

Preventing Foodborne Illness: *Clostridium botulinum*¹

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This fact sheet is part of a series that discusses foodborne pathogens of interest to food handlers, processors, retailers, and consumers.

What is *Clostridium botulinum*?

Clostridium botulinum is the bacterium that causes botulism. These Gram-positive organisms are characterized by their slightly curved, motile, and anaerobic rods that produce heat-resistant spores. The spores, which are very resistant to a number of environmental stresses such as heat, high acid, etc.) can become activated in a low acid (pH greater than 4.6), anaerobic, high moisture environment with temperatures ranging from 3°C to 43°C (38°F to 110°F). Spores allow the bacteria to survive in adverse environmental conditions and germinate once conditions become more favorable.

C. botulinum is ubiquitous in nature, often found in soil and water. Although the bacteria and spores in themselves do not cause disease, the production of botulinum toxin is what leads to botulism, a serious paralytic condition that can lead to death.

There are seven strains of *C. botulinum* based on differences in antigenicity among the toxins, each characterized by its ability to produce a protein neurotoxin, enterotoxin, or haemotoxin. Types A, B, E, and F cause botulism in humans, while types C and D cause botulism in animals and birds. Type G was identified in 1970 but has not been determined as a cause of botulism in humans or animals (1).

What causes *Clostridium botulinum* foodborne illness?

There are five types of diseases associated with botulinum toxin (2).

1. Foodborne botulism results from the ingestion of pre-formed toxin in food. Botulinum toxin can be found in foods that have not been properly handled or canned and is often present in canned vegetables, meat, and seafood products.
2. Infant botulism occurs when infants ingest *C. botulinum* spores that germinate and produce toxin in the intestine. Honey is a common dietary source of *C. botulinum*

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spores and, therefore, infants less than one year of age should not consume honey.

3. Wound botulism results when *C. botulinum* infects a wound and produces toxin. The toxin can be carried to the rest of the body via the bloodstream.
4. Adult intestinal toxemia/colonization occurs in the same way as infant botulism except in adults.
5. Iatrogenic botulism is the accidental overdose of toxin, which has been caused by accidental inhalation by laboratory workers.

The incidence of botulism in the US is rare because of increasing knowledge and education in proper storage and handling of foods. There were 121 reported cases of botulism in 2009, 11 of which were foodborne, 84 infant, 23 wound and 3 of unknown botulism (3). There are an estimated 55 cases of foodborne botulism in the US per year, which is very small compared to the 1 million cases of foodborne disease caused by *Salmonella* in the U.S. per year. The death rate from botulism, however, is relatively high at 17.3% compared to 0.5% for *Salmonella* (4).

What are the symptoms associated with *Clostridium botulinum*?

Botulinum toxin is a neurotoxin, thus it affects the nervous system and is characterized by descending, flaccid paralysis that can cause respiratory failure. Foodborne botulism produces symptoms beginning in 6 to 36 hours, though some can even start after two weeks. Symptoms include double and blurred vision, slurred speech, difficulty swallowing, dry mouth, diarrhea, nausea, and muscle weakness that descends through the body. Recovery occurs with prompt administration of antitoxin and respiratory intensive care. Deaths that occur within the first two weeks of botulism are often the result of pulmonary or systemic infection and failure to recognize the disease. Often the symptoms of foodborne botulism are mistaken for symptoms associated with stroke, chemical intoxication, myasthenia gravis, and Guillain-Barre syndrome. Tests such as brain scans, spinal tap exams, nerve conduction exams, electromyography (EMG), and a tensilon exam can distinguish the above diseases from botulism (2).

In infant botulism, infants may appear lethargic, constipated, have poor feeding patterns, and have a weak cry. Infants can be treated with antibiotics to kill *C. botulinum* in the body and antitoxin to neutralize the toxin (2). Infant

botulism is less fatal than foodborne botulism, with <2% mortality rate (1).

Wound botulism produces the same neurological symptoms as foodborne botulism within 7 days of infection. Gastrointestinal symptoms do not occur. Wounds may not be obviously infected but are usually treated by surgically removing the source, followed by antibiotics (2).

Who is at risk?

Foodborne botulism is not spread from person to person. Although foodborne botulism is rare and one of the least common of the foodborne diseases, *C. botulinum* can infect anyone since intoxication can result from eating contaminated food. In fact, it takes only a small amount of toxin to cause illness. Immunocompromised individuals, young children, and elderly individuals may suffer from more serious symptoms.

What foods have been commonly associated with *Clostridium botulinum*?

C. botulinum is present in water and soil, so potentially any food that comes into contact with such vectors is a potential hazard. Home canned products, however, especially low acid food products, are attributed to most cases of foodborne botulism. Foods commonly associated with botulism are canned asparagus, green beans, garlic in oil, corn, soups, ripe olives, tuna fish, sausage, luncheon meats, fermented meats, salad dressings, and smoked fish. Spores have also been found on the surfaces of vegetables and fruits. Infant botulism has been linked to the ingestion of *C. botulinum* spores in honey, corn syrup, and other foods.

During the canning process, foods undergo a hot fill process and oxygen is removed, leaving the food in an anaerobic environment. Certain foods, such as meat, are able to bind oxygen to create an anaerobic environment that allows *C. botulinum* to grow. Home canning processes for low acid foods are extremely risky because the time and temperature food are heated are often inadequate. On a commercial scale, improperly handled food products have also contributed to outbreaks.

What sanitation methods are used to prevent infection?

The main limiting growth factors for *C. botulinum* are extreme temperature, pH < 4.6, low water activity, food

preservatives, and competing microorganisms. Strains of *C. botulinum* can be both mesophilic and psychotrophic, with growth between 3°C to 43°C (38°F to 110°F). Therefore, strains can grow not only at room temperatures, but at normal refrigeration and higher temperatures. Proper cooking and handling is important to eliminate *C. botulinum* in food, so refrigeration can be more effective.

While most bacteria cannot survive at a low pH, some proteins such as in soy and beef have protective agents that allow them to grow at pH < 4.5. Low water activity inhibits the growth of *C. botulinum*, which is why dehydrated foods and foods high in salt and/or sugar do not support its growth. Food preservatives such as nitrites, sorbic acid, phenolic antioxidants, polyphosphates, and ascorbates, as well as lactic acid bacteria, inhibit the growth of *C. botulinum*.

Most outbreaks of foodborne botulism are the result of poor home canning. Proper time, temperature, and pressure are required to destroy the heat-resistant spores, and proper storage methods are necessary to ensure the safety of the consumer. A pressure cooker can be used for home canning purposes because it can reach temperatures higher than boiling (212°F), which is necessary to kill the spores (2).

While the botulinum spores can survive in boiling water, the botulinum toxin is heat-labile. Heating food to a typical cooking temperature of 80°C (176°F) for 10 minutes before consumption can greatly reduce the risk of illness.

The suggestions below are good examples of how to prevent foodborne *C. botulinum*:

- If consuming home canned foods, heat low acid foods to at least 80°C (176°F) for 10 minutes and corn, spinach, and meats for 20 minutes.
- Oils infused with garlic or herbs should be properly refrigerated.
- Canned food products, both home and commercial, should be inspected before use. Cans with bulging or damaged lids, leakage, or off odors should not be used because growth of the bacteria can often produce a gas, causing the can to expand.
- Home canned foods should be canned in pressure cookers to ensure the proper time, temperature, and pressure requirements to avoid the growth of the bacteria and spores.

- Although commercial food products have a low rate of botulism, read the label and throw out any and all damaged or expired cans.
- If canning meats, use nitrites or salt in the brine in addition to heat to reduce the growth of *C. botulinum*.
- Vacuum packaged meats should be refrigerated or properly stored in the freezer for extended use.
- Keep hot foods above 57°C (135°F) and cold foods below 5°C (41°F) to prevent the formation of spores.
- Wash hands, utensils, and food contact surfaces with hot soapy water after they touch raw meat or seafood, before food preparation, and after using the bathroom.

Good practices for food product receiving, handling, processing, and storage

The FDA defines Current Good Manufacturing Practices (cGMPs) for food in Title 21, part 110 of the Code of Federal Regulations (CFR). These cGMPs outline minimal general sanitation requirements in FDA-inspected food handling and processing facilities (5). It is recommended that more specific and stringent standard operating procedures (SOPs) be developed for individual facilities. In addition, the sanitation recommendations for food service and retail food facilities outlined in the 2009 FDA Food Code have been adopted into many state and local regulations. As there may be some variation in Food Code adoption, it is important that each facility check with the appropriate state and/or local regulatory authority. Florida operates under the 2001 FDA Food Code and Title 33, chapter 509 of the Florida statutes (6).

In addition to setting and adhering to strict sanitation requirements in the facility, a retail establishment should also develop standard operating procedures (SOPs) for receiving and storage of food. If food will be processed, appropriate controls and requirements should be established and strictly adhered to. The 2009 FDA Food Code outlines appropriate processing and cooking requirements for many food products processed in a retail facility (7). The growing retail practice of cooking, preparing, and packaging foods traditionally processed in controlled plant environments raises safety concerns. Any processing of food at the retail level needs to be closely monitored.

As an establishment increases its cleanliness, it becomes harder to detect foodborne pathogens. At this point, testing becomes more limited in its ability to prevent foodborne illness. This is why programs that promote and monitor the use of barriers and/or hurdles are so important. When instituted properly, these activities will reduce the risk of a foodborne illness.

Receiving

Specifications for receiving can be found in section 3-202.11 of the 2009 Food Code (7). The following guidelines cover the basic points that should be addressed:

- Potentially Hazardous Food (PHF) should be at a temperature of 5°C (41°F) or below when received, unless specified by law (e.g., milk, shellfish).
- PHFs that are received hot should be at a temperature of 57°C (135°F) or above.
- PHF should be received with no evidence of temperature abuse such as evidence of thawing.

Processing

Cooking food thoroughly will eliminate the *C. botulinum* and its toxin. Foods that are served uncooked like fresh vegetables will obviously not benefit from the cooking process. For these items, other factors such as sanitation, worker hygiene, and proper storage take on much greater importance (Food Code 3-401.11 and 3-403.11).

- Cook fish, meat or foods containing these items to an internal temperature of 63°C (145°F) or above for a minimum of 15 seconds.
- Cook ground meat products to an internal temperature of 69°C (155°F) or above for a minimum of 15 seconds.
- Cook poultry to an internal temperature of 74°C (165°F) or above for a minimum of 15 seconds.
- Reheat previously cooked material to an internal temperature to 74°C (165°F).

Storage

Once a product has been received and/or processed, it should be properly stored. General guidelines governing these practices are outlined below (Food Code 3-501.11 to 3-501.17).

- Frozen food should remain frozen until it is used.

- If frozen food is displayed in a refrigerated case and allowed to thaw, the food should remain at 5°C (41°F) or below.
- Frozen food should be thawed at a temperature of 5°C (41°F) or below or under running water at a temperature of 21°C (70°F) or below.
- Frozen food can be thawed as part of the cooking process.
- Product must be cooled adequately. Refer to sections 3-501.14 and 3-501.15 of the 2009 Food Code.
- Cooked product should be maintained above 57°C (135°F) while displayed and stored at or under 5°C (41°F).
- Properly label all stored product.

Personal Hygiene

Wash your hands! The major cause of foodborne illness in retail establishments comes from poor personal hygiene, particularly a lack of proper hand washing. Dirty hands can contaminate food. Although hands may look clean, the bacteria that cause illness are too small to be seen. Therefore, if while preparing food you come in contact with items that are not part of the assembly process, *rewash your hands*. The same is true even when wearing gloves.

THERE IS NO FIVE SECOND RULE WHEN IT COMES TO FOOD SAFETY!

Millions of bacteria and other germs can be transferred on contact. Below is a list of times when you should wash your hands:

- Before handling, preparing food or serving food.
- Before handling clean utensils or dishware.
- After using the restroom.
- After touching your face, cuts, or sores.
- After smoking, eating, or drinking.
- After handling raw meat, especially poultry.
- After touching unclean equipment, working surfaces, soiled clothing, soiled wiping cloths, etc.
- After collecting and taking out the garbage.

WHAT IS THE PROPER PROCEDURE FOR HAND WASHING?

1. Wet your hands with warm water.
2. Apply soap and wash your hands for 20 seconds.
3. Rinse and dry with a single-use paper towel.
4. Use the paper towel to shut off the water.

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