company coming in on a longer cycle, say monthly, can validate that the daily oversight is being conducted and that the daily oversight program is effective. This third party may also be a training arm, training store associates to a standard, training new associates as they come onboard, and retraining existing associates if the daily SSOPs are deemed to have drifted away from the desired level.

9.10 Validation Methods: Microbiological, Adenosine Tri-Phosphate, or Other Methods

A more advanced method of validation/verification can include the use of technological methods to evaluate the effectiveness of the cleaning and sanitation steps. Three of the most likely to be encountered are microbiological swabbing, swabbing for the presence of Adenosine Triphosphate (ATP), or swabbing for the presence of some other residual component, such as a protein, soil, or allergen.

Microbiological analysis is obviously the best indication if the cleaning and sanitation step was truly effective. If the goal of cleaning and sanitizing is to remove and destroy bacteria, the best way to determine that would be to actually swab for their presence. Doing so as a standard practice on a daily basis is not feasible or necessary, and it is costly and logistically challenging. However, conducting a microbiological analysis at strategic times can be very useful in providing a corporate level perspective of the effectiveness of the cleaning and sanitizing program. Chains can use microbiological analysis on a nonregular basis to identify challenges in areas within certain departments, during specific operations, or even within certain geographical areas. It is not necessary to explore whether specific pathogens are present. Identifying total counts present, or the presence of coliforms, or yeasts and molds, can be sufficient to confirm if the cleaning and sanitizing step was successful.

9.11 Corporate Buy-In

Perhaps the most important aspect for the success of a cleaning and sanitation program in retail stores is the support from upper management. One can argue from a management's perspective that a store level associate has three major job functions: (1) to serve the customer; (2) to produce food for sale; and (3) to perform the cleaning and sanitation duties within the department. Obviously, the first two functions may take precedent over the third. It is the role of management to assure that all three functions are supported and given equal resources to allow them to be completed.

Two factors from a management level can impact whether the store level personnel can effectively maintain a sanitation program: resources and time. The sanitation program needs to be supported from a resource perspective. The store needs the correct tools and materials to conduct the program. Partnering with a chemical sanitation provider is often the manner by which a retailer can provide both the overall tools and products to properly support the store team in preparing to conduct the program. Challenges to the proper execution often come from other aspects that management may or may not knowingly place as an obstacle to the store team. Providing the structure of the cleaning and sanitation program for the stores is only half of the equation for success; the other is providing the time and manpower to perform the tasks. Labor or lack thereof is most often cited by store level associates as reasons for inadequate sanitation levels at the retail level. If the SSOPs of a given department with a retail store are evaluated through a time and motion study, the retailer would be able to identify exactly how many labor hours are required by the plan each day.

9.12 Summary

In a grocery store environment, the retailer is serving the customer both literally and figuratively. The grocery business is set up on service to the customer: from preparing the food, merchandizing the food, and serving it to the customer. However, they also serve the customer in another way. When a customer shops at a grocery store, the customer expects more than the service described; the customer expects to be served safe food. The service the retailer provides is not complete unless it involves the service of safe food. As described in this chapter, the retail environment and the products sold within it can be fraught with microbiological challenges. It is the role and responsibility of the retailer to minimize the food safety risks, both throughout the supply chain of the food it acquires, but also as it is handled and stored at the retail level.

Options for the elimination or reduction of microbial risks at the store level are few; cooking foods to a bactericidal level is one method and sanitization is the other. In reality, when compared to the thousands of foods offered for sale in a grocery store, very few foods are actually cooked at store level. Cleaning and sanitizing, therefore must be seen as an important tool the retailer can use to provide safe food. A successful cleaning and sanitation program for retailers must have many things go right: the right procedures, the right tools, the right chemistry and the right person. The management must support the whole program, both from a philosophical position but also from a financial one. Management must understand how the merchandizing schemes they set for the stores to follow may impact cleaning and sanitizing, and therefore food safety. They must provide the tools, time, labor and oversight for the store teams to achieve the goal of a clean and sanitary store. Ultimately, it is the job of management to set the store up for success.

Chapter 10
Retail Food Handler Certification and Food Handler Training

Oscar P. Snyder, Jr.

10.1 The Food Safety Problem

Customers who purchase food from food markets expect to be able to purchase food that will not cause illness or injury, and customers who dine out expect to be fed wholesome, safe food as well as food that lives up to its quality/sensory expectations. Nonetheless, according to Roberts et al. (2008), 59 % of foodborne illnesses can be traced to restaurant operations, and foodborne illness continue to be a significant problem. In 2011, the CDC (Centers for Disease Control and Prevention) estimated that about 1 in 6 Americans (approximately 48,000,000 people) are made ill annually by foodborne illness; almost 128,000 are hospitalized; and over 3,000 die (Scallan et al. 2011a, b). The total annual health-related economic burden of foodborne illness is $77.7 billion, as estimated by the CDC (Scharf 2012).

One foodborne illness caused by employee error can be costly and ruinous to a retail food business and its reputation due to any subsequent litigation, unwanted media attention and publicity, and loss of customers. Hence, proper training in, and performance of, correct procedures that develop into habitual behaviors are key to the protection of the business and the avoidance of a business disaster.

10.2 Training for Safe Food

Food production and acquisition have changed greatly over the years. Retail food establishments—to include the supermarkets and restaurants—have become the main source of food for consumers, providing them increasing variety and

O.P. Snyder Jr., Ph.D. (✉)
SnyderHACCP, P.O. Box 13734, Roseville, MN 55113, USA
e-mail: pete@snyderhaccp.com

J. Farber et al. (eds.), *Retail Food Safety*, Food Microbiology and Food Safety,
DOI 10.1007/978-1-4939-1550-7_10

convenience, offering consumers new benefits as well as food safety risks. One of the foundations of the retail food industry is protecting consumers from the significant hazards in the food coming from the land farms and water farms. Food safety has increasingly become a focus for regulatory officials and the retail food industry, and an increasing concern for consumers as they receive news and information through various media about foodborne illness outbreaks and incidents and food recalls.

It is widely considered that, in order for retail food safety programs to be effective, retail food establishment personnel, particularly managers, must be knowledgeable about food safety principles, policies, and procedures. Many states have mandatory food manager certification, while others have voluntary manager training.

Training for food handlers has not received as much regulatory attention, but the trend seems to be for jurisdictions to consider it to be relevant to the production of safe food. Nonetheless, the concept of food handler training, whether by regulatory officials or trained managers, is not new. Jackson (1954) cited that public health food service training began as long ago as in 1938, with Texas leading the way. Later, with aid from the Public Health Service, many states and other jurisdictions strove to teach food workers basic principles of health and sanitation applicable to their jobs. In his chapter, Jackson (1954) called for uniform regulations and industry sanitation programs, mutual cooperation and understanding between regulatory officials and food managers, and educating the industry. In addition, he stated that managers and employees alike need to understand the significance of foodborne illnesses and their prevention; know how to clean and care for equipment and the sanitization of utensils; receive instruction in pest control; and have "practical knowledge" of the care and storage of food, including refrigeration, and basic personal hygiene.

The 2009 FDA Food Code (FDA 2009c) identifies the Person(s) In Charge (PIC) as the person(s) in the facility who is committed to implementing correct policies, procedures, and standards. This presence of a trained manager or PIC, as mandated in several states, is accomplished by the manager or PIC obtaining some form of training, passing a test, and receiving a food manager certification, typically from the state's health department. The Conference for Food Protection has identified the learning outcomes for this training, and the leading manager/PIC testing companies (e.g., National Restaurant Association's ServSafe; Prometric; National Registry of Food Safety Professionals) use these outcomes to develop standardized tests.

While manager/PIC training and certification are thought to be a part of an effective food safety program, common sense also suggests that food worker/handler training will improve task performance and reduce foodborne illness and outbreaks (Hammond et al. 2005). A typical employee training program at a retail food facility would have in place, for instance, regular training sessions, to include training of new employees and then, continuing education at least annually, with onsite coaching as needed, for all employees, whether they be food handlers, service staff, or maintenance. Several states and jurisdictions have already mandated food handler training or have added the requirement for food handlers to earn a food card. They include: Florida, South Dakota, Washington, Arizona, Texas, and California

(Nakamura 2011). Also, there is interest in some jurisdictions (e.g., Kansas City, New York state, Minnesota) to collect data and study the effectiveness of these programs (Hammond et al. 2005; NEHA 2011).

Ultimately, a food establishment's success is due to its employees—the food handlers, food preparers, and service personnel—who prepare food products and provide services to their customers. Companies that focus on profits first and do not focus on providing a "culture" that allows employees to carry out their tasks with "zero defects" will not survive (Snyder 1994).

10.3 Education Versus Training

In order to describe what is food handler training, let's examine first the meaning of "education" and "training." While "education" encompasses society's transmission of knowledge, customs, values, and skills from one generation to another, particularly through systematic instruction provided by schools and universities, "training" concentrates on teaching people particular skills or types of behavior and competencies to bring them to a specific standard of proficiency. This performance-based instruction is aimed at improving people's capabilities as related to competencies required for correct performance of their jobs. (See "Education", "Training" references.) As related to food safety training, education could include information about foodborne illness and the biological, chemical, and physical hazards, regulatory requirements, company policies, etc., and training would be focused on the doing of specific tasks and procedures, perhaps on a one-on-one basis or by demonstration and hands-on practice.

Roberts et al. (2008) state that the learning experience for both managers and food handlers should include not only the HOW (training) but the WHY (education) correct food safety practices must be followed. Knowing the job is not the same as doing the job. If trainers do not give out information and communicate with their trainees (education) before they allow them to practice and build skills (training), there could be problems (Schier 2006). Knowledge alone does not guarantee improvement in behaviors.

This chapter will use the word, "training" to indicate the education/training process of teaching validated safe food handling procedures to employees who are responsible for carrying out these procedures so as not to cause customer foodborne illness or injury.

10.4 Training and Behavioral Change

In the past, the two major foodborne illness risk reduction methods have been (1) regulatory inspections and (2) training. However, neither inspection nor training has been shown to have satisfactory impact on the reduction of foodborne illness in retail food operations. If food safety is to improve, the way that food workers do their tasks—their behavior—needs to change (Yiannas 2010). In addition, Neal et al. (2012) suggest that mandatory food handler training does not necessarily ensure improved behavior.

10.4.1 Training Tools

It is not clear which instructional methods for food handler training have led to long-term, consistent improved practices and reduced incidents of customer foodborne illness. What, then, are some instructional methods or models that have the potential to produce long-term positive food handler behaviors?

First of all, it is suggested that when skills are taught, active learning—not merely lecture—stimulates thinking and improves knowledge retention (NEHA 2011). A combination of teaching-learning presentation modes and materials would provide the most variety and interest in the subject matter. Depending on the size of the food operation and availability of teaching materials and aids, the manager/PIC could train his or her new or current employees one-on-one or as a small group, or by type of task or department (e.g., deli preparation, bakery, meat preparation). Training could include self-instruction whereby the manager/PIC would provide the food handler with a textbook, prepared booklet, or other training materials. The food handler could be directed to take an online course. Hands-on demonstration training, whereby the instructor shows how a task is done and then, it is done by the food worker in the way it was taught, is a useful technique, particularly if language is a barrier and there are no resources for teaching in multiple languages. Visual aids (e.g., flip charts, photos, props, DVDs/videos, PowerPoint presentations) are also widely used as training tools and add visual interest. Any or all of these tools can be used to provide instruction.

10.5 Training to Mastery and Behavioral Change

In order for a food safety program to have any control of the foodborne illness-causing hazards in a facility, the food workers who actually carry out the hazard control procedures must be trained to mastery before they are allowed to handle or prepare food so that their actions never cause a customer foodborne illness or injury. Performing tasks to prepare food safely is a learned behavior, and when this behavior becomes a habit, the opportunity for the food handler to make a mistake and cause a foodborne illness or injury is reduced. Any person who is not trainable should be released. The PIC should not accept excuses such as, "I forgot" (Snyder 2002).

Neal et al. (2012) suggest that traditional approaches to employee food safety education and training may not be very effective, but that with behavioral approaches to training, whereby training is part of the facility's culture that encourages correct food safety behaviors, food handlers may be able to reduce the risk of foodborne illness outbreaks. Up to now, little research has been done to study food safety culture, but some food safety and industry professionals feel that this should be studied (Neal et al. 2012).

The process of changing behavior can be difficult and complex, as well as stressful, and it is inevitable that some people will resist change. To those who are being instructed in tasks that require a change in behavior, it means additional work, facing the unknown, and giving up something that seems right (Krause 1997; Yiannas 2010). How long does it take for a learned behavior to become a habit? It has been considered that, after 30–40 times, or after about 21 days, a behavior will become a habit. However, Lally et al. (2010) suggested that the process of habit formation varies greatly from person to person (18–254 days), and it may take a very long time. This should not, however, be a deterrent to training new employees and continued coaching of current employees so that learned tasks become habits.

10.6 Behavioral-Based Food Safety and the Food Safety Culture

10.6.1 Food Safety Culture

There has been increasing interest in the association between the ability of a retail food establishment to operate in a manner that decreases the risk of customer foodborne illness and the food safety "culture" (i.e., "the way we do things around here") of the establishment.

Every person in the organization has a personal responsibility for safe food preparation and service, and the organization as a whole shares the responsibility of ensuring safe food. How a retail food establishment carries out its safety policies, procedures, and standards—how it "does safety"—depends on its food safety culture. The facility's culture influences how people in the group think about food safety, their attitudes, and their ability and willingness to share their opinions. In other words, the culture influences the emphasis that the organization places on food safety.

Food handlers' sense of responsibility toward their learned tasks and the effect that their actions can have on the safety of their customers is important, because their actions affect the risk of foodborne illness outbreaks. Data collected by Neal et al. (2012) indicate that the development of a food safety culture in retail food establishments depends on: (1) management commitment and (2) employee food safety behavior. They further explain that attitudes and beliefs about an organization's food safety culture depend on leadership and motivation of the management, the manner in which food safety is communicated to workers, and how well workers trust what management tells them. Employees want management consistency, accountability, and involvement. Specifically, food workers want management to:

(1) continually emphasize and keep employees focused on food safety, even during busy times; (2) check to ensure that employees are properly carrying out their food safety tasks; (3) provide adequate food safety tools; and (4) follow its own food safety rules and visibly support the culture.

10.7 Behavior-Based Management

10.7.1 ABC System

The ABC system of behavioral management described by Krause (1997) and Snyder (1994) is based on the performance model of **A**ntecedent-**B**ehavior-**C**onsequence. This applies to all levels of a company's personnel, to include the CEO, manager, supervisor, and employees. It is important to consider that, typically, people do not change behavior unless it makes a difference to do so. While both antecedents and consequences have influence on behavior, antecedents indirectly influence behavior in that they serve to predict consequences, and consequences have a more direct influence. The effect of a consequence is based on the following three factors (Krause 1997):

1. *Timing*: If the consequence follows immediately after a behavior, such as a compliment from the supervisor to a food worker immediately following a task done correctly, it has a more powerful effect than if it comes later.
2. *Consistency*: If the consequence is expected and certain, it is more powerful than if it is variable or unpredictable. If a manager reinforces correct behavior by coaching employees who are performing a task incorrectly, their behavior is expected to change. However, if there is no follow-up or additional coaching for an incorrect performance that is repeatedly observed, there is no expectation by the employee that the correct behavior is really important or needs to be done.
3. *Significance*: A positive consequence has a more powerful influence than does a negative consequence. A compliment is more likely to generate a feeling of well-being and willingness to work hard, whereas a criticism may be felt to be unjustified or hurtful.

These three factors should be kept in mind when designing a training session and, importantly, when a food handler performs tasks as he or she was taught and deserves a compliment, or when coaching is needed if a task is observed being done incorrectly.

10.8 Behavior-Based Food Safety Management System

While identifying what food safety best practices for a specific food establishment may be useful and should be included in its food safety training program, that alone it is not the culture, and it is not the system. The term, "food safety management system," is typically a well-defined process-focused system that has prerequisite programs concerning the description of the (1) overall system (basic information, organization structure and job assignment, facility floor plan, large equipment, menu list, etc.); (2) management (food safety policies, procedures, and standards, record keeping, personnel training, etc.); (3) personal hygiene; (4) sanitation (cleaning, sanitizing, and maintenance of the facility), pest control; (5) supplies and qualified suppliers; and (6) Good Manufacturing Practices (GMPs). It can also include a science-based Hazard Analysis and Critical Control Points (HACCP) program and plan for food preparation, and plans for recall, etc. Such a program is critical to a food safety culture (Yiannas 2010).

The model for continuous quality improvement for a behavior-based system is as follows (Yiannas 2010): Expectation → Education and training → Communication → Goals and accountability → Measurement → Reinforcement.

10.9 Active Managerial Control and HACCP

The FDA Food Code's Annex 4 (FDA 2009a) states, "The common goal of operators and regulators of retail and food service establishments is to produce safe, quality food for consumers." Regulatory inspections historically have served to recognize and correct food safety violations that were observed during the inspection. Those violations have been handled via re-inspections and enforcement actions such as fines and closures—a reactive approach to food safety. However, while operators may correct the violations, they do not always put in place control systems to prevent recurrence.

Various government reports uphold that operators take a more proactive approach that involves the implementation of Food Safety Management Systems that are capable of preventing, eliminating, or reducing the occurrence of foodborne illness risk factors in order to reduce foodborne illness in retail food establishments. This is done by Active Managerial Control (AMC), which is defined by the FDA (2009a) as "the purposeful incorporation of specific actions or procedures by industry management into the operation of their business to attain control over foodborne illness risk factors." Two FDA reports (2000; 2009b) list five risk factors that are directly related to food safety concerns in retail food establishments.

1. Food from unsafe sources
2. Poor personal hygiene
3. Inadequate cooking
4. Improper holding temperatures
5. Contaminated equipment/protection from contamination

If the expectation of food handler training is to protect consumers' health by control of biological, chemical, and physical hazards in food, a reasonable training plan would include knowledge of these risk factors and the hazards associated with them and ultimately, practical training in how to perform validated hazard control procedures in order to develop habitual behaviors that protect public health.

It is apparent that the FDA supports training of all personnel, including food handlers, as a part of AMC, but it also supports the use of HACCP with AMC programs. The FDA Food Code's Annex 4 (FDA 2009a) describes at length and aligns AMC with HACCP principles for the identification, evaluation, and control of the biological, chemical, and physical hazards that are likely to cause foodborne illness or injury when they are not controlled. Therefore, the FDA points to HACCP programs as having the capability of ensuring the prevention, elimination, and reduction of hazards in a food before it reaches the customer.

The FDA (2009d) sets out to measure the effectiveness of the US retail food industry in the USA to control foodborne illness risk factors. As a result of this study, the FDA recommends that the retail food industry use AMC of foodborne illness risk factors and recommends that the industry: (1) develop and implement Standard Operating Procedures (SOPs) that incorporate critical limits and measureable standards; (2) train employees and provide proper equipment to enable them to carry out the SOPs; (3) establish monitoring procedures for critical processes and procedures; and (4) identify ways to regularly assess the SOPs' effectiveness.

10.10 Food Handler Training and the Facility's Culture

Just as a food safety culture is key to successful management of a food establishment, training, particularly as a prerequisite program to AMC-HACCP, is key to the success of the culture. The content of initial training and continuing education would include critical controls from the FDA Food Code and/or state and local regulations. Instruction in employee tasks would be based on the food establishment's scientifically correct and validated policies, procedures, and standards. The information and tasks to be learned need to be clearly presented in an understandable way, and those tasks need to be achievable.

The training program, based on the current emphasis on behavioral management, would include the WHY, not just the HOW, and needs to encompass what happens after the initial training. This means, employees—and supervisors—are expected to follow the food safety plan that they have been taught. Nelson (2012) cites that Dr. David Acheson, former chief medical officer for the FDA's CFSAN (Center for Food Safety and Applied Nutrition) has stated, "Training that doesn't change behavior and maintain good behavior isn't worth anything." Nelson (2012) further refers to Fred Pritzker, an attorney based in Minneapolis who has represented plaintiffs in foodborne illness cases. Mr. Pritzker believes that inadequate training whereby employees do not comprehend the consequences of a food safety mistake, and lack of proof that employees actually comprehend what they have been taught (e.g., where there is no employee proficiency testing), can lead to incorrect employee performance such as contamination of food consumed by customers and hence, a foodborne illness incident. This can occur when food establishments do not create a food safety culture that includes adequate training and monitoring.

10.11 Content of a Food Handler Training Program

When jurisdictions recognize that their regulatory authorities have a significant role in food establishments achieving compliance with food safety regulations, they can contribute by either requiring food handler training and certification or encouraging volunteer training, and by providing education programs or training guidelines for food establishments to follow. It is the operator's responsibility to ensure that their food handlers have the skills and knowledge to carry out their tasks safely and hygienically. The Canadian Food Inspection System Implementation Group (CFISIG 2004) suggests that the certification period for food handler (and operator) training should be 5 years, after which there is a required refresher course.

While employee training programs need to be generic enough to cover all aspects of food safety, they need to be flexible enough to consider specific food safety issues that are relevant to the type of retail food facility, types of technology and equipment used, the foods being handled and procedures being taught, and new food science research. Educational programs can be provided by institutions, the industry itself, or regulatory authorities, and there are several appropriate programs available, but they need to satisfy any learning and certification criteria set forth by the regulatory authority so that there is consistency within a jurisdiction and with other jurisdictions.

Suggested topics to include in a food handler training program are as follows (CFISIG 2004; The Training Center 2010): NRAEF 2012; NRFSP:

- Basic food safety: food handler's role and responsibility
- Personal hygiene and hand washing
- Preventing contamination and cross-contamination
- Cleaning and sanitizing; pest control
- Food storage
- Food properties
- Foodborne illness: causes; food safety control procedures
- Food allergens
- Microorganisms: sources; growth, multiplication, and death; harmful vs. harmless organisms
- Time and temperature control and monitoring: potentially hazardous food (PHF)/ Time-Temperature Control for Safety (TCS)
- Basic HACCP

County of San Diego Department of Environmental Health Food & Housing Division (2011) has published a food handler training resource with the following topics.

Major Causes of Foodborne Illnesses 2
What makes people sick from food?
What are germs, toxins, and chemicals?
What are the toxins in food that make people sick?
How do germs get into food?
Can you tell if food is contaminated?

Employee Health and Hygiene
Ways food handlers can spread disease
How to prevent foodborne illness?
Why should you wash your hands?
When should you wash your hands?
How should you wash your hands?
How should you use gloves?
What are you required to do if you are sick?
What is the person in charge required to do if you are sick?

Protection from Contamination
Store food so it is protected from contamination
Prepare food so it is protected from contamination
Protect food from chemical contamination
Protect food from physical hazards

Temperature Control
Required holding temperatures
Temperature recording logs and their use
How to calibrate your thermometer?
Adequate cooking of food
Proper cooling procedures
Safe thawing of food
Proper reheating of food

Consumer Advisories

Approved Food Sources
Food served or sold must be from an approved sources
Shellfish must be from safe sources and handled safely

Equipment and Utensils
Why is it important to wash dishes and utensils?
Steps in washing dishes and utensils by hand
Steps in washing dishes and utensils by machine
Utensil use and storage
What else needs to be kept clean?
Use wiping cloths properly

Pest Control
What can you do to control pests?

Garbage and Refuse
How often should trash be out?

Signs and Other Requirements
Required signs must be posted
Inspection reports

As another example, below is an outline of topics a four-hour employee training course and book developed by The Hospitality Institute of Technology and Management (Snyder 1993).

The Need for HACCP
The customer judges food safety
Reports of foodborne outbreaks in the USA
Factors that contribute to outbreaks of foodborne disease
Hazard Analysis—HA
Critical Control Points—CCP

Microorganisms
Food microorganisms
How do you know if food is hazardous or safe?
The biological hazard
The spore cycle (*Clostridia* and *Bacillus*)
Spoilage microorganisms—The quality problem

Foodborne Illness Microorganisms and Control
Types of foodborne illness
Growth of foodborne disease bacteria
Pasteurization reduction of *Salmonella*/destruction of bacteria in food
Salmonella HACCP
Salmonella control
Hepatitis A HACCP
Noroviruses HACCP
Staphylococcus aureus HACCP
Staphylococcus aureus control
Clostridium perfringens HACCP
Clostridium perfringens control
Critical pathogen temperatures

Temperatures, Measurement, Cooling and Control
Food cooling
Cooling HACCP
Temperature measurement of food
Food preparation methods

Personal Hygiene and Employee Food Handling Procedures
The body as a source of pathogens
Safe hand washing
Personal hygiene
Preventing prepared food cross-contamination

Cleaning and Sanitizing
Clean, sanitized and sterilized
Four-step surface sanitizing process
Using a sanitizing solution

Warewashing HACCP

Chemical and Physical Hazards
Chemical hazards and controls
Adverse reactions to food
Physical hazards

Food Production and Storage
Receiving packaging inspection HACCP
Dry storage, freezer and refrigerator storage HACCP
Thawing
Fruit and vegetable washing HACCP
The seven quality assurance recipe processes
Leftovers HACCP

Summary
Let's concentrate on making quality certain.

The content of these examples reflects the areas of knowledge that provide the HOW and the WHY of food safety and support food handler training to mastery. Described below is an example of a simple food handler training session, to include the following components: (1) training policy; (2) employee training checklist; (3) lesson plan (cleaning and sanitizing food contact surfaces), two formats, with demonstration as part of the lesson, and pictorial SOP, and (4) training follow-up (coaching and feedback).

Training policy. An example of a food establishment's training policy is as follows: "All new employees undergo thorough training in the written policies, procedures, and standards of the facility as before they are allowed to handle or prepare food. When employees are hired, they will be given a copy of the policies, procedures, and standards manual to read."

Employee training checklist. Figure 10.1 is an example of an employee training checklist that can be used as a guide to the learning outcomes during training and reflects the food safety hazard controls as would be described in the facility's policies, procedures, and standards. A signed record of all employee training is kept.

Lesson plan. Figures 10.2 and 10.3 are examples of written lesson plan formats for cleaning and sanitizing food contact surfaces as a part of food safety training for newly hired food handlers or as a continuing education/coaching lesson. This lesson provides discussion as to the WHY and WHEN of proper food contact surface cleaning and sanitizing. Figure 10.4 is a pictorial version of the cleaning and sanitizing procedure.

10.12 Continuing Education and Training Follow-Up

The Canadian Food Inspection System Implementation Group (CFISIG 2004) states that, "Every food premise should promote food safety education through ongoing training, which may include additional classroom instruction, on-the-job

(U.S. Food Code Performance Standards*)

Critical Control Points	Demonstrated Correct Performance	Evaluation Date ______
Prerequisites **Personal hygiene** If I have vomiting or diarrhea, I will tell the Person In Charge (PIC). I know how and when to wash my hands. I do not touch my skin, face, or hair when working with food. Immediately finishing a task for which I have worn gloves, I remove the gloves and wash my hands. **Receiving** Any food that is damaged or spoiled will be returned to the supplier or discarded. Cold food is promptly refrigerated at 41°F (5°C) or colder. **Storage** I store raw food on the bottom shelves in the refrigerator and ready-to-eat food above the raw food, 41°F (5°C) or colder. I know the temperatures of the refrigerators and report any refrigerator above 41°F. I store chemicals completely separate from food. **Equipment** I know how to clean my equipment and work area. I make sure that equipment is working correctly and the work area is clean before I begin food preparation. **Food process hazard controls** I double wash raw fruits and vegetables before using in menu items. During pre-preparation, I remove physical hazards from food. I know if any ingredient in a recipe is an allergen so that I can accurately answer customer questions. If in doubt, I refer allergen questions to the kitchen manager. After handling raw meat / fish / poultry, I decontaminate my hands, equipment, and work area before touching ready-to-eat food. I know how to use a thermometer or thermocouple properly. I cook foods to the following center temperatures: a. Solid steaks, chops, fish: 145°F (62.8°C), 15 seconds b. Ground meat, fish: 155°F (68°C), 15 seconds c. Poultry: 165°F (74°C), 15 seconds OR: as ordered by the individual customer. I hold hot food 135°F (57°C) or hotter, or for less than 4 h, if time is used as a control. When cooling, I place no more than 2 inches of solid food in a pan, no more than 1 gallon of liquid in a container.		
When making a cold combination such as salads, I pre-cool ingredients to 50°F (10°C) or colder. When mixing, I wear gloves or use a utensil. I hold cold ready-to-eat food at 41°F (5°C) or colder for no more than 7 days. It is labeled. I do not add leftovers to a fresh food.		

On __________, I trained ______________________ to know the above food safety information, and I verified that he/she could apply it in his/her work.

________________________________ ________________

Trainer Date

* These temperatures do not reflect temperature requirements of all jurisdictions.

(Snyder 2009; (FDA 2009c)

Fig. 10.1 Employee food HACCP training checklist

CLEANING AND SANITIZING FOOD CONTACT SURFACES

Date: ________________

Instructor: Supervisor / PIC / Manager (name) **Trainees: Food handlers (names)**

Learning objectives / employee outcomes: By the end of this lesson, employees will be able to:

1. Demonstrate the immersion cleaning and sanitizing of a food contact surface (e.g., cutting board). This begins with preparing the 3-compartment sink and gathering cleaning equipment. The steps in the process include: 1) remove gross soil from the surface; 2) wash and scrub the surface; 3) rinse; 4) sanitize surface; 5) air dry. This is followed by a clean-up step.
2. Explain:

a. What is the hazard to be controlled? (cross-contamination of food pathogens)

b. When is cleaning and sanitizing to be done? (between preparation of food items, particularly between raw and cooked foods, and whenever items have been used or emptied)

c. Why is cleaning and sanitizing important? (to prevent foodborne illness by removing bacterial and viral pathogens to an acceptable level)

d. What is "clean as you go"? (cleaning up after each step of a procedure or after a task, before moving on to the next step or task)

Length of lesson: 20 minutes

Lesson outline / sequence

1. Overview of importance of cleaning and sanitizing: prevent cross-contamination; reduce pathogens on contaminated surfaces.
2. Review cleaning and sanitizing SOP (Figure4, pictorial procedure).
3. Demonstrate sink set up, cleaning / sanitizing procedures, and clean up; discuss reduction of bacterial and viral pathogens to an acceptable level.

Class activities

1. Have learners demonstrate sink set up; cleaning / sanitizing procedures; clean up. If there are several learners in the training session, individuals can be chosen to demonstrate the different steps to the procedure.

Materials (instructional aids, instructions / handouts / overheads / visuals):

1. 3-compartment sink; cleaning and sanitizing equipment; item(s) to be cleaning and sanitized (e.g., cutting board, knives, etc.)
2. Cleaning and sanitizing SOP (Figure4, pictorial procedure)

Instructor signature ___________________________

Trainee signature ___________________________ Trainee signature ___________________________
Trainee signature ___________________________ Trainee signature ___________________________
Trainee signature ___________________________ Trainee signature ___________________________

Fig. 10.2 Lesson plan #1

training, food safety certification from a recognized program of instruction, seminars, and employee meetings."

Coaching and feedback are other aspects of training follow-up that help sustain a food establishment's food safety culture. They are most effective when done consistently and in a manner that instills in employees a sense of confidence, commitment, and "ownership" of their task performance as they were taught, as well as a work atmosphere that encourages employee attitudes and behaviors that are consistent with the company's policies, procedures, and standards. Observations of employee task performance allow the observer to acknowledge strong performance and to recognize when improvement and possibly further training or coaching are

Employee Training
Critical Controls / Standard Operating Procedures

Facility ______________________ **Training Date** ____________

CLEANING AND SANITIZING FOOD CONTACT SURFACES

Trainees	employees at time of hiring; coaching and review during employment
Hazard	Cross-contamination of food pathogens from one food contact surface to another food contact surface or to food, particularly between surfaces touched by raw foods and then, cooked foods
Control	Clean / sanitize to remove bacterial and viral pathogens (to 5-log reduction of APC) for ready-to-eat food, to prevent cross-contamination of foods and maintain a safe level of microorganisms of ≤100 microorganisms per 8 square inches (50 square centimeters) on the surface between preparation of different food items, particularly between raw and cooked foods, and any time after these items have been used or emptied. Clean as you go.
Equipment	3-compartment sink: 1^{st} sink: clean dish washing detergent solution; 2^{nd} sink: rinse water; 3^{rd} sink: sanitizer solution; scrub pad / brush Clean In Place (CIP): 1 bucket each of: detergent solution, rinse water, sanitizer solution; scrub pad / brush Dish washer: Sanitizer strips
Steps	SEE PICTORIAL PROCEDURE. (Figure 4)
Monitoring / records	Employee: Signs training record for this module. Tests sanitizer strength with sanitizer strips and records on sanitizer log. Makes visual observation of cleanliness. PIC: Maintains training record. Maintains updated cleaning and sanitizing schedule. Makes sure that employees are following schedule. Makes sure that cleaning and sanitizing supplies and equipment are maintained and available.
Corrective action	Employee: Clean / sanitize any food contact surface prior to use. Re-clean / sanitize any food contact surface that shows signs of not being cleaned. If sanitizer strength is not correct, re-make sanitizer solution and re-test. Document on corrective action report. PIC: Retrain / coach employees who do not follow facility's cleaning and sanitizing procedures.
PIC Verification	Observe and verify that food contact surfaces are being cleaned and sanitized. Verify that cleaning and sanitizing schedule is updated and being followed. Verify that cleaning and sanitizing equipment and supplies are maintained and available. Verify sanitizer strength by reviewing sanitizer log. Review corrective action report.

Employee training roster: ______________________________ ______________________________ _____
______________________________ ______________________________ ________________________
______________________________ ______________________________ ________________________
Instructor signature ______________________________ _____________ Date ___________________

Fig. 10.3 Lesson plan #2

needed to change the behavior from remembering and doing a task to doing a task because it has become a habit.

Coaching and feedback provide the opportunity, not to criticize or to discipline, but to strengthen communications between management and employees through discussion of the company's desire to meet its food safety standards and goals. Coaching and feedback can be very effective when done in a manner that focuses on an employee's specific behavior, not his or her personality, and allows the employee to maintain, and even enhance, his or her self-esteem by putting faith in the employee that he or she is capable of changing behaviors to work toward meeting the company's expectations. This approach has the potential for lessening the need for conflict management. Some companies implement performance evaluations on, for instance, an annual basis, at which time an employee's contributions, accomplishments, and to the company can be further assessed (UCSF 2014).

In addition, as a follow-up to training and implementation of the food establishment's food safety program, the manager/PIC checks regularly to verify that critical food safety tasks are performed consistently, and equipment and facility are

CUTTING BOARDS AND OTHER FOOD CONTACT EQUIPMENT AND UTENSILS
(Immersion Cleaning and Sanitizing Process in a 3-Compartment Sink)

Hazard Control Policies, Procedures, and Standards

Dept.: ______________________ Person responsible: __________________________ Effective date: ___

The Hazard: Cross-contamination. To prevent cross-contamination, cutting boards, large bowls, pans, kettles and knives must be washed and sanitized between preparation of different food items, particularly between raw and cooked foods, and any time after these items have been used or emptied.

Process and Output Specifications: To wash and sanitize cutting boards and other food contact equipment and utensils in a
3-compartment sink to prevent cross-contamination of foods and maintain a safe level of microorganisms of ≤100 microorganisms per 8 square inches (50 square centimeters) on the surface.

Get ready.
Check to be sure that supplies are adequate: scrub brush or pad, detergent, sanitizer, hot water. Clean and rinse all compartments of the 3-compartment sink with hot water and detergent solution before start-up each morning and at any other time during the day, if the compartments are dirty. The wash water and rinse water are critical control points. The wash water should be changed often enough to keep microbial counts <1,000 APC/ml. If the sink will not be used for an hour or more, drain the wash and rinse compartments and leave them empty until time for use.

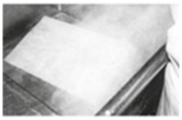
Fill sinks.
Fill wash compartment with detergent solution. Use ____ oz. of ____________ (detergent) per gallon of water at 110 to 120°F (43 to 49°C). Fill the second compartment of the sink with water at a temperature of 110 to 120°F (43 to 49°C). Fill the third compartment with sanitizer solution containing ____ oz. of ____________ (sanitizer) in ____ gallons of water (75 to 100°F/24 to 37.8°C).

Remove gross soil.
Scrape, rinse and remove gross soil from the surface ofitems to be washed with hot (110 to 120°F or 43 to 49°C) water before putting any utensil, cutting board, pot or pan into the wash sink. This critical step controls the rate at which food soil (debris and grease) gets into the wash water. Food soil in the wash water decreases the effectiveness of the detergent and hampers the adequate removal of surface contaminants (microorganisms, chemicals and hard foreign objects).

Wash and scrub surface.
In the first compartment of the sink, wash and scrub surface(s) with the scrub brush / pad. Loosen and remove all soil. Use the brush / pad to get into the cracks of cutting boards. Regularly check the wash water. When it will no longer produce suds and is dirty, it must be changed. (Do not put knives or objects with sharp edges in the bottom of the sink. These items should be washed immediately after use.) If a metal scrub pad must be used, check carefully for metal pieces that break off and stick to the item, which could get transferred to the customers' food and cause injury.

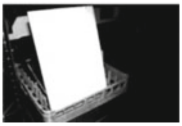
Fig. 10.4 Pictorial procedure

Rinse.
Rinse equipment, cutting boards, utensils, etc. by immersion in hot rinse water. Change the rinse water as it cools or shows the presence of detergent suds. If the detergent and dirty water from the first sink are not rinsed off thoroughly, the sanitizer will be neutralized by the soap and soil.



Sanitize surface.
When the surface is clean, immerse the item for 1 minute in the third compartment of the sink containing the sanitizer solution. If there is no third compartment, items can be sanitized by flooding the surface with sanitizer solution (75°F/24°C).) from a squirt bottle and wiping the sanitizer solution across the surface with a clean disposable paper towel. After use, throw away the paper towel.

As an alternative to using chemical sanitizers, items can also be sanitized in the third sink by immersion in hot water at 170 to 180°F (76.7 to 82°C) for 30 seconds.



Air dry.
Allow surfaces to air dry thoroughly. This is another critical control. Since there is still a small but safe amount of soil and microorganisms on the surface, microorganisms will multiply perhaps 100 to 1,000 times in 6 to 8 h on a wet surface. Microorganisms do not multiply on dry surfaces.

Clean sink.
At the end of daily operations, drain the sinks. Clean sink compartments with brush and hot detergent solution. Rinse sinks with hot water. Allow sinks to air dry, and keep dry until used again. Dispose of water. Clean the area. Get more chemicals and other cleaning aids. Do not refill containers. Replace with new containers, because microorganisms can grow in many chemicals, or oil chemicals will react with and reduce the effectiveness of fresh chemicals, if mixed with new.

NOTES:

Employee training roster: ____

____

____

Instructor signature ___________________________________ Date _______________

Snyder (1995)

Fig. 10.4 (continued)

maintained. Figure 10.5 is a simple weekly checklist that checks on what food handlers and other employees have been taught. It also allows for the documentation of any corrective actions that need to be taken.

10.13 Measuring the Effectiveness of Food Handler Training

While in-house manager/PIC-led training sessions themselves may include tests and employee demonstration to assess the level of knowledge comprehension, retention, and skill learning, "outside" evaluations have also attempted to assess the effectiveness of food handler training. However, measuring the effectiveness of such training is a challenge. According to the National Environmental Health Association (NEHA 2011), few jurisdictions have tried to assess the outcomes of food handler training. Evidence supporting the effectiveness of training is inconclusive, with published evaluations showing mixed results (Roberts et al. 2008; NEHA 2011), and a number of investigations have had only limited success. A "best" evaluation method has yet to be developed or established.

Evaluator ______________________ **Date** ____________ **Time** ____________

PREREQUISITE HACCP REQUIREMENTS	**PERSON / ITEM : OBSERVATION**	**CORR. ACT #**
Personal Hygiene (Person: Health, cleanliness, double hand washing when coming from toilet, single hand washing for raw food / RTE food control, gloves control)	1. ________ : ____________ 2. ________ : ____________ 3. ________ : ____________	
Environment / facilities (Item: Cleaned, maintained, pests, trash, chemicals, water, plumbing controlled)	1. ________ : ____________ 2. ________ : ____________ 3. ________ : ____________	
Equipment (Item: Cleanliness, temperature, maintenance, sanitizer concentration, thermometers / instrument calibration)	1. ________ : ____________ 2. ________ : ____________ 3. ________ : ____________	
Supplies (Food: temperature, use by; inventory rotation; approved supplier, protected, RTE on top)	1. ________ : ____________ 2. ________ : ____________ 3. ________ : ____________	
FOOD HACCP PROCESSES	**FOOD : OBSERVATION**	**CR ACT #**
Physical hazards (Food: hard foreign objects, choking, thermal)	1. ________ : ____________ 2. ________ : ____________	
Chemical hazards (Item: separate from food, used at correct level)	1. ________ : ____________ 2. ________ : ____________	
Allergen control (Food: allergen control; do not add fresh to old; do not combine different leftovers	1. ________ : ____________ 2. ________ : ____________	
Double wash fruits and vegetables (Food: adequate physical wash)	1. ________ : ____________ 2. ________ : ____________	

Fig. 10.5 Weekly QA checklist

Cooking (pasteurizing) (Food: temperature and time, pH, water activity)	1. ___________ : ______________________________ 2. ___________ : ______________________________ 3. ___________ : ______________________________	
Hot hold, transport, serve / catering (Food: temperature 57ºC/ 135ºF*, hold time, surface humidity)	1. ___________ : ______________________________ 2. ___________ : ______________________________ 3. ___________ : ______________________________	
Cooling (<2 inches thick, <1 gallon) (Food: container, date)	1. ___________ : ______________________________ 2. ___________ : ______________________________ 3. ___________ : ______________________________	
Cold hold, transport, serve / catering (Food: temperature, protection)	1. ___________ : ______________________________ 2. ___________ : ______________________________ 3. ___________ : ______________________________	
Salads mixed with cold ingredients (Food: temperature)	1. ___________ : ______________________________ 2. ___________ : ______________________________	
Leftovers (Food: temperature, age, refrigeration, freezing)	1. ___________ : ______________________________ 2. ___________ : ______________________________	
Take out / donated: food handling (Food: temperature, time)	1. ___________ : ______________________________ 2. ___________ : ______________________________	

* Food Code (FDA 2009c)

(Snyder 2010)

Fig. 10.5 (continued)

Hammond et al. (2005) studied food worker training in Florida prior to and following a 2000 change in Florida's mandatory training law that mandated that all food workers in food establishments inspected by the Florida Department of business and Professional Regulation receive training. Prior to this, only food managers had to be certified in food safety and sanitation. Hammond et al. (2005) reviewed seven possible methods for assessing the effectiveness of mandatory food handler training in Florida and discussed their limitations (Table 10.1). The researchers selected #7.

Any one of these assessment methods may be suitable, depending on the situation. Nonetheless, NEHA (2011) states that using inspection violations to assess efficacy of food worker training seems to be the most frequently used method.

A study by McIntyre et al. (2013) evaluated food handlers who were trained and certified under the FOODSAFE training program in British Columbia, Canada. Their data, collected in a telephone survey, showed that, even though knowledge scores of FOODSAFE-trained workers decreased gradually but significantly over a 15-year period following certification, with much of the decrease occurred within up to a year following initial training, the trained group of food workers scored much higher than the untrained group. While other factors that influenced worker knowledge, such as life experience in both trained and untrained workers, one's education, place of employment, and ethnicity, to include language

Table 10.1 Assessment methods for effectiveness of food handler training

No.	Method	Limitation
1	Compare the number of foodborne illness outbreaks before and after mandatory food handler training has been implemented	Lack of specificity due to variety of outbreak causes and variability in reporting and detection
2	Compare the number of cited critical violations before and after mandatory food handler training has been implemented	Data on violations prior to training unavailable
3	Correlate the number of foodborne illness outbreaks with the number of trained food handlers following the implementation of mandatory training	Lack of consistent training records throughout a jurisdiction; worker mobility
4	Compare outbreak contributing factors to facilities where food handler training is required vs. facilities where such training is not required	Differences in workforce, types of food facilities, education backgrounds, language, foods served, and preparation procedures
5	Compare foodborne illness outbreak trends and cases associated with specific pathogens (e.g., *E. coli*, *Salmonella* spp.)	Not specific enough vis a vis food handler training; too many complicating factors
6	Compare rate of employee compliance to training in food facilities that have outbreaks vs. facilities that do not	Data may not be easily available
7[a]	Compare trends in foodborne illness contributing factors before and after mandatory food handler training has been implemented in licensed food establishments in a given jurisdiction	Outbreaks with a variety of causes; inconsistency in detection and reporting

[a]Used by Hammond et al. (2005)

difficulty, the study recommended that, because of the decline in knowledge, food handlers receive not only initial food safety training, but also refresher training periodically.

10.14 Measuring the Food Safety System

Traditional evaluations of a food facility such as regulatory inspections focus on observing the physical conditions of the facility and environment, taking hot and cold food temperatures, and observing cleanliness and sanitation, and personnel. This only reveals the status of the facility at the time of the inspection. Even an excellent inspection score cannot show if food safety processes are consistently carried out as they should be or if the score was a lucky accident. Measurement—inspection and testing—of the processes is more likely to detect any food safety problems. This includes measurement of knowledge of managers and employees as well as behavior. Krause (1997) describes a way to analyze the food safety system in order to improve it through identification and observation of safety behaviors, providing feedback, and using the observational data for continuous improvement.

10.15 Summary

Consumer expectations and the data showing that 1 in 6 Americans are made ill each year by a foodborne illness, as well as the damage to a business when a foodborne illness is shown to have been caused by employee error, suggest the need for effective food handler training. While a major focus of food safety training has been on the manager, food handler training for the preparation of safe food is not a new concept and has been implemented in some jurisdictions. Both training and regulatory inspections are considered to be essential to the reduction of foodborne illness risk, but attempts to measure the effectiveness of food handler training have not revealed conclusive results.

Food handler training should include not only the learning of specific food safety tasks—the HOW—but also information about foodborne illness and protecting customer health—the WHY—of safe food preparation. There are many choices that managers/PICs can make in terms of how to present the material to be learned—self-instruction, classroom, one-on-one instruction, online training, visual aids, and hands-on demonstration—and can be used in combination to enhance the learning experience.

The concept of effective food handler training has developed over the years to include training to mastery and changing employee behavior, which is much more difficult and complex than merely learning a task. Training is considered to be a significant part of the food safety culture of a food establishment. In other words, food handler training is an integral part of "the way a company does things." Management theories and methods based on a behavioral approach, as related to food handler training, include: the ABC (Antecedent-Behavior-Consequence) system, behavior-based food safety management, and AMC and HACCP, as described by the FDA in Annex 4. These approaches address the importance of training within the context of a food safety management system and as an essential part of the food safety culture of a food establishment for the reduction of foodborne illness risk.

Consistent, strategic coaching and constructive feedback as part of training follow-up can serve to not only guide employees to change their behaviors without feeling criticized but to allow for praise for a job well done. While it is difficult to test and measure food handler behavior, the manager/PIC can observe the employees performing their tasks, and provide coaching and feedback and corrective action when needed.

Without food handler training, there is no apparent management recognition of the importance of reducing the risk of foodborne illness hazards through consistent performance of safe food handling procedures. While its effectiveness may be difficult to measure, training of all personnel, including food handlers, is widely accepted as a critical component of the overall food safety management system, which is essential to maintaining a food safety culture of a retail food establishment.

References

CFISIG (Canadian Food Inspection System Implementation Group) (2004) Food retail and food service code. http://www.cfis.agr.ca/english/regcode/frfsrc-amendmts/codeang-2004.pdf. Accessed 15 Nov 2012

County of San Diego Department of Environmental Health Food & Housing Division (2011) The health of the public is in your hands: a food handler's guide to food safety. http://www.sdcounty.ca.gov/deh/food/pdf/publications_fhbooklet.pdf. Accessed 15 Nov 2012

FDA Retail Food Program Steering Committee (2000 Aug 10). Report of the FDA retail food program database of foodborne illness risk factors. http://www.fda.gov/Food/FoodSafety/RetailFoodProtection/FoodCode/FoodCode2001/ucm123544.htm. Accessed 7 Sep 2012

FDA (2009a) Food Code Annex 4—Management of food safety practices—achieving active managerial control of foodborne illness risk factors. http://www.fda.gov/Food/FoodSafety/RetailFoodProtection/FoodCode/FoodCode2009/ucm188363.htm. Accessed 14 Sep 2012

FDA (2009b) FDA report on the occurrence of foodborne illness risk factors in selected institutional foodservice, restaurant, and retail food store facility types. FDA National Retail Food Team. http://www.fda.gov/Food/FoodSafety/RetailFoodProtection/FoodborneIllnessandRiskFactorReduction/RetailFoodRiskFactorStudies/ucm224328.htm. Accessed 7 Sep 2012

FDA (2009c) Food code. U.S. Public Health Service, U.S. Dept. of Health and Human Services. Washington. http://www.fda.gov/Food/FoodSafety/RetailFoodProtection/FoodCode/FoodCode2009/. Accessed 7 Sep 2012

FDA (2009d) Measuring the effectiveness of the nation's foodservice and retail food protection system. http://www.fda.gov/Food/FoodSafety/RetailFoodProtection/FoodborneIllnessandRiskFactorReduction/RetailFoodRiskFactorStudies/ucm096181.htm. Accessed 20 Sep 2012

Hammond RM, Brooks RG, Schlottmann J, Johnson D, Johnson RJ (2005) Assessing the effectiveness of food worker training in Florida: opportunities and challenges. J Environ Health 68(3):19

Jackson ER (1954) Technics used to obtain proper planning in food and food handler sanitation. Am J Public Health 44(5):635–640, http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1620952/pdf/amjphnation00358-0076.pdf. Accessed 12 Sep 2012

Krause TR (1997) The behavior-based safety process: managing involvement for an injury-free culture, 2nd edn. Van Nostrand Reinhold, New York

Lally P, van Jaarsveld CHM, Potts HWW, Wardle J (2010) How are habits formed: Modelling habit formation in the real world. Eur. J. Soc. Psychol., 40: 998–1009. doi: 10.1002/ejsp.674

McIntyre L, Vallaster L, Wilcott L, Henderson SB, Kosatsky T (2013) Evaluation of food safety knowledge, attitudes and self-reported hand washing practices in FOODSAFE trained and untrained food handlers in British Columbia, Canada. Food Control 30(1):150–156, http://dx.doi.org/10.1016/j.foodcont.2012.06.034. Accessed 1 Oct 2012

Nakamura G (2011) What you need to know about the 2011 California food handler card law: new food safety training and certification legislation (Senate bill 602). http://www.deltatrak.com/2011-california-food-handler.phtml. Accessed 5 Sep 2012

Neal JA, Binkley M, Henroid D (2012) Assessing factors contributing to food safety culture in retail food establishments. Food Prot Trends 32(8):468–476

NEHA (National Environmental Health Association) (2011) Evaluation of a local health department's food handler training program. http://www.thefreelibrary.com/Evaluation+of+a+local+health+department%27s+food+handler+training…-a0245116242. Accessed 11 Sep 2012

Nelson LD (2012) Training is key to FSMA compliance. Food Quality. Aug/Sep: 13–14. http://www.foodquality.com/details/article/2498101/Training_is_Key_to_FSMA_Compliance.html. Accessed 25 Sep 2012

NRAEF (The National Restaurant Association Educational Foundation) (2012) ServSafe Food Handler Program. http://www.servsafe.com/ss/FoodHandler/FHoverview.aspx. Accessed 15 Nov 2012

NRFSP (National Registry of Food Safety Professionals) (___) Food safety first principles for food handlers. http://www.nrfsp.com/en/Food%20Handler.aspx. Accessed 15 Nov 2012
Roberts KR, Barrett BB, Howells AD, Shanklin CW, Pilling VK, Brannon LA (2008) Food safety training and foodservice employees' knowledge and behavior. Food Prot Trends 28(4): 252–260
Scallan E, Griffin P, Angulo FJ, Tauxe RV, Hoekstra RM (2011a) Foodborne illness acquired in the United States—unspecified agents. Emerg Infect Dis 17(1):16–22
Scallan E, Hoekstra RM, Angulo FJ, Tauxe RV, Widdowson MA, Roy SL, Jones JL, Griffin PM (2011b) Foodborne illness acquired in the United States—major pathogens. Emerg Infect Dis 17(1):7–15
Scharf RL (2012) Economic burden from health losses due to foodborne illness in the United States. J Food Prot 75(1):123–131
Schier TJ (2006) Education versus training. 2012. EzingArticles.com. http://ezinearticles.com/?Education-Versus-Training&id=299318. Accessed 13 Sep 2012
Snyder OP (1993) (2012 ed.) Preparing food safely in retail food operations. Hospitality Institute of Technology and Management, St. Paul
Snyder OP (1994) Achieving successful total quality through behavioral management. Food Technol 48(9):144–151
Snyder OP (2002) (Jan. 2008 ed.). Retail food operations policies, procedures, and standards manual. Hospitality Institute of Technology and Management, St. Paul
Snyder OP (2009) Jun. ed. Employee food HACCP training checklist. HITM, St. Paul
Snyder OP (2010) Mar. ed. Weekly QA checklist. Hospitality Institute of Technology and Management, St. Paul
The Training Center (2010) Food safety training. http://www.foodservicepermits.com/foodsafety.htm. Accessed 15 Nov 2012
UCSF (University of California, San Francisco) Human Resources (___) Chapter 7: performance management. http://ucsfhr.ucsf.edu/index.php/pubs/hrguidearticle/chapter-7-performance-management. In: Guide to managing human resources. http://ucsfhr.ucsf.edu/index.php/pubs/HRGuide/. Accessed 6 Mar 2014
Yiannas F (2010) Food safety culture: creating a behavior-based food safety management system. Springer, New York

Education

Oxford Dictionaries (April 2010) "Education". Oxford University Press. http://oxforddictionaries.com/definition/english/education. Accessed 10 Sep 2012
Wikipedia (2012) "Education". http://en.wikipedia.org/wiki/Education. Accessed 10 Sep 2012

Training

Oxford Dictionaries (April 2010) "Training". Oxford University Press. http://oxforddictionaries.com/definition/english/training. Accessed 10 Sep 2012
Collins English Dictionary—Complete and Unabridged (2003) "Training". HarperCollins Publishers. http://www.thefreedictionary.com/training. Accessed 10 Sep 2012
Wikipedia (2012) "Training". http://en.wikipedia.org/wiki/Training. Accessed 10 Sep 2012

Chapter 11
Retail Food Safety Risks for Populations of Different Races, Ethnicities, and Income Levels

Jennifer J. Quinlan

11.1 Introduction

Research in Public Health and Nutrition over the past decade has demonstrated differential retail food access for populations of different demographics. In general, populations of low socioeconomic status (SES) as well as minority racial and ethnic populations tend to have less access to supermarkets but greater access to corner markets and small independently owned grocery stores (Moore and Diez Roux 2006; Zenk et al. 2005; Hilmers et al. 2012). This research has been conducted primarily to better understand the nutritional quality of retail food available to these vulnerable populations and therefore possibly understand underlying causes of higher rates of obesity and related chronic diseases. This area of research has generally found that the nutritional quality of food available in corner markets and small grocery stores is lower than that found in supermarkets with fewer fruits, vegetables, and healthy food choices available (Zenk et al. 2006; Baker et al. 2006). The term "food desert" has emerged to describe a geographic area which has limited access to healthy foods. Since 2009 the US Department of Agriculture has released multiple reports (Ver Ploeg et al. 2009; Dutko et al. 2012) identifying and characterizing food deserts and in 2011 the Food Marketing Institute issued a report on opportunities and challenges for food retailers in underserved areas (Food Marketing Institute 2011). While this topic of differential food access has gained attention and scrutiny from the perspective of nutrition, health equity, and business opportunities, none of the aforementioned reports address food safety or sanitation, despite the fact that they revolve around retail food access. Research is only beginning to emerge examining whether this differential retail food access results in food which

J.J. Quinlan, Ph.D. (✉)
Department of Nutrition Sciences and Department of Biology, Drexel University,
516 Bellet, 245 N. 15th Street, Philadelphia, PA 19102, USA
e-mail: jjq26@drexel.edu

J. Farber et al. (eds.), *Retail Food Safety*, Food Microbiology and Food Safety,
DOI 10.1007/978-1-4939-1550-7_11

is of poorer microbial quality and safety (Koro et al. 2010; Gillespie et al. 2010; Signs et al. 2011). This chapter will review what is known about differential retail food access as well as how and why it might result in availability of poorer microbial quality of food to low socioeconomic and minority racial/ethnic populations. It will discuss the methods available to try to detect if differences exist and will review the literature available to date about the potential safety and microbial quality of food available at the retail level to populations of different demographics. Finally, it will identify areas where further research is needed.

11.2 Food Deserts and Low Socioeconomic and Minority Racial and Ethnic Populations

Compared to residents of high SES areas, it has been found that residents of low SES areas have less access to large scale, chain stores, i.e., supermarkets (Morland et al. 2002; Baker et al. 2006). Residents of low SES areas, however, have greater access to smaller, independently operated food markets and fast-food/take-out restaurants, compared to those of high SES (Morland et al. 2002; Zenk et al. 2005; Baker et al. 2006; Moore and Diez Roux 2006). Examination of retail food outlets in selected areas of Mississippi, North Carolina, Maryland, and Minnesota found that wealthier neighborhoods had more supermarkets than the poorest neighborhoods and that there were four times more supermarkets in white neighborhoods compared to African American neighborhoods (Morland et al. 2002). In Detroit, it was found that impoverished neighborhoods where African Americans resided were, on average, 1.1 miles further from a supermarket than impoverished Caucasian neighborhoods (Zenk et al. 2005). Moore and Diez Roux examined selected census tracts in North Carolina, Maryland, and New York and found that both low-income and increased minority populations were associated with fewer supermarkets, but more grocery stores (Moore and Diez Roux 2006). Research has identified that areas of differential food access exist in rural communities as well. Examination of a rural county in South Carolina found that convenience stores outnumbered supermarkets and were less likely to carry healthy foods (Liese et al. 2007).

With mounting evidence of differential food access and increasing concerns about the rise of obesity and associated conditions in low-income and minority populations, the 2008 Farm Bill directed the US Department of Agriculture to perform a 1 year study on low food access (LFA). This study resulted in a report to congress which defined a food desert as a US census tract which met both low-income and low-access criteria (Ver Ploeg et al. 2009). Low income was defined as a census tract with a poverty rate greater than or equal to 20 % or in which the median family income did not exceed 80 % of the statewide or metro-area median family income. Low access was defined as greater than one mile away from a supermarket in urban areas, assuming walkability or greater than 20 miles away in a rural area. It is important to note that in this study, supermarkets and large grocery stores which provided high access were defined as food stores with at least $2 million in sales that contain all the major food departments found in a traditional supermarket. This means that low-access areas may have access to retail food outlets, but as a wealth of research has demonstrated, these retail food outlets may be small independently owned corner markets and convenience stores. Using these definitions, the 2009 USDA report found that 23.5 million people live in low-income areas that are further than one mile from a supermarket and that of those people, 11.5 million were low income themselves. Additionally, 2.2 % of households in the USA live more than a mile from a supermarket and do not have access to a vehicle and another 3.2 % of households live between one-half to one mile from a supermarket and do not have access to a vehicle. USDA has also made available an online tool to identify food deserts in the USA (USDA-ERS 2012). A more recent USDA report examined characteristics and influential factors of food deserts and found that areas with high levels of poverty are more likely to be food deserts and with the exception of very dense urban areas, the higher the percentage of minority population, the more likely the area is to be a food desert (Dutko et al. 2012). In 2009 McKinnon et al. reviewed the body of literature published on measures of the food environment from 1990 to 2007. They identified a total of 137 articles at that time—a number which is likely greatly expanded by now. None of the 137 articles at that time assessed microbial safety or sanitation issues of the food environment (McKinnon et al. 2009).

From the perspective of food safety, if we assume that food access by low socioeconomic and minority populations is more likely to be through small, independent retailers than large chain supermarkets, the question arises whether small independent retailers in areas of low income pose a greater risk to food safety and sanitation than chain supermarkets. Methods to determine differences in potential safety or sanitation might include (1) Comparison of microbial quality of food available from the different types of retailers, (2) Comparison of compliance to food safety guidelines through inspection scores for the different types of retailers, and (3) Retrospective analysis to determine where those who have been diagnosed with a foodborne illness accessed food. The limited studies available which have attempted to address this area are discussed later in this chapter.

11.3 Rates of Foodborne Illness Among Low Socioeconomic and Minority Racial and Ethnic Populations

In addition to having differential access to food, evidence indicates that individuals of low SES and minority racial/ethnic groups may suffer from greater rates of foodborne illness (Bytzer et al. 2001; Shiferaw et al. 2004; Lay et al. 2000; Chang et al. 2009; Shiferaw et al. 2004; Quinlan 2013). Because of the way data has historically been collected and categorized with respect to foodborne illness, however, it is not possible to say with certainty at this time why this might be.

FoodNet is a surveillance network of the Center for Disease Control's (CDC) Emerging Infections Program which quantifies and monitors the incidence of laboratory-confirmed cases of *Campylobacter*, *Listeria*, *Salmonella*, Shiga toxin-producing *E. coli*, *Shigella*, *Yersinia*, and *Vibrio*. As pointed out by Hardnett et al. 2004, the population whose cases are reported to FoodNet was not chosen to equally represent all racial/ethnic groups and even in the expanded FoodNet population, Hispanics and those living below the poverty level are underrepresented when compared to the American Population (6 % vs. 12 %, and 11 % vs. 14 %, respectively) (Hardnett et al. 2004). Regardless of this difference in representation, efforts have been made to examine whether or not the data that has been obtained shows differences in incidence of pathogens in populations of certain racial and/or ethnic background. When FoodNet data from 1996 to 1998 was analyzed specifically for demographic trends in the incidence of *Shigella* it was found that the incidence (cases/100,000 population) of *Shigella* was greater in African Americans and Hispanics (4.1 and 11.2, respectively) when compared to Caucasians (1.6) (Shiferaw et al. 2004). FoodNet data from 1998 to 2000 was analyzed for disparities between the incidence of *Salmonella enteritidis* among groups of different ages, races, and ethnicities. Among individuals over 3 years of age, it was found that the incidence of *S. enteritidis* per 100,000 was highest among African Americans (2.0), followed by Hispanics (1.2) and then Caucasians (1.1) (Marcus et al. 2002). Rates of *Campylobacter*, *E. coli* O157:H7, *Salmonella*, *Shigella*, *Vibrio*, and *Yersinia* among Hispanics, African Americans, Asians, and Caucasians were analyzed using 2000 FoodNet data. It was found that the incidence of *Shigella* and *Salmonella typhi* was greater in Hispanics than Caucasians, the incidence of *Shigella* and *Yersinia* was higher in African Americans than Caucasians and the incidence of *Shigella*, *Vibrio*, and *S. typhi* was greater in Asians than Caucasians (Lay et al. 2002). Finally, Samuel et al. analyzed the epidemiology of *Campylobacter* infections utilizing FoodNet data from 1996 to 1999 and found the average incidence over all 4 years to be greatest among Hispanic and Asian populations (31.6 and 33.5/100,000, respectively), while Caucasian populations had an incidence of 21.9/100,000 and African Americans had the lowest incidence of 13.0/100,000 (Samuel et al. 2004). In 2008 FoodNet began releasing rates of foodborne illness by race and ethnicity in Annual Reports (Quinlan 2013).

An ecological analysis was conducted of sociodemographic factors associated with the three most commonly reported nationally notifiable enteric bacterial diseases in the USA, salmonellosis, shigellosis, and *E. coli* O157:H7 infection. Data from the National Notifiable Diseases Surveillance System for infections reported in all US counties from 1993 to 2002 was analyzed. Consistent with FoodNet data reported above, it was found that percent African American and percent Hispanic population were positively associated with incidence of both salmonellosis and shigellosis, but not with *E. coli* O157:H7 infection. Additionally, it was determined that percent urban population was also positively associated with incidence of salmonellosis and shigellosis, but not with *E. coli* O157:H7, while number of food handlers in the population was positively associated with incidence of all three infections (Chang et al. 2009). There are a few studies which have found that low-income populations are more likely to experience greater rates of gastrointestinal illness, however none of these were with populations in the USA (Bytzer et al. 2001; Borgnolo et al. 1996; Olowokure et al. 1999).

It is unclear why there might be higher rates of foodborne illness among minority racial/ethnic populations. While consumer handling may certainly play a role, research on the food safety knowledge and practices among minority populations has demonstrated mixed results, with high income, more highly educated, and male consumers reporting engaging in more risky food handling and consumption practices (Patil et al. 2005). To date there is no evidence which clearly links the persistence of food deserts with increased risk for foodborne illness. There is, however, data emerging which may indicate that at the very least food deserts may result in poorer sanitation and refrigeration at the retail level because of the limitations, challenges, and lack of resources small retailers face in comparison to chain supermarkets. Presently in the literature there are three ways to attempt to assess differences in the potential safety, sanitation, and cleanliness among small retail markets when compared to chain supermarkets. The first is to sample, test, and compare microbial quality and potential safety of perishable food products from the different types of stores. The second is to use existing data regarding inspection scores and critical code violations and compare the data for small retailers and chain supermarkets. A third potential method is to retrospectively determine where those who have been diagnosed with a foodborne illness obtained their food. There is limited data emerging for each of these approaches—the pros and cons of each and the data available to date are discussed below.

11.4 Comparison of Microbial Quality and Potential Safety of Food Available at the Retail Level to Different Populations

There is a paucity of data regarding the microbial quality and/or safety of foods available in small independently owned markets located in food deserts. Koro et al. performed a longitudinal study over a 15 month period comparing product quality in three supermarkets in high SES census tracts and one supermarket and two independently owned grocery stores in low SES census tracts. Each store was visited monthly and the microbial quality of a range of fresh produce, dairy and meat and poultry products was determined. Higher microbial loads were found on produce from markets in low SES areas (Table 11.1) Specifically, ready to eat (RTE) bagged greens, strawberries, and cucumbers had significantly higher yeast and mold counts (Y&M) and RTE greens and strawberries also had significantly higher Aerobic Plate Counts (APC). The presence of the pathogens *Salmonella* and *Campylobacter* on raw chicken leg samples from high SES markets and low SES markets were not statistically different, consistent with the concept that the introduction of these pathogens is at the level of the farm or processing facilities.

Table 11.1 Comparison of microbial counts on products purchased in high vs. low SES neighborhoods

Sample type	Aerobic plate count (Log_{10} CFU/g)		Yeast and mold count (Log_{10} CFU/g)		Total coliform count (Log_{10} MPN/g)	
	High SES	Low SES	High SES	Low SES	High SES	Low SES
RTE salads	6.2 ± 0.7*	6.7 ± 0.8*	6.3 ± 0.5*	7.0 ± 0.7*	1.9 ± 1.4	2.0 ± 1.2
Broccoli	4.3 ± 1.4	4.3 ± 0.9	4.6 ± 1.3	4.9 ± 0.9	0.6 ± 0.8	0.5 ± 0.7
Watermelons	4.3 ± 1.9	4.8 ± 1.6	3.0 ± 1.5	3.6 ± 1.4	1.4 ± 1.1	1.7 ± 1.3
Strawberries	3.3 ± 0.9*	3.9 ± 1.2*	4.1 ± 1.1*	4.9 ± 0.6*	ND	ND
Cucumbers	5.8 ± 0.9	6.2 ± 1.1	3.7 ± 0.9*	4.4 ± 1.2*	2.1 ± 1.1	2.6 ± 1.2
Orange juice	1.2 ± 0.9	0.9 ± 0.2	ND[a]	ND[a]	ND[a]	ND[a]
Milk	2.1 ± 0.8	2.4 ± 0.9	2.0 ± 0.8	2.2 ± 1.1	ND[a]	ND[a]
Ground beef	6.7 ± 0.6*	6.3 ± 0.6*	–[b]	–[b]	3.0 ± 1.0	2.9 ± 0.8

*$p < 0.05$
[a]ND = None detected
[b]Not determined

Eighty percent lean ground beef was found to have a significantly higher APC when purchased in markets from high SES census tracts but coliform counts between ground beef from markets in the high and low SES tracts were not significantly different (Koro et al. 2010).

Signs et al. performed a larger cross-sectional study over a 2 year period and sampled a range of perishable food products from retail food stores present in census tracts representing each of the following demographic categories: (1) Caucasian, (2) African American, (3) Asian, (4) Hispanic, (5) High SES, and (6) low SES. Approximately 60 stores in tracts representing each demographic category were sampled. Products sampled included lunchmeat, sandwiches, RTE fruit, RTE greens, herbs, milk, and eggs. Results indicated increased risks for improperly held eggs in markets in Asian census tracts as well as increased risks for fecal coliform contamination on RTE greens, herbs, and fruit purchased in markets in Asian or low SES census tracts (Table 11.2). Sandwiches from markets in Asian tracts were also significantly more likely to be contaminated with fecal coliforms when compared to sandwiches from markets in Caucasian census tracts. Additionally, while temperatures at time of sampling were not significantly different, APCs were significantly higher in milk samples from low SES and Hispanic tracts when compared to milk samples from high SES tracts. Hoagie sandwiches purchased from markets in high SES markets had significantly higher coliform counts than hoagie sandwiches purchased in all other census tracts, but there were not significant differences in the presence of fecal coliforms or *Staphylococcus aureus* in sandwiches from any tracts (Signs et al. 2011). It is interesting that while both of these studies found poorer quality produce (and therefore high nutritional quality food) available to low SES and minority populations, they also both found higher microbial quality meat products (ground beef and hoagie sandwiches).

Table 11.2 Results of microbial testing for indicator organisms and pathogens on RTE food products sampled from markets in census tracts representing different population demographics. Means or percentages with the same capital letter within the same food product/column are significantly different ($p \leq 0.05$)

Food product	Tract category	Levels of Total coliforms[a]		Percentage of positive samples Fecal coliforms		*S. aureus*
Sandwiches	Caucasian ($n=117$)	2.6 ± 1.5	a,b	17.9	a	8.5
	African American ($n=112$)	2.5 ± 1.3	c	21.4		8.9
	Asian ($n=66$)	2.6 ± 1.4	d	33.3	a	10.6
	Hispanic ($n=96$)	2.2 ± 1.5	a,e	26		5.2
	High SES[b] ($n=110$)	3.2 ± 1.5	b,c,d,e,f	22.7		7.3
	Low SES ($n=60$)	2.3 ± 1.5	f	21.3		5.3
Lunchmeat	Caucasian ($n=58$)	1.0 ± 1.3		10.3		3.4
	African American ($n=58$)	1.1 ± 1.2		10.3		5.2
	Asian ($n=38$)	1.1 ± 1.1		7.9		2.6
	Hispanic ($n=57$)	1.2 ± 1.4		19.3		3.5
	High SES ($n=55$)	0.9 ± 1.0		12.7		5.5
	Low SES ($n=49$)	0.9 ± 1.1		14.3		2
RTE fruit	Caucasian ($n=16$)	2.0 ± 1.3		18.8		18.8
	African American ($n=6$)	2.8 ± 1.7		16.7		ND[c]
	Asian ($n=29$)	2.5 ± 1.7		27.6	a	ND
	Hispanic ($n=8$)	2.4 ± 1.8		ND		12.5
	High SES ($n=57$)	2.2 ± 1.2		10.5	a	7
	Low SES ($n=13$)	2.6 ± 1.7		30.8		ND
RTE greens	Caucasian ($n=11$)	3.6 ± 1.1	a,b	45.5	a	9.1
	African American ($n=2$)	4.4 ± 0.0	c	ND	b	ND
	Asian ($n=28$)	4.1 ± 0.7	d	71.4	c	ND
	Hispanic ($n=4$)	2.1 ± 1.8	a,c,d,e,f	25	d	ND
	High SES ($n=46$)	4.0 ± 0.7	e	26.1	c,e	8.7
	Low SES ($n=7$)	4.4 ± 0.0	b,f	100	a,b,d,e	ND

[a]Means Log_{10} MPN/g ± SD
[b]SES = Socioeconomic status
[c]ND = None detected

A pilot study in Baltimore, MD, attempted to compare the prevalence of *S. aureus* and *E. coli* in raw chicken and ground beef between small and large stores in areas of high food access (HFA) and areas of LFA. Overall, results of the prevalence of *S. aureus* and *E. coli* in meat available in this urban area were within the ranges of other recent retail studies. While the data appeared to indicate that small stores were more likely to carry meat and poultry contaminated with the organisms, the researchers were not able to attain a sufficient sample size for statistical analysis. This was a result of the challenge of locating equal numbers of stores carrying raw meat and poultry in both HFA and LFA areas (Silbergeld et al. 2013). This research highlights the challenges, therefore, of assessing differences in food safety through sampling and microbial testing at the retail level.

Limitations of the types of studies described above include the large number of samples which must be obtained and tested in order to obtain statistically significant results. Additionally, given the sporadic nature of the contamination of food with pathogens such as *E. coli* O157:H7 and *Listeria* it is unlikely such studies could ever detect differences in risk exposure for these pathogens. Finally, even when large enough to detect significant differences, studies such as those described above may still only represent a very limited geographic region and may not be able to be extrapolated to all food desert environments.

11.4.1 Qualitative Research with Consumers and Retailers

Qualitative research with low-income consumers identified the internal store environment and product quality as two of the five themes consumers revealed as concerns regarding purchasing produce. Consumers reported store cleanliness to be associated with the perception of fresh food and larger chain stores were perceived as cleaner than smaller, non-chain stores. One low-income consumer's comment when discussing smaller corner stores declared "here sometimes you have to blow the dust off and check the date" (Webber et al. 2010).

A survey of owners and managers of non-supermarket food retailers found that a percentage of retailers reported "self-supplying"—that is purchasing product from a supermarket or warehouse and transporting it themselves to their store. Milk was reported as self-supplied by 15 % of the retailers interviewed and fresh fruits and vegetables were reported as self-supplied by 78 % of the retailers (Andreyeva et al. 2011). This transport of food in unrefrigerated, personal vehicles between retail outlets certainly represents an unsafe branch in the farm to fork continuum that consumers who purchase these products are exposed to.

11.4.2 Unique Cultural Foods

It should be noted that in addition to poorer quality mainstream food products, another potential risk for populations accessing food from small, particularly ethnic, retailers may be the presence of unique cultural foods, about which safety of the products is unknown. There is precedence for this with the example of fresh Mexican cheese consumed by Hispanic populations resulting in increased listeriosis among those populations (MacDonald et al. 2005). A recent survey of Public Health Inspectors found that 60 % of respondents reported at least one such specialty food product that they did not feel confident about their knowledge of its safety and 64 % of respondents could identify at least one such specialty product about which they did not feel there is enough food safety information currently available (Pham et al. 2010).

11.4.3 Live-Bird, Live Animal-Slaughter, and Farmers Markets

The preference to purchase meat and poultry at Live-Bird and Live Animal-Slaughter markets (LBM) and (LAM), respectively, by minority racial and ethnic populations for cultural or religious reasons has also been noted in the literature (Henley et al. 2012; Imanishi et al. 2014). This practice has increasingly been associated with outbreaks of Salmonellosis. Living in a household where meat purchased from a LBM or LAMs is handled or consumed appears to be risk factor for Salmonellosis (Imanishi et al. 2014). While these facilities are inspected and must meet sanitation standards set by local authorities, most are exempt from Food Safety and Inspection Service pathogen reduction performance standards. Similarly many poultry vendors at farmers markets are exempt from pathogen reduction performance standards (USDA-FSIS 2006). A comparison of the prevalence of pathogens on raw poultry from farmers markets and supermarkets found that whole chicken from farmers markets was commonly contaminated with *Salmonella* (28 %) and *Campylobacter* (90 %). This contamination rate was greater than that seen for *Salmonella* and *Campylobacter* on either conventionally processed organic (20 % and 28 %, respectively) or nonorganic chicken (8 % and 52 %, respectively) purchased in supermarkets (Scheinberg et al. 2013). Increased presence of pathogens and increased outbreaks associated with poultry purchased at the retail level from small vendors exempt from USDA performance standards indicates a need for greater food safety training for both retailers and consumers handling such products.

11.5 Food Safety Code Compliance by Retail Facilities in Food Deserts

Food retailers that operate in underserved areas with high poverty levels face a number of barriers and challenges. These have been identified as including, but not limited to, high costs associated with security and insurance, challenges to recruitment and retention of employees as well as transportation infrastructure (Food Marketing Institute 2011). In urban areas congestion and very small streets may present challenges to delivery, especially of perishable products, while in rural areas long distances from distribution centers may make delivery cost prohibitive. Additionally, it is known that food desert census tracts tend to have smaller populations with lower incomes (and therefore potentially an inadequate demographic base to support a medium or large-sized market) as well as higher rates of abandoned or vacant homes (Food Marketing Institute 2011). Abandoned or vacant homes may lead to sanitation challenges in that they may serve as a breeding ground for pests and/or rodents. Pothukuchi et al. investigated why a report of higher prevalence of food safety violations in stores in poorer neighborhoods and with higher populations of African Americans might exist. Similar to the more recent FMI report, they suggested that poor infrastructure, crime, and employee turnover likely all contributed to challenges for small retailers (Pothukuchi and Mohamed 2008). In addition to time and money, Yapp et al. identified potential barriers to food safety compliance to include lack of trust in food safety regulations and compliance, as well lack of motivation, knowledge, and understanding of food safety legislation (Yapp and Fairman 2004). These findings would all imply the likelihood that small independent markets would have more critical and non-critical code violations. Kwon et al. found this to be true for ethnic restaurants in Kansas, with significantly more violations reported in ethnic restaurants for categories including time and temperature controls, physical facility maintenance, protection from contamination, and demonstrated knowledge (Kwon et al. 2010).

Geographic Information Systems (GIS) technology has been used extensively to map the access different populations have to different types of retail food outlets (Charreire et al. 2010). Darcey and Quinlan used GIS technology to map critical health code violations (CHV) in retail facilities across a range of population demographics in Philadelphia, Pennsylvania. Data regarding CHV over a 3 year period was obtained from publically available health inspection data. Overall, it was found that food service facilities in higher poverty areas had a greater number of facilities with at least one CHV and had more frequent inspections than facilities in areas with lower poverty (Table 11.3). Additionally, CHV rates in census tracts with

Table 11.3 Distribution of zero/nonzero critical health code violation (CHV) establishments, average CHV, and days between inspections by poverty category

	Distribution of food service facilities w/Zero CHV rate		Critical health code violations		Days between inspections	
Neighborhood poverty (n=# of census tracts)	Zero CHV per inspection (% of area vendors)	>0 CHV per inspection (% of area vendors)	Total vendors (N)	Average CHV per inspection	Total vendors (N)	Average days between inspection
1. Low ($n=85$)	689 (46 %)	809 (54.0 %)	1,498	0.93[a]	1,039	241.2[b]
2. Low-medium ($n=95$)	1,497 (51.7 %)[c]	1,396 (48.3 %)	2,893	0.73	2,154	247.6[b]
3. Medium ($n=80$)	1,079 (44.7 %)	1,334 (55.3 %)	2,413	0.75	1,825	207.2
4. High-medium ($n=67$)	996 (44.5 %)	1,241 (55.5 %)	2,237	0.72	1,703	204.1
5. High ($n=41$)	788 (43.3 %)[c]	1,030 (56.7 %)	1,818	0.77	1,444	214.4

[a]Average CHV per inspection significantly greater for low poverty (high income) category ($p<0.001$)

[b]Average days between inspections were significantly greater for the two lowest poverty (high income) categories ($p<0.001$) when compared to all other categories

[c]The second lowest poverty category had the greatest number of facilities with zero CHVs and the highest poverty category had the lowest number of facilities with zero CHVs and these differences were found to be statistically significant when compared across all groups ($p<0.001$)

high Hispanic populations were greater than for CHV rates in tracts of any other population demographic. However, it was also seen that facilities in lower poverty areas had the highest average number of CHV per inspection, but a greater by number of days between inspections, which is counterintuitive to what would be expected if facilities in low poverty areas had more CHVs (Darcey and Quinlan 2011). These results indicate that while GIS technology may have potential applications to exploring relative safety and sanitation of retail facilities, the technology is dependent on health inspection data to be completely objective and not influenced by potential inspector bias (Medeiros and Wilcock 2006). The limitation to the use of this technology is the assumption that the number of critical code violations and/or facility overall "scores" are true predictors of food safety. The benefit of this technology is that it is less labor intensive than microbiological testing and much of the data may already be available through inspection records.

11.6 Retrospective Analysis of Food Purchasing Habits

While outbreaks of foodborne illness routinely include investigation of where food has been accessed, sporadic cases of foodborne illness are not traditionally tracked back to where food was purchased. Gillespie et al. examined laboratory surveillance data on listeriosis cases reported in England between 2001 and 2007. It was reported that incidence of listeriosis was highest in the most deprived areas of England when compared to the most affluent. Additionally, cases of listeriosis were more likely to be associated with the purchasing of foods from convenience stores or local bakers, butchers, fishmongers, and greengrocers when compared to the general public (Gillespie et al. 2010). This type of retrospective analysis, therefore, more directly links cases of foodborne illness with retail purchasing habits rather than just risks for foodborne illness (i.e., microbial contamination or inspection reports) with retail outlets. This approach may more definitively be able to be used to determine whether the food desert phenomenon contributes to increased rates of foodborne illness among populations of low SES and/or minority racial or ethnic background.

11.7 Conclusions and Needs for Further Research

It is generally agreed that differential retail food access in food deserts results in low-income and minority populations having greater access to small independently owned and convenience markets and fewer supermarkets. In addition to lower nutritional quality food, the limited data available indicate that perishable foods available in these small markets may also be of poorer microbial quality and potentially less safe. Additionally, both analysis of rates of critical code violations and empirical research have identified barriers to safe food handling and sanitation for small, independent retailers with limited resources. Only one study has retrospectively linked purchasing of food at smaller markets with listeriosis, but it would appear that this approach may hold great potential to better understand if the food desert phenomenon contributes to higher rates of foodborne illness among low-income and minority consumers.

In attempts to combat high rates of obesity and chronic diseases associated with it, many initiatives have been proposed and/or begun to increase access of affordable, nutritious food in food deserts. In addition to efforts such as Pennsylvania's Fresh Food Financing Initiative (The Reinvestment Fund 2010) and the First Lady's "Let's Move" Campaign, (Anonymous 2010) in October of 2009 the US Special Supplemental Nutrition Program for Women, Infants and Children (WIC) began giving participants vouchers for new food packages including fruit and vegetables, whole grains, and other nutritious products (Oliveira and Frazao 2009). Seemingly left out of the conversation is the fact that many of the nutritious, healthy foods being promoted are perishable products. This is especially of concern in light of increased outbreaks and incidences of foodborne illness due to fresh produce (Sivapalasingam et al. 2004). Efforts to increase the presence of perishable products in stores, neighborhoods, and homes that may lack the infrastructure to ensure proper refrigeration, sanitation, and pest control may result in unintended consequences in the form of foodborne illness or at the very least, wasted perishable products.

Policy changes may be needed to ensure proper refrigeration, transportation to, and storage of, healthy perishable products in small independent markets in food desert areas. Since proprietors of small markets do not possess the knowledge or experience of food microbiologists there is a need to include the food safety community and the food processing community in efforts to increase the nutritional quality of food available to populations of low socioeconomic and minority racial/ethnic populations.

Finally, there is a need to better understand if unique food safety risks may be present for populations in rural food deserts, as there is no research to date examining any aspect of food safety in the rural food desert environment.

References

Andreyeva T, Middleton AE, Long MW, Luedicke J, Schwartz MB (2011) Food retailer practices, attitudes and beliefs about the supply of healthy foods. Public Health Nutr 14:1024–1031

Anonymous (2010) Taking on food deserts. Let's Move Blog. http://www.letsmove.gov/blog/2010/02/24/taking-food-deserts. Accessed 20 Dec 2010

Baker E, Schootman M, Barnidge E, Kelly C (2006) The role of race and poverty in access to foods that enable individuals to adhere to dietary guidelines. Prev Chronic Dis 3:1–11

Borgnolo G, Barbone F, Scornavacca G, Franco D, Cinci A, Iuculano F (1996) A case-control study of Salmonella gastrointestinal infection in Italian children. Acta Paediatr 85:804–808

Bytzer P, Howell S, Leemon M, Young LJ, Jones MP, Talley NJ (2001) Low socioeconomic class is a risk factor for upper and lower gastrointestinal symptoms: a population based study in 15,000 Australian adults. Gut 49:66–72

Chang M, Groseclose S, Zaidi A, Braden C (2009) An ecological analysis of sociodemographic factors associated with the incidence of salmonellosis, shigellosis and E. coli O157:H7 infections in US counties. Epidemiol Infect 137:810–820

Charreire H, Salze P, Simon C, Chaix B, Banos A, Badariotti D, Weber C, Oppert JM (2010) Measuring the food environment using geographical information systems: a methodological review. Public Health Nutr 13:1773–1785

Darcey VL, Quinlan JJ (2011) Use of geographical information systems technology to track critical health code violations in retail facilities available to populations of different socioeconomic status and demographics. J Food Prot 74:1524–1530

Dutko P, Ver Ploeg M, Farrigan T (2012) USDA-ERS Characteristics and influential factors of food deserts. ERR-140, U.S. Department of Agriculture, Economic Research Service

Food Marketing Institute (2011) Access to healthier foods: opportunities and challenges for food retailers in underserved areas. http://www.fmi.org/docs/health-wellness-research-downloads/access_to_healthier_foods.pdf?sfvrsn=2. Accessed 13 Sep 2011

Gillespie IA, Mook P, Little CL, Grant KA, McLaughlin J (2010) Human listeriosis in England, 2001–2007: association with neighborhood deprivation. Euro Surveill 15:7–16

Hardnett FP, Hoekstra RM, Kennedy M, Charles L, Angulo FJ et al (2004) Epidemiological issues in study design and data analysis related to FoodNet activities. Clin Infect Dis 38(3): S121–S126

Henley SC, Stein SE, Quinlan JJ (2012) Identification of unique food handling practices that could represent food safety risks for minority consumers. J Food Prot 75:2050–2054

Hilmers A, Hilmers DC, Dave J (2012) Neighborhood disparities in access to healthy foods and their effects on environmental justice. Am J Public Health 102:1644–1654

Imanishi M, Anderson TC, Routh J, Brown C, Giuseppe C, Glenn L et al (2014) Salmonellosis and meat purchased at live-bird and animal-slaughter markets, United States 2007–2012. Emerg Infect Dis 20:167–169

Koro ME, Anandan S, Quinlan JJ (2010) Microbial quality of food available to populations of differing socioeconomic status. Am J Prev Med 38:478–481

Kwon J, Roberts KR, Shanklin CW, Liu P, Yen WSF (2010) Food safety training needs assessment for independent ethnic restaurants: review of health inspection data in Kansas. Food Prot Trends 30:412–421

Lay J, Varma J, Vugia D, Jones T, Zansky S, Marcus R, Segler S, Medus C, Blythe D (2000) Racial and ethnic disparities in foodborne illness. Infectious Diseases Society of America, Chicago

Lay J, Varma J, Marcus R, Jones T, Tong S, Medus C, Samuel M, Cassidy P, Hardnett F, Barden C (2002) Higher incidence of Listeria infections among Hispanics: FoodNet, 1996–2000. International Conference on Emerging Diseases, Atlanta

Liese AD, Weis KE, Pluto D, Smith E, Lawson A (2007) Food store types, availability and cost of foods in a rural environment. J Am Diet Assoc 107:1916–1923

MacDonald PDM, Whitwam RE, Boggs JD, MacCormack JN, Anderson KL, Reardon JW, Saar JR, Graves LM, Hunter SB, Sobel J (2005) Outbreak of listeriosis among Mexican immigrants as a result of consumption of illicitly produced Mexican style cheese. Clin Infect Dis 40:677–682

Marcus R, Rabatsky-Her T, Lay J, Mohle-Boetani J, Farley M, Shiferaw B, Hawkins M, Zansky S, Jones T, Hadler J (2002) Age, ethnic and racial disparity in Salmonella serotype Enteritidis (SE): FoodNet, 1998–2000. International Conference on Emerging Infectious Diseases, Atlanta

McKinnon RA, Reedy J, Morrissette M, Lytle L, Yaroch A (2009) Measures of the food environment: a compilation of the literature 1990–2007. Am J Prev Med 36:S124–S133

Medeiros P, Wilcock A (2006) Public health inspector bias and judgement during inspections of food service premises. Food Prot Trends 26:930–340

Moore L, Diez Roux A (2006) Associations of neighborhood characteristics with the location and type of food stores. Am J Public Health 96:325–331

Morland K, Wing S, Diez Roux A, Poole C (2002) Neighborhood characteristics associated with the location of food stores and food service places. Am J Prev Med 22:23–29

Oliveira V, Frazao E (2009) The WIC Program: Background, Trends, and Economic Issues, 2009 Edition, Economic Research Report No 73. ERS United States Department of Agriculture.
Olowokure B, Hawker J, Weinberg J, Gill N, Sufu F (1999) Deprivation and hospital admission for infectious intestinal diseases. Lancet 353:807–808
Patil S, Cates S, Morales R (2005) Consumer food safety knowledge, practices, and demographic differences: findings from a meta-analysis. J Food Prot 68:1884–1894
Pham MT, Jones AQ, Sargeant JM, Marshall BJ, Dewey CE (2010) Specialty food safety concerns and multilingual resource needs: an online survey of public health inspectors. Foodborne Path and Dis 7:1457–1462
Pothukuchi K, Mohamed R (2008) Explaining disparities in food safety compliance by food stores: does community matter? Agric Hum Values 25:319–332
Quinlan JJ (2013) Foodborne illness incidence rates and food safety risks for populations of low socioeconomic status and minority race/ethnicity: a review of the literature. Int J Environ Res Public Health 10:3634–3652
Samuel MC, Vugia DJ, Shallow S, Marcus R, Segler S, McGivern T, Kassenborg H, Reilly K, Kennedy M, Angulo F, Tauxe RV et al (2004) Epidemiology of sporadic Campylobacter infection in the United States and declining trend in incidence, FoodNet 1996–1999. Clin Infect Dis 38(3):S165–S174
Scheinberg J, Doores S, Cutter CN (2013) A microbiological comparison of poultry products obtained from farmers' markets and supermarkets in Pennsylvania. J Food Safety 33:259–264
Shiferaw B, Shallow S, Marcu R, Segler S, Soderlund D, Hardnett F, Van Gilder T (2004) Trends in population-based active surveillance for shigellosis and demographic variability in FoodNet sites, 1996–1999. Clin Infect Dis 38(Suppl 3):S175–S180
Signs RJ, Darcey VD, Carney TA, Evans AA, Quinlan JJ (2011) Retail food safety risks for populations of different races, ethnicities, and income levels. J Food Prot 74:1717–1723
Silbergeld EK, Frisancho JA, Gittelsohn J, Steeves ETA, Blum MF, Resnick CA (2013) Food safety and food access: a pilot study. J Food Res 2:108–119
Sivapalasingam S, Friedman CR, Cohen L, Tauxe RV (2004) Fresh produce: a growing cause of outbreaks for foodborne illness in the United States, 1973–1997. J Food Prot 67:2342–2353
The Reinvestment Fund (2010) Pennsylvania fresh food financing initiative. http://www.trfund.com/pennsylvania-fresh-food-financing-initiative/. Accessed 24 Feb 2014
USDA-FSIS (2006) Guidance for determining whether a poultry slaughtering or processing operation if exempt from inspection requirements of the Poultry Products Inspection Act. Food Safety and Inspection Service. Washington
USDA-ERS (2012) USDA ERS Food Access Research Atlas. http://www.ers.usda.gov/data-products/food-access-research-atlas/go-to-the-atlas.aspx#.Uw41iYU2Bj1. Accessed 24 Feb 2014
Ver Ploeg M, Breneman V, Farrigan T, Hamrick K, Hopkins D, Kaufman P, Lin B, Nord M, Smith T, Williams R, Kinnison K, Olander C, Singh A, Tuckermanty E (2009) Access to affordable and nutritious food: measuring and understanding food deserts and their consequences. Report to Congress. http://www.ers.usda.gov/publications/ap-administrative-publication/ap-036.aspx#.Uw45_4U2Bj0. Accessed 25 Feb 2014
Webber CB, Sobal J, Dallahite JS (2010) Shopping for fruits and vegetables. Food retail qualities of importance to low-income households at the grocery store. Appetite 54:297–303
Yapp C, Fairman R (2004) Factors affecting food safety compliance within small and medium-sized enterprises: implications for regulatory and enforcement strategies. Food Control 17: 42–51
Zenk SN, Schulz AJ, Israel B, James SA, Bao S, Wilson M (2005) Neighborhood racial composition, neighborhood poverty, and the spatial accessibility of supermarkets in metropolitan Detroit. Am J Public Health 95:660–667
Zenk SN, Schulz AJ, Israel B, James SA, Bao S, Wilson M (2006) Fruit and vegetable access differs by community racial composition and socioeconomic position in Detroit, Michigan. Ethnicity & Dis 16:275–280

Index

J. Farber et al. (eds.), *Retail Food Safety*, Food Microbiology and Food Safety,
DOI 10.1007/978-1-4939-1550-7