

A GUIDE TO MICROORGANISMS

Food safety is an increasing concern worldwide. Much of the alarm is a result of foodborne illness, or the ingestion of food that is contaminated with pathogenic bacteria. Microorganisms are found everywhere in nature. Some disease-causing bacteria can survive and/or grow at refrigerator temperatures, some require little or no oxygen, and some make consumers sick in very low numbers. While some bacteria are life-threatening pathogens, some bacteria are beneficial to humans. All food handlers, including consumers, have a responsibility to practice proper food handling, preparation, and storage procedures. The more we know about these tiny living creatures (which cannot be seen by the naked eye), the easier it will be for us to reduce the risk of foodborne illness.

The food industry uses many control measures to limit the risks of foodborne illness. Heat treatments, such as pasteurization and canning, kill or inactivate disease-causing bacteria or spores. Dehydration, freezing, refrigeration, anti-microbial preservatives, and/or specialized packaging are also used to limit the risk. Quality control measures also contribute to the safety of food until it reaches the consumer.

Since food is capable of supplying consumers with nutrients, it is equally capable of supporting the growth of pathogenic bacteria. Some pathogens are found normally in the intestinal tract of healthy animals and humans. Thus, certain microorganisms are found everywhere in

nature, occurring on soil and vegetation, in animal wastes, and on animal carcasses. Human skin surfaces and nasal passages

harbor staphylococci. Water supplies contaminated with fecal material may contain pathogens. So it becomes obvious how difficult it is to prevent one or more pathogens from entering raw foods. There is a need for everyone to be aware of the potential danger of improper food handling and how to reduce the risk of contaminating food with pathogenic microorganisms. Data collected by the Centers for Disease Control suggest that 76 million Americans become sick from foodborne illness each year. Of these, 300,000 are hospitalized, and 5,000 die.

Five Ways to Avoid Foodborne Illness

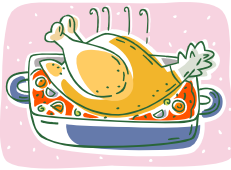
- 1.) **Cook** food to the proper internal temperatures.
- 2.) **Store** foods at the correct temperature and discard items past the expiration date. Separate raw foods from ready-to-eat foods to prevent cross contamination.
- 3.) **Clean** and sanitize all cooking utensils, equipment, and surfaces as often as needed.
- 4.) **Wash** hands thoroughly and practice good personal hygiene when handling food. Sick people should not handle food.
- 5.) **Purchase** food from reputable dealers. Wash produce before eating.

Pathogens of Concern

Salmonella

There are over 2,000 serotypes of the bacteria *Salmonella*. Salmonellosis is one of the most common causes of foodborne illness, with a reported 40,000 cases in the United States each year. It is believed to be grossly under-reported, because it is usually misdiagnosed as intestinal flu.

Symptoms include diarrhea, abdominal cramps, vomiting, and fever, which generally ends within one to seven days. In extreme cases, it can cause reactive arthritis and serious infections. Symptoms occur within six to 48 hours and may cause illness from ingestion of as few as 15 to 20 cells. Salmonellosis is different from a staphylococcal intoxication, in that staphylococci have an incubation period of two to four hours, absence of fever, and symptoms normally disappearing within 24 hours.



In the United States, raw meats, poultry, eggs, milk and other dairy products, shrimp, frog legs, yeast, coconut, pasta, and chocolate have been the most frequently reported sources. Improper cooling, inadequate cooking, ingestion of contaminated raw products, and cross-contamination are the most frequently identified contributing factors of salmonellosis.

Proper cooking techniques usually kill *Salmonella*. *Salmonella* is so prevalent that it is impossible to eliminate, but proper food handling techniques will greatly reduce the incidence of salmonellosis.

Staphylococcus aureus

Staphylococcal food intoxication is the second most prevalent foodborne illness. Under proper conditions, *S. aureus* grows rapidly, and many strains may produce enterotoxins. The heat-stable enterotoxins, rather than the bacteria itself of this illness actually cause the severe gastroenteritis (inflammation of the stomach lining).

Common symptoms include nausea, vomiting, retching, abdominal cramping, sweating, chills, weakness, weak pulse, shock, shallow respiration, and subnormal body temperature. The onset of the illness may occur within 30 minutes to eight hours following consumption of the toxin-containing food. Recovery from the intoxication, which is rarely fatal, usually occurs within 24 to 48 hours.

S. aureus is found in the nose and throat and on the hair and skin of more than 50% of healthy individuals. Therefore, any food which requires handling in preparation may easily become contaminated. Infected wounds, lesions, and boils of food handlers may also be sources of contamination.

Staphylococci grow well in foods such as meat and meat products, poultry, fish and fish products, milk and dairy products, cream sauces, salads such as ham, chicken and potato, puddings, custards, and cream-filled bakery products. Because Staphylococci are usually outnumbered by harmless microorganisms in raw food, raw food is never implicated in staphylococcal foodborne illness. Cooking eliminates the normal competitive bacteria of raw foods, so contaminating staphylococci may be permitted to grow in prepared foods such as meat, potato and macaroni salads, custards and cream-filled bakery products. As the bacteria multiplies, so does the infecting toxin.

For staphylococcal foodborne illness to occur, the food must be contaminated with enterotoxin-producing staphylococci capable of supporting growth held at temperatures within the danger zone for a sufficient period of time to produce the enterotoxin, and then consumed. Therefore, important control measures include adequate heat processing and cooking, proper cooling and refrigeration, and proper sanitation by the individual who is handling the food.

Clostridium perfringens

Clostridium perfringens is an anaerobic (growth without oxygen) pathogenic bacteria, with five toxin types, A to E. Only type A strains produce foodborne illness. Diarrhea and severe abdominal pain are the most common symptoms. Symptoms last less than a day. Fatalities are rare.

Foodborne illness usually occurs eight to 12 hours after the ingestion of food containing large numbers of bacterial cells. The illness is caused by the production of spores by the bacterial cells in the food itself or in the intestines, accompanied by the production of an enterotoxin.

Meat and poultry products are the most common source of contamination. Since *C. perfringens* will not grow at refrigerated temperatures, the principal cause of illness is the failure to properly hold, cool, and refrigerate cooked foods, especially large portion sizes.

Clostridium botulinum

There are seven types of *Clostridium botulinum*, A to G. All types produce neurotoxins that are toxic to humans and animals. Some are more lethal than others. The toxin is absorbed into the bloodstream through the respiratory membranes or the stomach and intestines.

Foodborne botulism results after the consumption of food where *C. botulinum* grows and produces toxin. After absorption, the toxin irreversibly binds to peripheral nerve endings. Symptoms include nausea, vomiting, fatigue, dizziness, headache, dryness of skin, mouth, and throat, constipation, paralysis of muscles, double vision, and difficulty in breathing. These develop four to 36 hours after consumption of the toxin-containing food. Duration of the illness ranges from one to ten days or more, depending on the individual's resistance, type and amount of toxin ingested, and the type of food.

Treatment includes administration of an antitoxin along with supportive care, including respiratory assistance. Recovery may take several weeks to months, with the mortality rate at less than 10 percent.

Infant botulism, which affects infants under 14 months of age, is thought to be caused by the ingestion of *C. botulinum* spores that colonize in the intestine and produce a toxin. Honey and syrup have been indirectly implicated. Thus, it is recommended that children under the age of 1 do not eat these products.

Heat-resistant spores are the major concern in processed low-acid canned foods. Low heat-resistance spores are a concern in pasteurized or unheated foods. Home-processed vegetables account for most illnesses. Fish products, chilies, tomatoes, meat products, baked potatoes, and garlic-in-oil mixtures have also been implicated. The toxin can be inactivated by heating food to 176 F for 10 minutes. Using USDA recommended recipes and following proper canning procedures is very important for control.



Campylobacter jejuni

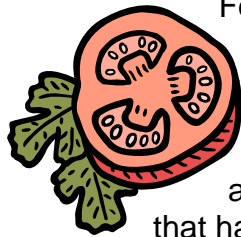
Campylobacteriosis is thought to be a leading cause of acute gastroenteritis in humans. Common symptoms include profuse diarrhea (sometimes bloody), abdominal cramps, nausea, and fever. Ingesting small numbers of *Campylobacter jejuni* can produce illness. Raw milk and poultry are the most common sources of infections. Other foods include raw beef, clams, and untreated water. Studies have revealed that since the bacteria is naturally found in the intestinal tracts of animals, as many as 30 percent of poultry, 5 percent of pork, 5 percent of beef, and 8 percent of lamb found in the retail market contain *C. jejuni*. The most common cause is fecal contamination by infected food handlers.

C. jejuni will not grow below 86 F, requires little or no oxygen for growth, grows slowly even under optimal conditions, and does not compete well with other microorganisms. *C. jejuni* infections can be prevented by properly pasteurizing and cooking foods and avoiding cross-contamination of cooked meats or ready-to-eat foods. Although the organism does not survive well in foods, refrigeration prolongs survival.

Listeria monocytogenes

Infants, the elderly, and ill individuals are highly susceptible to pathogenic species of *Listeria*. Flu-like symptoms may occur, or no symptoms may occur and a carrier state may develop. Sometimes *Listeria* may multiply in the body, causing septicemia (blood poisoning). During this stage, *Listeria* may have access to all body areas, including the fetus of pregnant women. If illness occurs during the third trimester of pregnancy, the organism may cause the fetus to be aborted or stillborn. Septicemia and meningitis may occur in adults. Death is rare in healthy adults, but the mortality rate can run 30 percent in newborn, very young, or elderly individuals.

Listeria is found everywhere in nature, so is frequently carried by humans and animals.



Foods implicated in illness include unpasteurized milk, raw meat, soft cheeses, deli meats, hot dogs, celery, tomatoes, cabbage, and lettuce. Vegetables grown on fields fertilized with fecal matter have ample opportunity to be contaminated. Because *L. monocytogenes* can withstand harsh environmental conditions such as pH extremes, heat and freezing, storage, and distribution, control measures are important. Also, discarding products

that have passed their due-date and preventing cross contamination between raw and ready-to-eat foods can decrease the possibilities of foodborne illness from *L. monocytogenes*.

Enteropathogenic Escherichia coli

Enteropathogenic *Escherichia coli* are the major cause of diarrhea in developing countries and areas of poor sanitation. Foodborne illness in the United States is usually a result of *E. coli* O157:H7. There are four subgroups of enteropathogenic *E. coli*. Some strains produce a heat-stable toxin, which can not be destroyed by heat, or a heat-labile toxin, which can be destroyed by heat, or they produce both. The illness is similar to cholera, causing profuse watery diarrhea. Other strains invade the cells of the colon, causing dysentery-like symptoms similar to shigellosis.

E. coli O157:H7 causes a severe illness characterized by bloody diarrhea and severe abdominal cramps, with around 61 deaths a year. In children, *E. coli* O157:H7 can cause hemolytic uremia syndrome, a severe life-threatening urinary tract infection and the leading cause of acute kidney failure in children.

Feces and untreated water are the most likely sources for contamination of food. Sandwiches, inadequately-cooked hamburger, mold-ripened cheese, and contaminated produce have been the main causes of illness. Foods of animal origin may become contaminated during slaughter procedures or post-processing recontamination. Humans are thought to be the principal reservoir of some strains, contaminating foods via contact of processing equipment with water contaminated by human feces. Monitoring critical control points for the presence of coliform bacteria may help eliminate contamination in food processing situations. Food service establishments should monitor the personal hygiene of food handlers, the adequacy of cooking, holding times, and temperatures. The current recommendation for cooking hamburger is 160 F.

Yersinia enterocolitica

Yersinia enterocolitica is not a common disease in the United States, but symptoms are severe when it does occur. Yersiniosis infection causes gastroenteritis. Children are most severely affected with symptoms of intense abdominal pain (often mimicking appendicitis, which has caused many unnecessary appendectomies), diarrhea, fever, and vomiting. Fatalities are rare. Recovery usually takes one to two days.

Y. enterocolitica is present in all foods. Chocolate milk, unpasteurized milk, and tofu packed in un-chlorinated spring water have caused yersiniosis. The bacteria is one of the few that can grow at refrigerated temperatures.

Vibrio

Vibrio species have been associated with foodborne illness. *V. cholerae* causes cholera. Symptoms include diarrhea with large volumes of “rice-water” stool (clear fluid with sloughed off dead intestinal cells). Severe dehydration and death can occur if left untreated. Diarrhea can last one to five days and is usually accompanied by vomiting.

V. parahaemolyticus causes acute gastroenteritis, with symptoms of nausea, vomiting, abdominal cramps, low grade fever, chills, and diarrhea (usually watery, sometimes bloody). Raw seafood or seafood that has been contaminated after cooking is the main sources of the illness.

All illness-causing vibrios are naturally occurring in the marine environment, making it impossible to prevent the contamination of fresh seafood. Larger numbers of vibrios are found in marine life during the warmer months, so consumption of raw seafood should be avoided during this time. All species are rapidly killed by heating, so adequate cooking is an important control measure. Always purchase seafood from an approved and reputable supplier.



Shigella

Shigellosis or bacillary dysentery is caused by the bacteria *shigella*. *Shiigella* is normally found in the human intestinal tract but rarely found in animals. The main source is asymptomatic carriers or persons recovering from the disease. The illness is caused by an enterotoxin that invades the intestinal lining. Relatively low numbers of the bacteria can cause illness. Symptoms include diarrhea, abdominal pain, fever, and vomiting after an incubation period of one to seven days. The severity varies from very mild to severe. Symptoms may last from three to 14 days. The principal foods involved are salads and seafood. Heat treatment and proper sanitation are the best control.

Bacillus cereus

Two enterotoxins of *Bacillus cereus* cause foodborne illness. The diarrheal-type closely resembles the symptoms of *C. perfringens* foodborne illness, usually occurring within eight to 20 hours of ingestion. Large numbers are required to cause illness. The emetic-type (vomiting), closely resembles the symptoms produced by staphylococcal enterotoxin, occurring within one to five hours of ingestion. It requires the ingestion of a preformed toxin in the food to cause illness. Recovery is complete within 24 hours after onset.

Spores formed by *B. cereus* will survive cooking. Problems arise when foods are held in the danger zone for more than two hours. Under these conditions, the organisms grow to large numbers and release toxins in the food or in the intestines. Foods implicated in the diarrheal-type include cereal dishes that contain corn and cornstarch, mashed potatoes, vegetables, meat products, puddings, soups, and sauces. The emetic-type is associated with fried or

boiled rice and other starchy foods such as macaroni and cheese. Specific recommendations are developed for handling rice and fried rice.

Beneficial Microorganisms

There are many microorganisms that can be used to alter food products. Starter cultures, naturally-occurring bacteria, or yeast are used to produce fermentations such as sauerkraut from cabbage; pickles from cucumbers; dairy products such as buttermilk, sour cream, yogurt, and some cheeses; sour dough and yeast-leavened baked products; vinegar, beer, and wine.

References

- Food and Drug Administration (2006), *Bad Bug Book*.
- National Institute of Allergy and Infectious Diseases (2006), *Foodborne Disease Fact Sheets*.
- National Restaurant Association Education Foundation (2006), *ServSafe*.

Clip art by Microsoft® 2007

Sandra Bastin, PhD, RD, LD, CCE
Extension Food and Nutrition Specialist

June 1996; Revised September 2007

pyright © 2007 for materials developed by University of Kentucky Cooperative Extension. This publication may be reproduced in portions or its entirety for educational or nonprofit purposes only. Permitted users shall give credit to the author(s) and include this copyright notice.

Educational programs of Kentucky Cooperative Extension serve all people regardless of race, color, age, sex, religion, disability, or national origin.