RETAIL

FOOD SAFETY

Food Safety Hazards in Foodservice and Food Retail Establishments

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Foodborne Illness

The United States has the safest food supply in the world. However, an estimated 25-250 million illnesses and 10,000 estimated deaths occur because of eating contaminated foods each year (1995 Food Code). There are many areas within the food production chain, from the farm to the retail establishment, where foods may be contaminated and/or mishandled. It is therefore important for all areas of food production to be carefully monitored and controlled so that the risk of foodborne illness is decreased. Many foodborne illnesses occur because of mishandled foods in foodservice and food retail establishments. Since foods prepared in these establishments are the closest link to ingestion by the consumer, monitoring, and control of foodborne hazards is most critical at the foodservice and food retail end of the food production.

Foods can be contaminated by biological, chemical, or physical hazards. This publication will address each type of foodborne hazard and will focus primarily on biological hazards since they are the most common hazard in foodservice and food retail.

If you have ever had food poisoning, you know that it is an experience that you don't ever want to have again. Symptoms of foodborne illness are not pleasant and usually include one or more of the following: diarrhea, vomiting, headache, nausea, and dehydration. Foodborne illness is generally classified as an infection, an intoxication, or a toxico-infection (Figure 1).

Figure 1. Classification of foodborne illness.

Infection - Ingestion of a harmful microorganism within a food.

Intoxication - Ingestion of a harmful toxin produced within a food.

Toxico-infection - Ingestion of a harmful microorganism within a food that produces a toxin in the human body.

An infection is caused when a living microorganism is ingested as part of a food. After ingestion, the microorganism can then attach to the gastro-intestinal tract and begin to grow. This can lead to the common symptoms of foodborne illness like diarrhea. In some instances, the microorganisms may be carried in the blood stream from the gastro-intestinal tract to other parts of the body. Foodborne viruses and parasites are good examples of microorganisms that can cause infection. An example of a bacterial infection is *Salmonella* spp.

An intoxication is caused when a living microorganism grows in or on a food and produces a toxin. The food containing the toxin is then ingested and the toxin itself causes illness. A good example of a food intoxication is bacteria like *Clostridium botulinum* and *Staphylococcus aureus*. An intoxication

may also occur due to the consumption of a toxic chemical such as a cleaning chemical.

An toxico-infection is caused when a living microorganism is consumed (like an infection) and then the microorganism produces a toxin in the body, as opposed to in the food, that leads to illness. It is different from an intoxication. A good example of a food toxico-infection is from *Clostridium perfringens*.

It is important to understand that, under the right set of circumstances, anyone can become ill due to eating contaminated foods. A healthy adult may be without symptoms or may have gastro-intestinal symptoms. In most cases, the healthy adult host will recover in a few days. However, the risks and dangers associated with foodborne illness are much greater for the elderly, infants, pregnant women, and people who have a weakened immune system (Figure 2). For these groups of people, symptoms and length of foodborne illness can be much more severe, even life threatening.

Figure 2. People at greater risk of acquiring foodborne illness.

Elderly

Infants

Pregnant Women

Immuno-compromised/Weakened immune system

Foodborne illness not only affects the health of individuals who become ill, but it can also have a dramatic economic impact to the eating establishment. An estimated $7.7-23 billion dollars every year spent each year on foodborne illness in the food industry (1995 Food Code). The costs associated with foodborne disease and the damage to the reputation of the establishment can be a high price to pay.

Foodborne Hazards

Foodborne hazards are generally classified as either biological, chemical, or physical. Among these, there are over 200 foodborne hazards known that cause foodborne illness. Biological hazards are dangers from disease-causing microorganisms and from poisonous toxins that they may produce. Biological hazards are by far the most important foodborne hazard in foodservice and food retail. They are the cause for most foodborne illnesses, and include bacteria, viruses, and parasites (Figure 3). Chemical hazards include unwanted substances such as cleaning solutions and pesticides. Chemicals, as well as other non-food substances, should never be placed near food items. Physical hazards are dangers posed by the presence of particles that are not supposed to be a part of the food, such as glass, metal, or bone.

Bacterial Growth in Foods

Bacteria are the most troublesome and important biological foodborne hazard for the foodservice and food retail establishment. Bacteria are living microorganisms that are a single cell. Bacterial cells can exist in two different states: the vegetative state and the spore state (Figure 4). All bacteria live in a vegetative state which can grow and reproduce. Few bacteria are able to change into a special state called the spore state. Spores are produced when the bacterial cell is in an environment where it cannot grow (frozen foods, dried foods). Spores are not able to grow or reproduce. Instead, spores are a means of protection when bacteria are in an environmental that they cannot grow.

Bacteria are usually classified by their requirements needed for growth and as a spoilage or pathogenic microorganism. Spoilage bacteria break down foods so that they look, taste, and smell bad. They affect quality. Pathogenic bacteria are disease-causing microorganisms and, if ingested in a food, can make people ill. Both spoilage and pathogenic bacteria are important to those preparing and serving foods. Since pathogens affect food safety, they will be emphasized. Keep in mind, however, that the more effort taken to ensure that foods are safe will generally lead to a better quality food as well.

Bacteria have different required temperatures for growth (Figure 5). Psychrophiles (cold-loving) bacteria grow within a temperature range of 6-70°F. These microorganisms are particularly important since they can grow at room temperature and at refrigerated temperatures. Most psychrophilic bacteria are spoilage microorganisms, but some are patho-

Figure 3. Common biological hazards in a food retail operation.

Bacteria	Viruses
Bacillus cereus	Hepatitis A
Campylobacter jejuni	Norwalk virus group
Clostridium perfringens	Rotavirus
Clostridium botulinum	
Escherichia coli	Parasites
Listeria monocytogenes	*Anisakis spp.*
Salmonella spp.	*Crytosporidium parvum*
Shigella spp.	*Giardia lamblia*
Staphylococcus aureus	*Trichinella spiralis*
Vibrio spp.	

(From FDA Food Code, 1995)

Figure 4. The vegetative state and spore state of bacterial cells.

Presence	Vegetative state Optimal conditions	Spore state Stress conditions
Reproduction	Yes	No
Growth	Yes	No
Produce toxin	Yes	No
Resistance to stress	No	Yes
Dangerous if ingested	Yes	No

genic. The next group, mesophiles, grow between 70°F and 110°F with best growth at human body temperature (98.6°F). There are many examples of spoilage and pathogenic mesophiles. Bacteria growing above 110°F are called thermophiles. All thermophiles are spoilage microorganisms.

Bacteria also differ in their requirements for oxygen (Figure 5). Aerobic bacteria require an oxygen level normally present in the air (about 21%) for growth. These microorganisms grow only when exposed to air. Anaerobic bacteria, on the other hand, cannot tolerate any oxygen; it is toxic to them. Anaerobic bacteria grow well in vacuum packaged foods or canned foods where oxygen is not available. Facultative anaerobic bacteria can grow with or without oxygen (0-21% oxygen).

Most pathogenic foodborne microorganisms are facultative anaerobes. Microaerophilic bacteria require a specific amount of oxygen for growth. They must have between 3-6% oxygen to grow and will not grow outside this narrow oxygen range.

Bacterial Growth Cycle

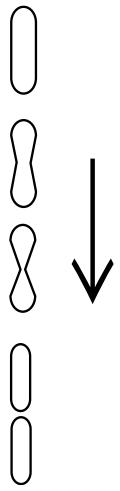
Bacteria reproduce by dividing (Figure 6). During each cycle of growth, each bacterial cell divides into two cells. This is called binary fission. The reproduction of bacteria, or increase in numbers, is referred to as bacterial growth. This means that during each growth generation, each cell gives rise to another cell.

Generation time, or time for cell numbers to double, for bacterial cells is typically 20-30 minutes but can be as quick as 15 minutes. Under optimal

Figure 5. Growth requirements for bacterial cells.

	Temperature range	Gas requirements
Psychrophile	6-70°F	-
Mesophile	70-110°F	-
Thermophile	above 110°F	-
Aerobic	-	21% oxygen
Anaerobic	-	No oxygen
Facultative Anaerobe	-	0-21% oxygen
Microaerophilic	-	3-6% oxygen

Figure 6. Reproduction of bacterial cells.



conditions, this means that a single cell can generate over 1 million cells in just 5 hours (Figure 7)! That's why it is very important not to give bacteria an opportunity to grow. Proper storage and handling of foods helps to prevent bacterial growth.

What Do Bacteria Need to Grow?

Bacteria need 6 conditions in order to grow in foods (Figure 8). They need a source of Food, an Acidic environment above pH 4.6, a Temperature between 41° and 140°F, 4 hours Time, different Oxygen requiring environments, and Moisture. Remember the requirements with the acronym F-A-T-T-O-M. Since many foods inherently contain microorganisms, we need to be sure to control these six conditions to prevent bacterial growth.

Source of Food

The presence of a suitable food supply is the most important condition affecting bacteria growth. The food must contain the appropriate nutrients needed for growth. Bacteria generally prefer foods that are high in protein like meats and dairy items (Figure 9).

Figure 7. Bacterial growth.

# of cells	1	2	4	16	>1000	>1million
Time	0	15min	30min	60min	3hr	5hr

Figure 8. Bacterial growth needs.

Food - High protein

Acid - Foods with pH 4.6 or higher

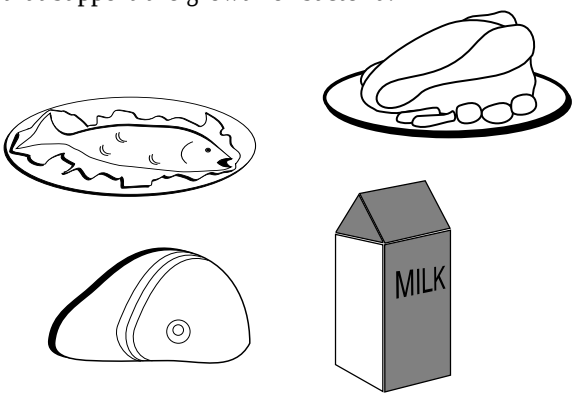
Temperature - 41°-140°F

Time - 4 hours

Oxygen - Aerobic, Anaerobic, Facultative anaerobic, Microaerophilic

Moisture - Water activity (A_w) greater than 0.85

Figure 9. Foods that support the growth of bacteria.



Acidity

Disease-causing bacteria grow at a pH of more than 4.6. The term pH is used as a symbol to designate the degree of acidity of a food. The scale for measuring pH is from 0 to 14 (Figure 10). A pH of a food that is 7.0 is neither acidic or basic and is considered "neutral". A pH less than 7.0 indicates that a food is "acidic." A pH range greater than 7.0 refers to a food that is "basic". Most foods are in the acidic range, or less than 7.0 pH.

Bacteria tend to prefer conditions that are near pH 7.0 but are capable of growing in a pH range of 4.6-7.0. There are many retail foods that fall within this range (Figure 11). Foods that are at a pH less than 4.6 will not support growth of disease-causing bacteria.

Temperature

Temperature is probably the most critical factor affecting growth of bacteria in foods. Most disease causing bacteria grow within a temperature range of 41°-140°F. This is commonly referred to as the "Temperature Danger Zone" (Figure 12).

Careful monitoring of temperature is the best way for a food retail manager to prevent bacteria from growing on foods. There is an old saying "Keep cold foods cold and hot foods hot." This means that all cold foods should be stored at less than 41°F and all hot foods held at more than 140°F (after proper cooking).

Time

Because bacteria grow in such a fast manner, it doesn't take long before many cells are produced. A rule of thumb in the food industry is that bacteria need about 4 hours to grow to high enough numbers to cause illness. This includes total time that a food is between 41°-140°F. Remember, a single bacterial cell can produce over 1 million cells in just 5 hours under ideal conditions.

Oxygen

As discussed earlier, different bacteria require different amounts of oxygen to grow. Some require a lot of oxygen (aerobic), others cannot tolerate oxygen (anaerobic), some only grow within a narrow oxygen range (microaerophilic), while others can grow with or without oxygen (facultative anaerobes).

Moisture

Just like most other forms of life, moisture is an important factor affecting bacterial growth. That's why humans have been preserving foods for thousands of years by drying them. Scientists have determined that it isn't how much moisture is in a food that most affects bacterial growth. Growth is influenced most by the amount of "available water" which is designated with the symbol A_w.

A_w is water that is not bound to the food and is available for bacterial growth. A_w is measured on a scale from 0-1.0. Disease causing bacteria can only grow in foods with A_w greater than .85 (Figure 13). There are many preservation processes that can be done to reduce the A_w of foods including sun drying and freeze drying. The addition of salt or sugar can also be used as a means to reduce available water, however, very high amounts need to be used making this method impractical.

Figure 10. The pH scale.

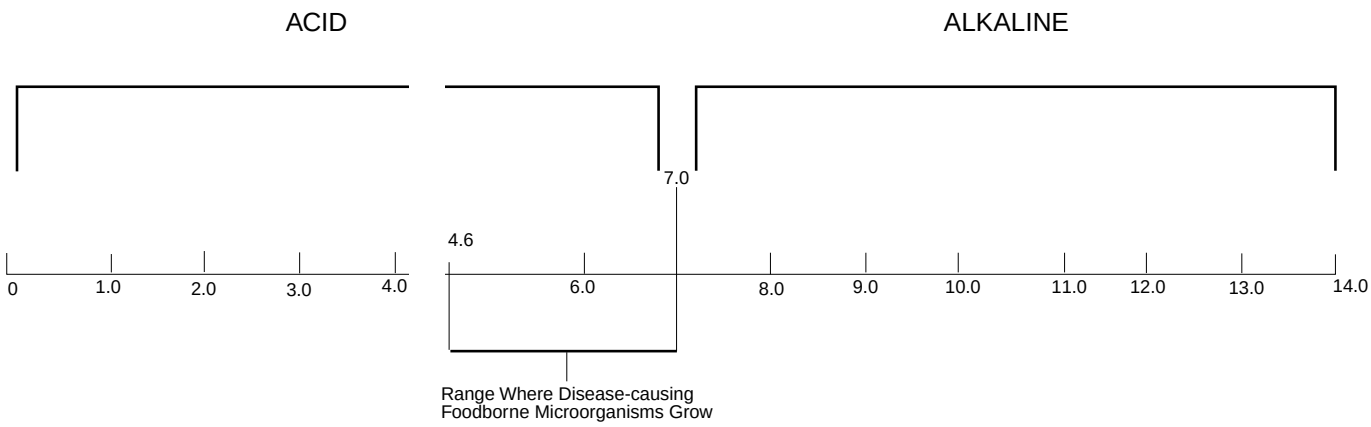


Figure 11. Acidity range of common foods prepared in food retail establishments.

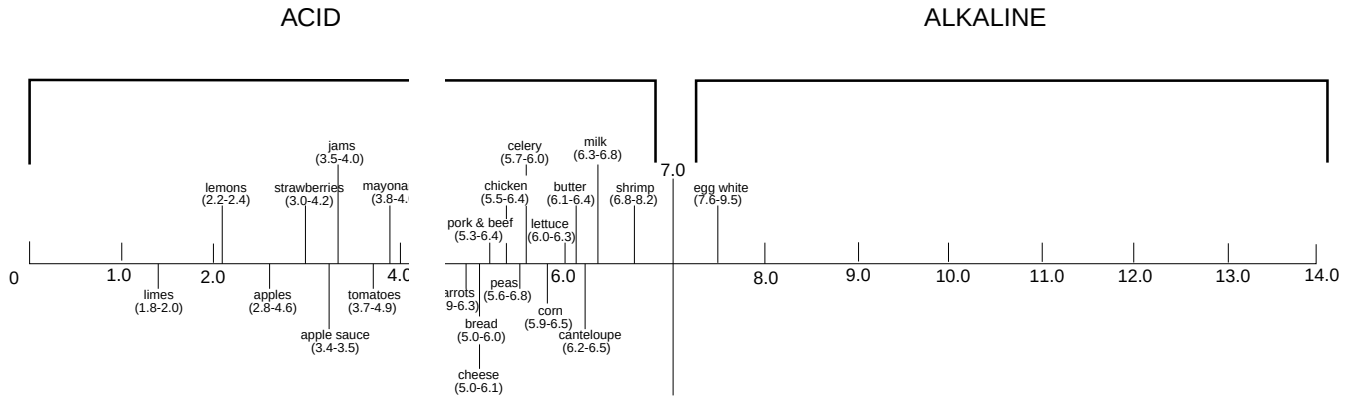
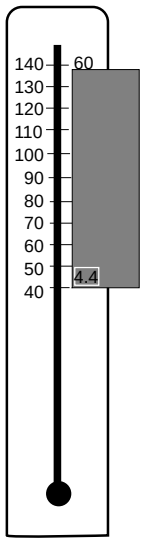
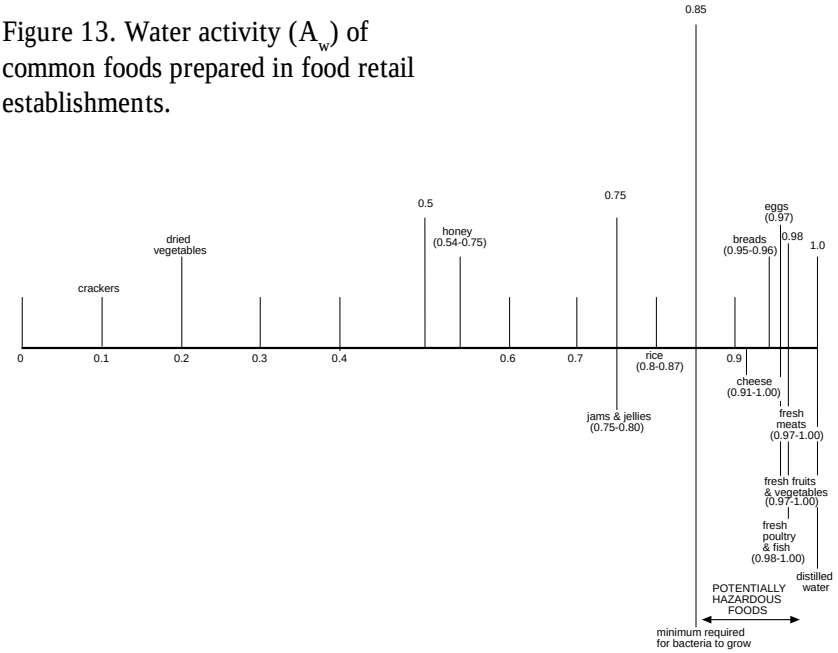


Figure 12. The Temperature Danger Zone.



40-140°F range where disease-causing micro-organisms grow.

Figure 13. Water activity (A_w) of common foods prepared in food retail establishments.



Potentially Hazardous Foods

Foods that are high in protein, contain a pH greater than 4.6, and have a A_w greater than .85 are called "potentially hazardous foods." If these foods are stored between 41-140°F for enough time, they can permit the growth and/or toxin production of disease-causing foodborne bacteria. Potentially hazardous foods pose the highest risk of foodborne illness. There are many examples of potentially hazardous foods prepared in food retail establishments. For example, beef, chicken, milk, eggs, seafood etc. Therefore, it is critical to control the handling and storage of potentially hazardous foods to prevent bacterial growth.

Bacterial, Viral, and Parasitic Foodborne Hazards

Biological hazards are the greatest concern to the foodservice and food retail operator. They have been classified here as spore-forming bacteria, non-spore-forming bacteria, viruses, and parasites. In the following sections, each type of bacterial hazard is described, the common foods and route of transmission are identified, and ways to prevent the hazards are discussed.

Spore-Forming Foodborne Bacteria

The following group of bacteria can produce a spore structure. Recall that a spore structure allows a cell to withstand environmental stress such as cooking, freezing, high salt foods, dried foods, and very acidic foods. Generally, bacterial spores are not harmful if ingested. However, if conditions of the food are changed that permit the spore to turn into a vegetative cell, the vegetative cell can grow in the food and cause illness if eaten.

Spore-forming bacteria are generally found in ingredients that are grown near the soil like vegetables and spices. They can be particularly troublesome in food retail-type environments because they can survive on foods as a spore. When conditions are improved, such as the addition of dried spices to a beef stew mixture, spores can become vegetative cells.

For example, imagine that a restaurant was preparing a 10-gallon pot of chili for the next day's lunch special. All the ingredients (beans, meat, spices, tomato base) of the chili are mixed together and cooked to a rapid boil. A rapid boil will destroy all vegetative cells, but spores may survive. The chili is then kept in the 10-gallon container and allowed to cool overnight in a walk-in refrigerator. It takes the chili 8 hours to cool from 140° to below 41°F. If given enough time at the right temperature during the cooling process, spore-forming bacteria that survived the cooking process may change into vegetative cells and grow.

To keep spore-forming bacteria from changing to the dangerous vegetative state, it is critical that hot foods be maintained at 140°F or above and cold foods be maintained at less than 41°F. Cooking, reheating, and cooling of foods should also be done as quickly as possible. Important spore-forming pathogens in the food retail industry include *Bacillus cereus*, *Clostridium perfringens*, and *Clostridium botulinum.*

Bacillus cereus

Description: *Bacillus cereus* is facultative anaerobic, spore-forming bacterium that has been associated with two very different types of illnesses. Depending on the toxin that is produced from the bacteria onto the food, illness can either be associated with diarrhea or vomiting. The diarrheal illness is due to a toxico-infection and the vomiting illness is due to an intoxication.

Common foods: A wide variety of foods, including meats, milk, vegetables, and fish have been associated with the diarrheal-type disease. The vomiting-type illness is usually associated with starchy foods such as rice, potatoes, and pasta products.

Transmission in foods: Illness due to *Bacillus cereus* is most often attributed to foods that are improperly stored (cooled, hot-held) to permit the conversion of spores to vegetative cells. Vegetative cells then produce the toxin or grow to high enough numbers in the food to cause illness.

Prevention: Foods must be cooked and cooled rapidly.

Clostridium perfringens

Description: *Clostridium perfringens* is an anaerobic, spore-forming bacterium that is one of the most commonly reported causes of foodborne illness, especially for foods that have been temperature abused. *Clostridium perfringens* causes illness due to an toxico-infection where the ingested cells produce a toxin in the human intestinal tract.

Common foods: The microorganism is widely distributed in foods, especially spices. It is often implicated in meat dishes and dishes containing gravy. Gravy can create an anaerobic environment which allows the microorganism to grow.

Transmission in foods: Illness due to *Clostridium perfringens* is most often attributed to foods that are temperature abused. Foods that are improperly cooled (food in the temperature danger zone for greater than 4hrs.) and then not reheated properly create an ideal condition for the growth of *Clostridium perfringens*.

Prevention: Foods must be cooked and cooled rapidly.

Clostridium botulinum

Description: *Clostridium botulinum* is an anaerobic, spore-forming bacterium that causes foodborne intoxication due to improperly heat processed foods (especially home-canning). The microorganism produces a neurotoxin which is one of the most toxic biological substances known to humans.

Common foods: Foods with a pH greater than 4.6, that are not properly heat processed and then packaged anaerobically (can or vacuum pouch), and held at above 41°F. A good example would be improperly home-canned foods.

Transmission in foods: Illness due to *Clostridium botulinum* is almost always attributed to ingestion of foods that were not heat processed correctly and packaged anaerobically.

Prevention: Discard damaged cans. Do not can or vacuum package foods in a food retail establishment.

Nonspore-Forming Foodborne Bacteria

The following group of bacteria are not capable of producing a spore structure; they are always in the vegetative state. Compared to spore-forming bacteria that are in the spore state, vegetative cells are easily destroyed by proper cooking. There are numerous examples of nonspore-forming foodborne bacteria that are important in the food retail industry.

Campylobacter jejuni

Description: *Campylobacter jejuni* is considered by many food scientists as the number one agent that causes foodborne illness. The microorganism, which causes infection, is unique compared to most other foodborne pathogens because it has a very strict gaseous requirement for growth. It is classified as a microaerophile because it can tolerate only 3-6% oxygen for growth. The infective dose for *Campylobacter jejuni* is foods is low.

Common foods: This microorganism is commonly found in raw milk and in raw chicken. Some scientists estimate that *Campylobacter jejuni* may be present in nearly 100% of retail chickens.

Transmission in foods: *Campylobacter jejuni* is often transferred from raw meats to other foods by cross-contamination. This is typically done by transfer from a food contact surface (such as a cutting board) or from food worker's hands.

Prevention: Cook raw meats properly. Do not use raw (unpasteurized) milk. Thoroughly clean food contact surfaces (cutting boards) and hands after handling raw foods.

Escherichia coli

Description: The *Escherichia coli (or E. coli)* group of bacteria includes four strains of foodborne pathogens; enterotoxigenic *E. coli*, enteropathogenic *E. coli*, enterohemorragic *E. coli*, and enteroinvasive *E. coli.* The most important of the group is a particular type of enterohemorrhagic *E. coli* called *E. coli* 0157:H7. This is a facultative anaerobic bacterium that can be found in the intestines of warm blooded animals. Illness can be due to an infection and a toxico-infection. Illness due to *E. coli* 0157:H7 is particularly serious in infants because it can cause kidney failure and bloody diarrhea.

Common foods: This microorganism has been isolated from raw milk and raw ground beef.

Transmission in foods: *E. coli* is usually transferred to foods like beef by contact with the intestines of animals. Transmission can also occur if employees are carriers and do not wash their hands properly after going to the bathroom.

Prevention: Cook hamburger patties until well done or until all the juices run clear. Do not use raw milk products. Make sure that employees practice good personal hygiene.

Listeria monocytogenes

Description: *Listeria monocytogenes* is a facultative anaerobic bacterium that causes foodborne infection. It is important to food retail operations because it can survive under many conditions such as high salt foods. Unlike many other foodborne pathogens, it can grow at refrigerated temperatures below 41°F. Listeriosis, the illness caused by *Listeria monocytogenes*, usually causes gastro-intestinal symptoms for the healthy adult. However, disease complications can be life threatening (septicemia, meningitis, encephalitis) for people with weakened immune systems.

Common foods: This microorganism has been isolated from many foods and is most common in raw meats, raw poultry, dairy products (cheeses, ice cream, raw milk), raw vegetables, and seafood.

Transmission in foods: Transmission to foods can occur by cross-contamination. Also, foods that are not cooked properly can contain live cells.

Prevention: Cook foods thoroughly. Practice good personal hygiene.

Salmonella spp.

Description: *Salmonella* is a facultative anaerobic bacterium that frequently causes a foodborne infection. Like *E. coli*, the source for *Salmonella* is the intestinal tracts of warm blooded animals.

Common foods: This microorganism exists in many foods, especially raw meat and poultry products, eggs, milk, dairy products, pork, milk chocolate, and cream- filled desserts.

Transmission in foods: Transmission to foods is very common by cross contamination from raw foods (especially poultry), from food contact surfaces (cutting boards), or from food handlers.

Prevention: Cook foods thoroughly. Practice good personal hygiene, and clean and sanitize food contact surfaces after use with raw foods.

Shigella spp.

Description: *Shigella* is a facultative anaerobic bacterium that causes about 10% of foodborne illnesses in the U.S. The microorganism is frequently found in the intestines of humans and warm blooded animals. The microorganisms can cause an infection or toxico-

infection. A common illness caused by *Shigella* is bacillary dysentery.

Common foods: This microorganism is common in ready-to-eat salads (i.e. potato, chicken), milk and dairy products, poultry, and raw vegetables.

Transmission in foods: Water that is contaminated by fecal material and unsanitary handling by food workers are common transmission routes.

Prevention: Practice good personal hygiene and wash foods with potable water supply (suitable for drinking).

Staphylococcus aureus

Description: *Staphylococcus aureus* is a facultative anaerobic bacterium that produces a very heat-stable toxin as it grows on foods. It is therefore an example of an intoxication. The microorganism is normally present on human skin, hands, and nasal passages, and can be transferred to foods easily. It also survives in high salt conditions.

Common foods: This microorganism is common to cooked ready-to-eat foods, salads, meats and poultry products, custards, and high salt foods (like ham), and milk and dairy products.

Transmission in foods: Since humans are the primary source, cross-contamination from the worker's hands is the most common way the microorganism is introduced into foods. Foods requiring large amounts of food preparation and handling are especially susceptible.

Prevention: Practice good personal hygiene. Keep ready-to-eat foods out of the temperature danger zone.

Vibrio spp.

Description: There are three species within the *Vibrio* group of bacteria that cause been implicated in foodborne infections. They include *Vibrio cholera, Vibrio parahaemolyticus, and Vibrio vulnificus.* All are important since they are very resistant to salt and are common in seafood.

Common foods: *Vibrio spp*. are commonly found in raw, under-processed, improperly handled, contaminated fish and shellfish. These bacteria are generally found more in the summer months and from warmer waters.

Transmission in foods: Since the microorganism exists in many raw seafood, transmission to other foods by cross contamination is a concern. Most illnesses are caused due to eating raw or undercooked seafood, especially oysters.

Prevention: Cook seafood properly. Avoid consumption of raw seafood. Practice good personal hygiene.

Foodborne Viruses

Foodborne viruses differ from foodborne bacteria. They are the smallest and simplest form of life known. Viruses require a living host (animal, plant, or human) to grow and reproduce. Unlike bacteria, they do not reproduce or grow in foods. They are usually transferred from one food to another, from a food handler to a food, or from a water supply to a food. There are three viruses that are important in food retail preparation; Hepatitis A, Norwalk virus, and rotavirus.

Hepatitis A

Description: Hepatitis A is a foodborne virus that is associated with many foodborne infections. It is a particularly important hazard to retail food establishments because it has an incubation period of 10-45 days. This means that a food worker can harbor the microorganism for up to 6 weeks and not show symptoms of illness. However, during this time, the food worker can contaminate foods and other workers in the food retail establishment.

Common foods: Ready-to-eat foods that are washed with a non-potable water supply or foods that are handled excessively can be contaminated with Hepatitis A. Examples include raw vegetables and raw seafood. Due to the long incubation period, it is very difficult to identify the food source of a Hepatitis A infection.

Transmission in foods: The virus is primarily transmitted from person-to-person contact, by cross contamination, and by fecal contamination.

Prevention: Handle and cook foods properly. Avoid consumption of raw seafood. Practice good personal hygiene.

Norwalk virus group, Rotavirus

Description: The Norwalk virus and rotavirus are other common foodborne viruses that are associated with many foodborne infections, with some outbreaks involving up to 3000 people.

Common foods: Raw seafood. Raw fruits and vegetables that are washed with a contaminated water supply. Non-heated foods that are handled by people who are shedding the virus.

Transmission in foods: The virus is transmitted from person-to-person contact and by fecal contamination.

Prevention: Handle and cook foods properly. Avoid consumption of raw seafood. Practice good personal hygiene.

Foodborne Parasites

Foodborne parasites are another important foodborne biological hazard. Parasites are small or microscopic creatures that need to live on or inside a host to survive. There are many examples of parasites that can enter the food system and cause foodborne illness. Included here are a list of a few of the most troublesome ones that may appear in food retail establishments. Parasitic infection is far less common than bacterial or viral foodborne illness.

Anisakis spp.

Description: Anisakis spp. are nematodes (or roundworms) that have been associated with foodborne infection.

Common foods: They generally cause foodborne disease through consumption

of raw or undercooked seafood. The most common foods include seafood such as cod, haddock, fluke, salmon, herring, flounder and monkfish.

Transmission in foods: This parasite is transferred in the water in which the marine animal lives. This parasite may also be transferred to other foods by improper food handling.

Prevention: Handle and cook seafood properly.

Crytosporidium parvum, Giardia lamblia

Description: *Crytosporidium parvum* and *Giardia lamblia* are single cell microorganisms called protozoa. They can cause foodborne infections. These microorganisms are important because they are common causes of non-bacterial diarrhea in the United States.

Common foods: These parasites are most commonly associated with the consumption of contaminated water. Raw foods that are in contact with contaminated water, especially raw vegetables, can also be contaminated.

Transmission in foods: These parasites are transmitted from a contaminated water supply, person-to-person contact and by fecal contamination.

Prevention: Handle and cook foods properly.

Trichinella spiralis

Description: *Trichinella spiralis* is a foodborne roundworm that can cause parasitic infection.

Common foods: Pork is by far the most common food which carries *Trichinella spiralis*. It can also be found in bear meat.

Transmission in foods: This parasite is inherently carried by animals. It is generally thought that a possible route to the animal is through consumption from eating infected tissues from other animals and garbage.

Prevention: Cook pork until there are no signs of pink and always cook meats properly.

Chemical Hazards

Chemical hazards are usually classified as either naturally occurring chemicals or added chemicals (Figure 14). Naturally occurring chemicals include toxins that are produced by a biological organism. Added chemicals include chemicals that are intentionally or non-intentionally added to a food.

Figure 14. Common chemical hazards in a food retail operation.

Naturally occurring:
Ciguatoxin
Mycotoxin
Scombrotoxin
Shellfish toxins
Added chemicals:
Cleaning solutions
Food additives
Pesticides
Heavy metals

(From 1995 Food code)

Naturally Occurring Chemicals

Ciguatoxin

Description: Ciguatoxin is an example of a fish poisoning intoxication from the consumption of tropical fish. The origin of the toxin is from tiny sea creatures called algae. The toxin is heat stable and is not destroyed by cooking. Different marine fish ingest algae containing toxin, and the toxin accumulates in the fish over time. Symptoms of ciguatoxin poisoning include common foodborne illness symptoms and unique symptoms including weakness and slight paralysis of the mouth, tongue, throat, hands, and feet.

Common foods: Marine finfish most commonly cause ciguatoxin poisoning. Common marine species include barracudas, groupers, jacks, mackerel, snappers, and triggerfish.

Transmission in foods: The toxin is transferred to finfish after ingestion of toxin containing algae.

Prevention: The toxin is not destroyed by cooking, therefore, prevention can be very difficult. Purchasing seafood from a reputable supplier is the best preventative measure.

Scombrotoxin

Description: Scombrotoxin, also called histamine poisoning, is caused by eating foods high in a chemical compound called histamine. Histamine is usually produced by bacteria when they decompose foods. Histamine is not destroyed by cooking. Unique symptoms of illness include dizziness, a burning sensation, a facial rash or hives, and a peppery taste in the mouth.

Common foods: The most common foods causing scombrotoxin include tuna and mahi-mahi fish. Swiss cheese has also been implicated.

Transmission in foods: Over time, bacteria that are present in a particular food can break down histidine in food and cause the production of histamine. Temperature abuse also leads to more histamine production.

Prevention: Purchase seafood from a reputable supplier. Store seafood below 41°F and do not accept seafood that has been previously thawed.

Shellfish toxins

Description: There are numerous examples of shellfish toxins. The most common include Paralytic Shellfish Poisoning (PSP), Diarrheic Shellfish Poisoning (DSP), Amnesic Shellfish Poisoning (ASP), and Neurotoxic Shellfish Poisoning (NSP). All involve an accumulation of toxins produced in shellfish.

Common foods: Any shellfish may contain any of the toxins. PSP is more common with mussels, clams and scallops. DSP is more common with mussels, oysters, and scallops. ASP is

more common with mussels. NSP is common for Gulf Coast marine animals.

Transmission in foods: Inherent to marine shellfish.

Prevention: Purchasing food from a reputable supplier.

Mycotoxins

Another group of foodborne microorganisms that can cause disease include fungi. Fungi include both molds and yeasts. They differ from bacteria in that they are larger in size and usually prefer foods that are high in sugar or starches. They can often withstand more extreme conditions (highly acidic foods, lower A_w foods) compared to bacteria.

Foodborne molds are important because they can produce chemical compounds called mycotoxins. Mycotoxins have been linked to cancer. Yeasts do not cause foodborne illness.

There are several molds that produce mycotoxins. An important and common foodborne mycotoxin, called aflatoxin, is produced by *Aspergillus* spp. Mycotoxins are commonly found in dry and/or acidic foods. Common foods containing mycotoxins include corn, nuts, and grains . Many mycotoxins are not destroyed by cooking.

Added Chemicals

There is a long list of chemicals that are added to foods which can pose a health risk. Intentionally added chemicals may include food additives, food preservatives, and pesticides. Pesticides leave residues on fruits and vegetables, and can usually be removed by a vigorous washing procedure or by peeling off the skin. Use of intended food additives is regulated by the Food and Drug Administration and Environmental Protection Agency to assure that they are safe. Non-intentionally added chemicals may include contamination by chemicals such as cleaning compounds.

Physical Hazards

Physical hazards can enter the food system and cause foodborne illness (Figure 15). Animal bones are a good example of a particle that can easily be part of a food such as ground beef. Stones, rocks or wood particles can be associated with raw fruits and vegetables. For physical hazards, it is important to wash all raw fruits and vegetables thoroughly and visually inspect foods that cannot be washed (such as ground beef).

Figure 15. Common physical hazards in a food retail operation.

Bone particles
Glass
Metal
Stone
Wood

(From 1995 Food Code)

Conclusion

There are many foodborne hazards that a food retail establishment may encounter. Food retail operations are typically toward the end of the food production chain because foods are prepared and eaten there. It is very important to control activities in these operations and prevent foodborne hazards that could lead to foodborne illness. Control and prevention of foodborne hazards in a food retail establishment starts with understanding the different types of foodborne hazards. The next step is to understand how to control foodborne hazards with good personal hygiene, prevention of cross contamination, as well as proper storage, cooking, cooling, and reheating of foods.

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