CHAPTER

15

Food Safety and Technology: Protecting Our Food

Chapter Summary

Concerns about food safety have resulted from the large number of cases of foodborne illness reported every year. Food infections result from the consumption of food containing living microorganisms, such as bacteria, whereas food intoxications result from consuming food in which microbes have secreted toxins. The body has several defense mechanisms to rid itself of harmful substances. Microbes require a precise range of temperatures, humidity, acidity, and oxygen content to thrive.

Foodborne illness can be prevented by good hygiene, proper food storage and preparation, and wise choices when traveling and dining out. Food spoilage affects a food's appearance, texture, taste, smell, and safety. Natural food-preservation techniques include salting, sugaring, drying, smoking, and cooling. Synthetic food-preservation techniques include canning, pasteurization, addition of preservatives, aseptic packaging, irradiation, and genetic modification.

Food additives are natural or synthetic chemicals added to foods to enhance their color, flavor, texture, nutrient density, moisture level, or shelf life. The GRAS list identifies the several hundred food additives approved for use by U.S. food manufacturers. Persistent organic pollutants (POPs) have been found in virtually all categories of foods. Large predatory fish contain levels of mercury that can be toxic to the nervous system. Although pesticides prevent or reduce crop losses, they are potential toxins. The Environmental Protection Agency (EPA) regulates the labeling, sale, distribution, use, and disposal of all pesticides in the United States. Recombinant bovine growth hormone is a genetically engineered growth hormone injected into meat and dairy cows to increase meat production and milk output. There are possible health concerns associated with its use. Cows and pigs that receive antibiotics have become significant reservoirs for MRSA; however, it is not spread through meat consumption.

Organic standards established in 2002 provide uniform definitions for all organic products sold in the United States. Organic foods are safer because they limit exposure to pesticides, but they are not necessarily more nutritious.

Nutrition Myth or Fact addresses the question: Genetically modified organisms: a blessing or a curse?

Learning Objectives

After studying this chapter, the student should be able to:

1. Explain what foodborne illness is and why it is of concern (pp. 592–594).

2. Discuss the microorganisms and toxin responsible for most foodborne illnesses and deaths (pp. 594–599).
3. Identify four conditions that encourage the reproduction of microorganisms in food (p. 599).
4. Discuss strategies for preventing foodborne illness at home and while eating out (pp. 600–605).
5. Compare and contrast the various methods manufacturers use to preserve foods (p. 606).
6. Debate the safety of food additives, including the role of the GRAS list (pp. 607–609).
7. Identify five steps in recombinant DNA technology and the five most common reasons that crops are genetically modified in the United States (pp. 609–611).
8. Describe the process by which persistent organic pollutants accumulate in foods (pp. 611–612).
9. Discuss the potential health concerns associated with residues from heavy metals, plasticizers, dioxins, PFASs, pesticides, growth hormones, and antibiotics (pp. 611–615).
10. Identify the key characteristics of organic foods, and compare their nutrient and residue levels with those of foods conventionally grown (pp. 615–617).

Key Terms

bacteria
biomagnification
biopesticides
cross-contamination
danger zone
food additive
foodborne illness
fungi
Generally Recognized as Safe (GRAS)
genetic modification
helminth
irradiation
parasite
pasteurization
persistent organic pollutants
pesticides
prion
protozoa
recombinant bovine growth hormone (rBGH)
recombinant DNA technology
residues
toxin
viruses

Chapter Outline

I. What Is Foodborne Illness and Why Is It a Critical Concern?

A. Foodborne illness includes any symptom or illness that is transmitted by food or water contaminated by a pathogenic microorganism, its toxic secretion, or a toxic chemical.

B. Ingestion of contaminants prompts acute illness.

1. People most at risk for serious consequences of food poisoning include the very young, the very old, pregnant women, and those with chronic disease, immunodeficiency, transplants, and cancer.

C. Reducing foodborne illness has emerged as a major public health threat in recent years.

1. Foodborne illness is emerging as a major public health issue despite the safeguards.
2. More foods are mass produced, with a greater number of ingredient sources and processing facilities.

3. Because manufacturers are not always sure of the source of their ingredients, contamination is difficult to trace.
4. Federal oversight has declined drastically over the past several decades.

Key Term: foodborne illness

Figure and Table:

Figure 15.1: Food is at risk for contamination at any of the five stages from farm to table, but following food-safety guidelines can reduce the risks.

Table 15.1: Government Agencies that Regulate Food Safety

II. What Causes Most Foodborne Illness?

A. Foodborne illness is commonly caused by several types of microorganisms or their toxins. Several types of microorganisms contaminate food.

1. Viruses are extremely tiny noncellular agents that can survive only by infecting living cells.
   - **a.** Norovirus is common and extremely contagious and comes on suddenly as gastroenteritis, which causes cramps, vomiting, and diarrhea.
   - **b.** Hepatitis A (HAV) is transmitted person-to-person via contaminated food and water. Symptoms include an inflamed liver, jaundice, mild fever, abdominal pain, and nausea and vomiting that lasts a few weeks.
2. Bacteria are cellular microorganisms that lack a true cell nucleus that reproduce either by dividing in two or by forming reproductive spores.
   - **a.** Foodborne bacterial illness occurs most commonly when we ingest pathogenic bacteria living in undercooked or raw foods or fluids.
   - **b.** *Campylobacter, Clostridium perfringens, Listeria monocytogenes, Salmonella,* and *Staphylococcus aureus* are the five top bacteria of concern in foodborne illnesses and deaths.
     - **i.** *Salmonella* is responsible for the most deaths.
3. Parasites are microorganisms that simultaneously draw benefit from and harm their hosts.
   - **a.** Helminths, including tapeworms, flukes, and roundworms, are multicellular worms.
     - **i.** These microbes infect animals that, if eaten raw or undercooked, infect humans.
     - **ii.** Symptoms can be mild or serious enough to result in death.
   - **b.** Protozoa are single-celled organisms that commonly cause waterborne illness.
     - **i.** *Toxoplasma gondii* is contracted through eating or handling contaminated meat. Illness is usually mild but can have serious consequences to unborn fetuses.
     - **ii.** *Giardia intestinalis,* a parasite that causes giardiasis, one of the most common waterborne diseases, is a diarrheal illness.
4. Fungi are plant-like, spore-forming organisms that can grow as either single cells or cellular colonies. They rarely cause food infection.
5. Prions (proteinaceous, infectious, self-replicating particles) cause bovine spongiform encephalopathy and can infect humans if they consume contaminated meat.
6. Some microbes release toxins (such as neurotoxins or enterotoxins), which cause foodborne illness.

a. Bacterial toxins, such as the bacteria *Clostridium botulinum* causes botulism, a deadly neurotoxin found in pierced or bulging cans, raw honey, and improperly home-canned foods.

i. Other bacterial toxin include *Staphylococcus aureus*, the most common, shiga toxin-producing *E. coli*, and scombrotoxic fish poisoning.

b. Fungal toxins produce poisonous chemicals called mycotoxins, which cause illness, and long-term consumption leads to organ damage or cancer. They are usually found in grains stored in moist environments.

i. Poisonous mushrooms are a highly visible fungus that cause food intoxication and can be fatal.

c. Red tides are produced by certain types of toxic algae, which can lead to a food-borne illness called paralytic shellfish poisoning. Ciguatoxins are a common marine toxin contracted from eating large fish and cause intestinal and neurological symptoms that usually resolve themselves.

d. Plant toxins can be apparent in potatoes that have turned green, which may contain solanine, a toxin that can cause illness.

B. Certain environmental conditions help microbes multiply in foods.

1. The danger zone or temperature range of rapid multiplication is from 40°F to 140°F.

2. Many microorganisms require high moisture for growth.

3. Most microorganisms prefer a small range of pH.

4. With the exception of *C. botulinum,* most microorganisms require oxygen to thrive.

Key Terms: toxin, viruses, bacteria, parasite, helminth, protozoa, fungi, prion, danger zone

Figures and Tables:

Figure 15.2: Norovirus is responsible for about half of all foodborne illness in the United States.

Figure 15.3: *Salmonella* is the second leading cause of foodborne illness, after norovirus, and the primary cause of foodborne deaths.

Figure 15.4: Tapeworms have long bodies with hooks and suckers they use to attach to a host's tissue.

Figure 15.5: Molds rarely cause foodborne illness.

Figure 15.6: Some mushrooms, such as this fly agaric, contain fungal toxins that can cause illness or even death.

Figure 15.7: The danger zone is a temperature within which many pathogenic microorganisms thrive.

Table 15.1: Government Agencies That Regulate Food Safety

Table 15.2: Five Top Bacteria of Concern in Foodborne Illness and Deaths

III. How Can You Prevent Foodborne Illness?

A. When preparing foods at home, follow four simple rules: clean, separate, chill, and cook.

1. Wash hands, utensils, and surfaces after contact with each food.

2. Isolate raw foods and separate foods to prevent cross-contamination.

3. Store foods in the refrigerator or freezer.

a. Shop for perishable food last, checking for "sell by" or "use by" dates.

b. Within one hour of purchase, refrigerate foods wrapped in plastic.

c. Freeze foods that are not to be used within 48 hours, and thaw foods in the refrigerator or microwave.

d. Leftovers should be refrigerated within two hours of serving; one hour if they are outside at temperatures above 90°F.

e. Freeze foods in small packages, and thaw meat in the refrigerator or microwave.

f. Molds can be cut from the surface of cheese, but soft or fluid foods with mold should be discarded.

4. Cook foods thoroughly.

a. Use a meat thermometer to determine proper cooking temperatures.

b. When microwaving, cover foods, stir often, and rotate containers to prevent cold spots.

c. The safety of raw and semi-raw fish cannot be guaranteed.

d. Batters containing eggs should not be sampled.

B. Toxins are not killed by heat.

C. When eating out, take precautions to avoid foodborne illness.

1. Order foods to be cooked thoroughly.

2. When traveling to other countries, select foods and beverages carefully.

a. Carry hand sanitizer, and use it often.

b. Choose foods that are well cooked.

c. Use bottled water exclusively.

Key Term: cross-contamination

Figures and Table:

Figure 15.9: While it's important to keep a well-stocked refrigerator, it's also important to know how long foods will keep.

Figure 15.10: Food contamination can occur long after the microorganism itself has been destroyed.

IV. How Is Food Spoilage Prevented?

A. Natural methods of preserving foods have been used for thousands of years.

1. Salting, sugaring, drying, and smoking preserve food by drawing the water out of the plant or animal cell.

2. Forerunners of the modern refrigerator, natural methods of cooling have also been used for centuries and include cellars, caves, running streams, and cold pantries.

B. Modern techniques improve food safety.

1. Industrial canning extends the average shelf life of food to at least two years.

2. Pasteurization eliminates pathogens without altering taste and is particularly useful with dairy products.

3. Irradiation uses gamma rays to penetrate the food and its packaging to kill or disable microorganisms in the food.

a. Irradiated food is safe but the FDA requires that it carries a Radura symbol and a caution against irradiating the food again.

4. Innovative packaging techniques also preserve food.

a. Aseptic packaging eliminates the need to refrigerate foods and beverages such as juice.

b. Modified atmosphere packaging replaces oxygen with an inert gas and slows bacterial growth and spoilage.

c. High-pressure processing inactivates most bacteria while retaining food quality.

Key Terms: pasteurization, irradiation

Figure:

Figure 15.11: The U.S. Food and Drug Administration requires the Radura—the international symbol of irradiated food—to be displayed on all irradiated food sold in the United States.

V. What Are Food Additives, and Are They Safe?

A. Food additives can enhance a food's taste, appearance, safety, or nutrition.

1. Additives can be natural or synthetic, and can include nutrients (such as vitamins E, C, and D, or the minerals iodine and calcium) and preservatives.

2. Two preservatives that have raised health concerns are:

a. Sulfites, used in beer and wines and some processed foods, cause some to experience asthma, headaches, or other symptoms.

b. Nitrates, commonly used in processed meats, they can be converted into nitrosamines during cooking. Nitrosamines have been found to be carcinogenic in animals.

3. Flavorings are often used to replace the natural flavor that is lost during food processing.

a. Flavor enhancers have little or no flavor but accentuate the natural flavor of foods.

i. MSG is one of the most common flavor enhancers.

4. Food colorings are both natural and synthetic.

a. Tartazine is a coloring that is known to cause an allergic reaction in some.

5. Vitamins and other nutrients are added as preservatives or to add nutritive value.

6. Texturizers, stabilizers, and emulsifiers help improve and stabilize the texture of processed food.

7. Humectants and desiccants maintain the correct moisture levels of food.

B. Are food additives safe?

1. Before a new food additive can be used, the producer must provide evidence of its reasonable safety.

2. The GRAS (Generally Recognized as Safe) list identifies food additives that are considered safe.

3. The FDA's Adverse Reaction Monitoring System investigates complaints about foods.

Key Terms: food additive, Generally Recognized as Safe (GRAS)

Table:

Table 15.3: Examples of Common Food Additives

VI. How is Genetic Modification Used in Food Production?

A. Genetic modification (also called genetic engineering) alters the DNA of an organism to bring about specific changes in its seeds (or animal offspring) to enhance various qualities of a plant or food.

1. Advances in biotechnology have moved genetic modification beyond selective breeding for crops or animals.
2. Recombinant DNA technology manipulates DNA so that plants express desired traits.
3. Genetically modified organisms (GMOs) are used in agriculture to induce resistance to herbicides and pesticides, induce insect resistance, and increase the nutritional value of a crop.
4. The debate on the benefits and harm of genetically modified organisms is ongoing.

Key Terms: genetic modification, recombinant DNA technology

Figure:

Figure 15.12: Recombinant DNA technology involves producing plants and other organisms that contain modified DNA, which enables them to express desirable traits that are not present in the original organism.

VII. How Do Residues Harm Our Food Supply?

A. Residues are chemicals that remain in foods despite cleaning or processing.

1. Types of residues are of global concern: persistent organic pollutants, pesticides, and hormones or antibiotics.

B. Persistent organic pollutants (POPs) can cause illness.

1. When organic chemicals are released into the atmosphere, they eventually enter the soil and water and affect the food supply.
2. Biomagnification occurs when persistent organic pollutants become more concentrated in animal tissues as they move from one creature to another through the food chain.
3. POPs cause a range of harmful effects on the body. Some POPs are neurotoxins, some are carcinogens, and some others act as endocrine disrupters.
4. Mercury and lead are nerve toxins found in the environment.
   a. Pregnant and breastfeeding women and young children are advised not to eat large predatory fish which can have high levels of mercury.
   b. Lead exposure can cause learning and behavioral problems in children and kidney disease in adults.
5. Plasticizers found in plastic food containers and include bisphenol A (BPA) and phthalates leach into food and act as endocrine disrupters.
6. Dioxins are both carcinogens and endocrine disrupters. Dioxins accumulate in the fatty tissues of animals, so humans are primarily exposed through their dietary intake of animal fats.
7. Poly- and perfluoroalkyl substances (PFAs) that are used to limit leaking or staining are of growing concern and have been associated with organ damage, cancer, endocrine disorders, and other health problems.

C. Pesticides protect against crop losses.

1. The most common types of pesticides in food production are:
   a. Herbicides are used to control weeds and other unwanted plant growth.
   b. Insecticides are used to control insects that can infest crops.
   c. Fungicides are used to control plant-destroying fungal growth.
2. Some pesticides used today have a low impact on the environment and are not considered harmful to human health.

a. These include biopesticides, which are species specific and work to suppress, not eliminate, a pest's population.

3. Pesticides made from petroleum-based products can persist in the environment and cause various types of harm.

a. Children may be especially sensitive to pesticides.

4. Government regulations control the use of pesticides, and the EPA recommends:

a. Washing and scrubbing fruits and vegetables under running water.

b. Peeling fruits and vegetables.

c. Discarding animal fat whenever possible.

d. Eating a variety of foods from various sources.

D. Growth hormones and antibiotics are used in animals and are still very controversial.

Key Terms: residues, persistent organic pollutants (POPs), biomagnification, pesticides, biopesticides, recombinant bovine growth hormone (rBGH)

Figure:

Figure 15.13: Biomagnification of persistent organic pollutants in the food supply.

VII. Are Organic Foods Worth the Cost?

A. Organic is defined as crops, livestock, and multiple-ingredient foods that are processed in a way that protects natural resources, conserves biodiversity, and uses only approved substances.

B. To be labeled organic, foods must meet federal standards.

1. The USDA establishes standards and uniform definitions for organic food, and regulates organic farming.

a. "100% organic" products contain only organically produced ingredients.

b. "Organic" products contain 95% organically produced ingredients by weight.

c. "Made with organic ingredients" are products that contain more than 70% organic ingredients.

2. Organic foods are safer but not necessarily more nutritious.

a. To purchase organic foods on a budget, focus on buying only those foods known to have high pesticide residue.

Figure and Table:

Figure 15.14: The USDA organic seal identifies foods that are at least 95% organic.

Table 15.4: The Environmental Working Group's 2015 Shopper's Guide to Pesticides in Produce

Activities

1. Have students use their Food Composition Table supplement to compare selected nutrients for foods that are fresh, frozen, canned, or dried. Examples of nutrients that can be compared are:

a. Total Calories
b. Vitamin C
c. Sodium
d. Potassium
e. Sugar

Ask students to describe the effects of processing on the nutrient value of the foods we eat.

2. Host a tasting party. Ask students to volunteer to bring in organic foods and their nonorganic counterparts. Set up the tasting party so that only you know which foods are organic. Allow students to rate the foods they tasted for freshness and palatability and guess which foods are organic. Disclose the organic foods, and discuss the perceptions of the class.
3. Have students visit their local supermarket and check five to six products in the refrigerated section and five to six products in the produce section. Ask students to record the date of their visit, the name of the products they are investigating, and the "use by" or "sell by" date on each refrigerated product. Ask them to identify any products that have expired dates. Have students compare prices and appearance of organic and nonorganic produce. Students can share their observations with the class. Discuss the difference between "use by" and "sell by" dates and the difference between organic and nonorganic foods.
4. Have students learn about the President's Safe Food Working Group (www.foodsafetyworkinggroup.gov). As a class, develop one or more ideas to improve the safety of the nation's food supply. Ask students to submit their ideas through e-mail, Twitter, or Facebook (all venues are available through the website) and report back any responses they receive.
5. To help students understand how rapidly bacteria grow, set up the following demonstration by bringing one large clear glass jar, clear plastic bags, and jelly beans to class. Have the jelly beans counted into each of five bags as follows: bag #1: 5; bag #2: 15; bag #3: 60; bag #4: 240; and bag #5: 960. Pour bag #1 in the jar and tell the class, "If we start with 5 bacteria at optimum conditions, in 30 minutes we will have 20." Pour in the second bag. Bag #3 adds the amount of growth for 1 hour, bag #4 the additional growth at 1 ½ hours, and bag #5 at 2 hours. This explains why food must be handled safely and stored properly in a timely manner.

Diet Analysis Activity

6. Using the nutritional assessment previously completed, students should:
   a. Identify a processed food that they consumed and evaluate the ingredients list for this food to identify the ingredients they believe are food additives. Ask them to explain the function of each food additive they identify.
   b. Determine what food-safety issues are related to the food choices they made during the assessment.

Nutrition Debate Activity

7. Divide the class into the following groups: "farmers," "genetic engineers," "GMO opponents," and "general public." Have all students research genetic engineering from the point of view of their group. When research has been completed, have students present what they learned from the point of view of their group. "Engineers" and "GMO opponents" try to persuade "farmers" to their point of view. "Farmers" decide which option better meets their needs. The "general public" presents its needs and decides which group it supports.

Web Resources

FoodSafety.gov
www.foodsafety.gov

Centers for Disease Control Food Safety Homepage
www.cdc.gov/foodsafety

USDA Food Safety and Inspection Service

www.fsis.usda.gov/food_safety_education/index.asp

U.S. Environmental Protection Agency: Pesticides
www.epa.gov/pesticides

USDA National Organic Program
www.ams.usda.gov