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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. *Clostridium botulinum* is a Gram-positive, slightly curved, motile, anaerobic rod-shaped bacterium that produces heat-resistant endospores. These endospores, which are very resistant to a number of environmental stresses such as heat and high acid, can become activated in anaerobic environments, low acidity (pH greater than 4.6), high moisture content, and in temperatures ranging from 3°C to 43°C (38°F to 110°F). In hostile environmental conditions, the heat-resistant spores enable the bacteria to survive in a dormant state until conditions become more favorable.

Clostridium botulinum is ubiquitous in nature, often found in soil and water. Although the bacteria and spores alone do not cause disease, their production of botulinum toxin renders them pathogenic. Botulinum toxin is a neurotoxin that causes botulism, a serious paralytic condition that can lead to death.

There are seven strains of *C. botulinum,* each distinguished by its production of a serologically distinct botulinum type (CDC 2014). Of the seven types, A, B, E, and rarely 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 (FDA 2012).

Four Transmission Categories of *Clostridium botulinum*

The CDC categorizes human botulism cases into four transmission categories: foodborne, infant, wound, and other (CDC 2014).

1. Foodborne botulism results from the ingestion of pre-formed botulinum toxin in food. The toxin can be found in food that has not been properly cooked, processed, handled, or canned and is often present in canned food such as vegetables, meat, and seafood products (FDA 2012).

2. Infant botulism occurs when infants (persons less than one year of age) ingest *C. botulinum* spores that then

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germinate and produce the botulinum toxin in the intestines. Because honey is a common dietary source of *C. botulinum* spores, infants should never be fed honey (FDA 2012).

3. Wound botulism results when *C. botulinum* infects a wound and produces the toxin, which is then carried throughout the rest of the body via the bloodstream.

4. Botulism cases classified as "other" include those in which the patient is not an infant, has not ingested contaminated food, and does not have an infected wound. Essentially, the route of transmission is unknown. Adult intestinal toxemia/colonization (which occurs in the same way as infant botulism), and iatrogenic botulism (an accidental overdose of the toxin) are also included in the classification.

The incidence rate of botulism in the US is low due to increasing education and awareness of proper storage and handling of foods. There were 121 reported cases of botulism in 2009, of which 11 were foodborne, 84 infant, 23 wound, and 3 of unknown or other etiology (CDC 2014). In 2011, a total of 140 confirmed cases of botulism were reported to the CDC. Of these, 20 were foodborne, 102 infant, 13 wound, and 5 of unknown or other etiology (CDC 2014). While fewer cases of foodborne illness are caused by *C. botulinum* per year than by *Salmonella*, the death rate from botulism is relatively high, 17.3 percent, compared to 0.5 percent for *Salmonella* (Scallan et al. 2011).

What Are the Symptoms Associated With the Consumption of Botulinum Toxin?

The botulinum toxin produced by *C. botulinum* is a neurotoxin that causes descending, flaccid paralysis of the muscles, including those of the respiratory system. Respiratory failure is common in those affected. Onset of foodborne botulism symptoms generally begins within 18 to 36 hours of toxin ingestion, though some instances have varied from 4 hours to 8 days (FDA 2012). These 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 an antitoxin that blocks the action of the botulinum toxin in the body. In cases of severe botulism, patients may require respiratory intensive care for weeks or months until the paralysis alleviates (CDC 2014). Deaths that occur within the first two weeks of botulism are often the result of pulmonary or systematic infection and failure to recognize the disease. Often the symptoms of foodborne botulism are mistaken for symptoms associated with stroke, chemical intoxication, myasthenia gravis, or 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 (CDC 2014).

In the case of infant botulism, those affected may appear to be lethargic, constipated, have poor feeding patterns, and exhibit a weak cry. Infants can be treated with antibiotics to kill *C. botulinum* in the body and an antitoxin to neutralize the toxin (CDC 2014). Infant botulism is less fatal than foodborne botulism, with less than two percent mortality rate (FDA 2012).

Wound botulism produces the same neurological symptoms as foodborne botulism, but 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 (CDC 2014).

Who Is at Risk?

Foodborne botulism cannot be spread from person to person. Although it is one of the least common of the foodborne diseases, anyone is susceptible to *C. botulinum* illness (as a foodborne intoxication) even with the ingestion of only a small amount of toxin present in contaminated food. 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 both water and soil, so any food that comes into contact with such vectors is a potential hazard. Home-canned products, especially of low-acid foods, are attributed to most cases of foodborne botulism, because the time and temperature to which the food is heated are often inadequate. Susceptible foods include canned asparagus, green beans, garlic in oil, corn, soups, ripe olives, tuna, sausage, luncheon meats, fermented meats, salad dressings, and smoked fish. Additionally, spores of *C. botulinum* have been found on the surfaces of vegetables and fruits, and infant botulism has been linked to the ingestion of spores in honey, corn syrup, and other foods (FDA 2012).

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Improperly handled commercial food products also have contributed to outbreaks in previous years. In 2006, four cases of foodborne botulism associated with Bolthouse Farms carrot juice were reported to the CDC. The growth of *C. botulinum* in the juice was likely the result of poor refrigeration of the bottles during transport or storage (CDC 2006). Furthermore, in 2007, five cases of foodborne botulism associated with Castleberry's hotdog chili sauce were reported, thought to be the result of production deficiencies that allowed spores of *C. botulinum* to survive the commercial canning process (CDC 2007).

What Can Be Done To Prevent Infection?

Primary growth-limiting factors for *C. botulinum* include environmental temperature above 122°F (50°C) or below 50°F (10°C); high acidity (pH <4.6); low water activity (lack of available moisture); food preservatives such as nitrite, sorbic acid, phenolic antioxidants, polyphosphates, and ascorbates; a low redox potential (absence of oxygen); and competing microorganisms (CDC 1998). To be safe, the FDA (2015) recommends food be kept out of the "Danger Zone." Thus for safety against this pathogen and others store food items below 41°F (5°C) and hold hot food above 135°F (57°C). Due to their low water activity, dehydrated foods and foods high in salt and/or sugar do not support growth of the bacteria. Some strains of *C. botulinum* can be mesophilic, with an ideal growth temperature between 20°C–45°C (68°F–113°F), whereas others are psychotrophic, with ideal growth between 3°C–20°C (38°F–60°F). Proper cooking and handling of food is important in the elimination of *C. botulinum* because growth of these *C. botulinum* strains is possible at a wide range of environmental temperatures. Although *C. botulinum* typically will not grow in environments of pH <4.6, food proteins such as those in soy and beef can have a protective effect on the bacteria by providing localized areas or pockets of high pH, thus allowing for growth in high-acid foods (Wong et al. 1988).

As is evident in Table 1, most outbreaks of foodborne botulism are the result of improper canning at home. The heat-resistant spores produced by *C. botulinum* can only be destroyed under proper temperature and pressure for sufficient time. As temperatures higher than boiling (212°F) are necessary to kill the spores, a pressure cooker is suggested for home-canning purposes (CDC 2014).

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

The following are suggestions for preventing foodborne botulism at home:

- If consuming home-canned foods of low acidity, heat to at least 80°C (176°F) for 10 minutes. Canned corn, spinach, and meats should be heated for 20 minutes.
- Oils infused with garlic or herbs should be properly refrigerated during storage.
- Canned food products, including both those produced at home and commercially, should be inspected before use. Cans with bulging or damaged lids, leakage, or off-odors should not be used, as these are signs indicative of gas-producing bacteria growth within the can. To ensure that the proper time, temperature, and pressure requirements are met to eliminate growth of the bacteria and its spores, a pressure cooker should be used to produce canned food products at home.
- Although foodborne botulism is less commonly associated with commercially canned food products, be mindful not to consume the contents of expired or damaged cans. If canning meats at home, consider including food preservatives such as nitrites in the brine solution to reduce the growth of *C. botulinum*.
- Vacuum-packaged meats should be refrigerated or properly stored in the freezer for extended usage.
- During holding or storage, maintain proper food temperature. Put simply, keep hot foods hot (above 57°C/135°F) and cold foods cold (below 5°C/41°F) to prevent the formation of spores.
- Wash hands, utensils, and kitchen surfaces that come into contact with food using hot soapy water before food preparation, after contact with raw meat or seafood, and after using the bathroom.

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Table 1. A list all outbreaks of foodborne botulism reported to the CDC between 2008 and 2012.

Year	Number of cases	State	Toxin Type	Vehicle	Death
2008	1	AK	E	Whale blubber	No
	1	IN	A	Unknown	No
	4	OH	A	Home-canned green beans/carrot mix	No
	1	CA	A	Home-cured olives	No
	7	AK	E	Seal oil	No
	1	WV	A	Home-canned sausage soup	Yes
	1	AZ	A	Baked potato	No
	1	CA	A	Home-canned green beans	No
2009	1	OH	B	Home-canned mustard greens	No
	3	WA	A	Home-canned green beans	No
	2	CA	A	Home-canned tuna	No
	1	WA	A	Home-canned asparagus	No
	2	MN	A	Home-canned asparagus	No
	1	CA	A	Home-canned corn	Yes
	1	CA	A	Home-canned soup	No
2010	2	AK	E	Seal blubber	No
	1	MS	B	Home-canned beets	No
	1	CO	A	Baked potato	No
	1	NM	A	Home-canned foods	No
	1	AK	Unknown	Stinkheads†	No
	1	CA	A	Home-canned tuna	No
	2	AK	B	Unknown	No
2011	1	CA	A	Home-canned soup	No
	1	OH	A	Potato soup	No
	1	OR	A	Home-canned green beans	No
	1	OK	F	Homemade kimchi	No
	1	AK	E	Seal blubber	No
	1	GA	A	Potato soup	No
	3	AK	E	Salmon eggs	No
	1	NY	A	Homemade sauce; barley and cheese	No
	1	AZ	A	Baked potato	No
	8	UT	A	Pruno††	No
	1	AK	E	Beaver	No
2012	2	NY	B	Home-fermented tofu	No
	12	AZ	A	Pruno††	No
	3	OR	A	Home-canned beets	No
	1	OR	A	Home-canned beets	Yes
	1	OH	A	Home-canned green beans	No
	1	NJ	A	Home-canned soup	Unknown
	1	CA	B	Home-canned tuna	No
	1	AK	E	Beaver tail	No
	1	AK	E	Stinkheads†	No
	1	DE	B	Homemade garlic-infused oil	No
	1	AK	E	Seal oil and fat	No

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Year	Number of cases	State	Toxin Type	Vehicle	Death

† Stinkheads are fermented whitefish heads typically consumed in Alaska.
†† Pruno is a home-made alcohol typically made by fermenting fruit or bread. Its creation originated in jails and prisons.
Annual summaries of foodborne botulism are compiled by the CDC in partnership with the Council of State and Territorial Epidemiologists (CSTE) as part of the National Botulism Surveillance System (CDC 2014)