Summary of Food Hazards and Contamination

Food Hazard

A food hazard is defined as anything that could contaminate food and cause illness or injury, or could otherwise violate established food safety program criteria if left uncontrolled.

Understanding the hazards that contribute to foodborne illness and injury is important to determine the necessary steps to prevent, reduce to an acceptable level, or eliminate altogether hazards before food reaches the consumer.

In retail food establishments, there are three categories of hazards which contribute to foodborne illness and injury:

1. Physical
2. Chemical
3. Biological

1. Physical Hazards

A physical hazard is any foreign matter unintentionally introduced to food or a naturally occurring object which could cause illness or injury to the person consuming the food item.

Examples of physical hazards could include bones in fish, flaking paint, hair, dirt, metal fragments, and nails. Sources for contaminants include raw materials, badly maintained facilities and equipment, improper production procedures, and poor employee practices.

2. Chemical Hazards

Natural and manufactured chemicals can cause people to become sick if they have contaminated food at the source or during processing. Chemical hazards can be divided into two categories: chemical agents and toxic metals.

Chemical agents include cleaning or sanitizing agents, pesticides, or food additives. These can accidentally contaminate food if they are not stored or used properly. A common chemical hazard is using a chemical sanitizer with a much higher concentration than the regulatory standard.

Toxic metals can cause foodborne illness if food is stored in containers made from certain types of metal and the metals leach into the food. Examples of toxic metals include copper, zinc used in galvanized containers, and tin used in pewter.
3. Biological Hazards

While physical and chemical hazards have potential to cause foodborne illness, the majority of foodborne illnesses result from biological hazards such as bacteria, viruses, and parasites (referred to collectively as *pathogens*).

CDC has identified 31 different pathogens known to cause foodborne illness. The pathogens most commonly responsible for foodborne illness include:

- Campylobacter
- E.coli O157:H7
- Salmonella
- Listeria
- Vibrio
- Norovirus
- Toxoplasma

**Bacteria**

Bacteria are single-celled organisms that can grow quickly in food that is not stored or cooked properly. It is possible to develop illness as a result of bacteria in two ways, depending on the type of bacteria. Some bacteria, such as Salmonella and Campylobacter, cause foodborne infections when food containing the bacteria is consumed and the bacteria multiply within the intestinal tract and cause symptoms. Other types of bacteria, such as Staphylococcus and Clostridium botulinum, cause illness through intoxication. These bacteria produce toxins as by-products of growth and multiplication in food. The presence of the toxins in food causes illness.

After consuming bacteria or a toxin, there is usually an incubation period before symptoms develop. The incubation time and the duration of the illness depend on the type of bacteria or toxin consumed.

**Viruses**

Viruses are tiny infectious agents, much smaller than parasites or bacteria. They are not able to multiply in foods because they require living host cells to reproduce. However, viruses can remain infectious outside of the body and can be transported through food, causing a foodborne infection once they are ingested.

Viruses that cause foodborne illness reproduce within the intestinal tract and are excreted in the feces. Food can become contaminated by viruses when it is handled by an infected person who has practiced poor personal hygiene or when the food has come in contact with sewage which contains viruses. Viruses can be transmitted to others even if an infected person is not exhibiting any symptoms of a foodborne illness.
Viral foodborne infection only recently has been recognized as a major contributor to the disease burden. While there are many viruses known to inhabit the intestines, only a few have been proven to cause foodborne illness. This is due to a variety of factors, including the range of symptoms caused by viruses, the difficulty of detecting viruses in food, and the difficulty of conclusively diagnosing viral foodborne illness through stool samples.

Protozoa and Worms

In addition to bacteria and viruses, food may also be contaminated with protozoa (one-celled organisms, such as Giardia) and various parasitic worms (i.e., roundworms and tapeworms).

The most common sources of these parasitic diseases are:

- Undercooked fish and mollusks
- Undercooked game meat
- Contaminated water and/or ice
- Any food which has been contaminated by the stool of a person or animal infected with one of these organisms

Infections and Intoxications

Foodborne illness can be the result of infection or intoxication. Some bacteria, and all viruses and parasites cause illness through infection. Infection occurs when live pathogens ingested by a person multiply within a person's digestive track and cause the symptoms associated with foodborne illness. The period between the ingestion of pathogens and the development of symptoms can range from less than a day to several days to a few weeks.

Intoxication occurs from eating a food that contains a toxin, either manufactured or naturally occurring. In general, symptoms due to foodborne intoxication appear more quickly than those due to foodborne infection. Unlike most pathogens, most toxins cannot be destroyed by cooking or freezing. A notable exception is the toxin produced by Clostridium botulinum, which can be destroyed by heating at 80°C for 10 minutes or longer.

Food Contamination

Food can become contaminated at any point from farm to table as well as during production, shipping, and distribution. Many foodborne pathogens are present in healthy animals, causing food to become contaminated at the source.

For example, meat and poultry can become contaminated during slaughter by contact with the contents of animals' intestines. Similarly, fresh fruits and vegetables can be contaminated if they are washed or irrigated with water that has been contaminated with animal manure or human sewage.
Pathogens such as norovirus and Shigella can be introduced into food during processing and preparation by infected food handlers or by cross contamination with other raw foods. Inadequate cooking and improper holding temperatures can create conditions which allow for the growth of pathogens.

Identifying the behaviors and practices that have the most potential for causing foodborne illness is necessary if the risk of foodborne illness is to be reduced.

**FATTOM**

There are six conditions that affect the ability of pathogens to grow or multiply: food, acidity, time, temperature, oxygen, and moisture (FATTOM). With proper control of these conditions, the opportunity for the occurrence and spread of foodborne illness can be reduced.

1. **Food**

Pathogens require food in order to grow, multiply, and in some cases, produce toxins. Foods that support the rapid growth and replication of pathogens are called Time/Temperature Control for Safety (TCS) foods (formerly potentially hazardous foods or PHFs). Standards for these foods are addressed in codes and regulations.

Most TCS foods consist of ingredients that are high in protein, high in moisture content, and have a relatively neutral pH level. TCS foods require time-temperature control to keep them safe for human consumption.

2. **Acidity**

Most pathogens can only grow in foods that are slightly acidic to neutral in their pH levels (pH scale ranges from 0 to 14, with 7 being neutral).

3. **Temperature**

While there are species of bacteria that have adapted to survive in extremely hot or cold environments, almost all pathogens can grow between 41°F to 135°F and most have optimum growth around human body temperature (98.6°F).

Proper refrigeration of food can slow the rate of growth of pathogens, while freezing can stop growth altogether. However, refrigeration and freezing do not kill pathogens. Adequate cooking temperatures are necessary to do this and if food is heated to an internal temperature of at least 165°F, most pathogens (but not toxins) are unable to survive.
4. Time

There is a lag period when pathogens are introduced to a food during which they acclimate to the environment. If the conditions are ideal, their growth becomes rapid as soon as they acclimate. The growth rate of bacteria varies by strain, but in general, populations can double every 9-20 minutes during the log phase.

5. Oxygen

Many pathogens do not require oxygen for growth and metabolism. In terms of their oxygen needs, bacteria are classified as aerobic, anaerobic, and facultative anaerobic.

- Aerobic bacteria require oxygen for growth (i.e., Campylobacter jejuni and Bacillus cereus)
- Anaerobic bacteria do not need any oxygen to grow (i.e., Salmonella spp., Listeria monocytogenes, E. coli, and Staphylococcus aureus)
- Facultative anaerobic bacteria prefer using oxygen for metabolism, but they can also grow without any oxygen (i.e., Clostridium botulinum and Clostridium perfringens)

6. Moisture

Moisture levels in food are presented by a value called water activity (Aw) which is used as a general indication of how much water is available to pathogens present in food.

Lower levels of moisture (< 0.85 Aw) inhibit growth and generally do not require refrigeration. Higher levels (> .85 Aw) support pathogens, so other control measures (i.e., refrigeration) are necessary.

Hazard Analysis and Critical Control Points (HACCP)

HACCP is a management system designed to address food safety through the analysis of physical, chemical, and biological hazards. HACCP focuses on prevention rather than the inspection of final products and involves identifying possible hazards that can cause injury or illness, monitoring these hazards, and implementing corrective action if deviations have occurred.

HACCP examines all phases of the food system from raw material production, procurement and handling, to manufacturing, distribution, and consumption of the finished product.

HACCP has seven central principles:
1. **Conduct a Hazard Analysis**

   Collection and evaluation of information on hazards associated with the food under consideration to decide which are significant and must be addressed in the HACCP plan.

2. **Determine the Critical Control Points (CCP)**

   Steps where controls can be applied to prevent or eliminate a food safety hazard or reduce it to an acceptable level.

3. **Establish Critical Limits (CL)**

   Maximum and/or minimum values to which a biological, chemical or physical parameter must be controlled at a CCP to prevent, eliminate or reduce to an acceptable level the occurrence of a food safety hazard.

4. **Establish Monitoring Procedures**

   A planned sequence of observations or measurements to assess whether a CCP is under control and to produce an accurate record for future use in verification.

5. **Establish Corrective Action**

   Procedures that must be followed when a deviation from a CL occurs to ensure that food items that may be harmful to health do not reach consumers.

6. **Establish Verification Procedures**

   Activities, other than monitoring, plan and determine the validity of the HACCP plan and that the system is operating according to that plan.

7. **Establish Record-Keeping and Documentation Procedures**

   An effective record keeping system to ensure that an ongoing, effective HACCP system is in place.

While some food establishments have formal HACCP plan requirements, many do not. Regardless, these seven principles can be used in by food operators, managers, and inspectors to evaluate each establishment’s control over risk factors.