



# FOOD SAFETY

## Botulism

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### Quick Facts...

The Western United States has one of the highest incidences of botulism in the United States because of soil and high altitude.

Conditions that favor botulism include a high-moisture, low-salt, low-acid environment in which food is stored without oxygen or refrigeration.

Anaerobic conditions can develop in canned foods, smoked fish, sausages and some cooked foods.

Botulism can be controlled in home-canned foods if home canners are made aware of the dangers and how to prevent it.

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Four classifications are being used currently in the United States to discuss botulism in humans. These are 1) **food-borne botulism**, caused by consuming food containing botulinum toxin 2) **infant botulism**, caused by production of botulinum toxin after germination and growth of the spores within the infant's intestines; 3) **wound botulism**, resulting from germination and growth of *Clostridium botulinum* within a wound; and 4) **undetermined botulism**, occurring in persons older than 12 months, in which no food or wound is implicated.

The majority of reported cases of botulism have traditionally been food-borne in nature. In recent years around 30 cases per year have been reported.

Infant botulism was first recognized in 1976. Currently, around 100 cases are reported each year. The age range has been 22 days to 14 months.

Although the possibility of wound botulism was recognized as early as 1920, no actual cases were reported until 1943. Since the 1980s, the incidence has steadily increased, mostly among injection-drug users.

### The Botulism Organism

There currently are seven known types of *Clostridium botulinum* bacteria. These differ in such characteristics as proteolytic activity, tolerance to salt and reduced water activity, minimum growth temperature and heat resistance.

The proteolytic type A, B and F strains produce very heat-resistant spores which are a major concern in the processing of low-acid foods. These types digest proteins in foods and produce a foul odor that may warn consumers of spoilage.

The nonproteolytic B, E and F strains can grow at refrigerated temperatures, but produce spores of very low heat resistance. These types cause problems primarily in pasteurized or unheated foods. Because they are nonproteolytic, no off-odor or evidence of spoilage may be produced with toxin development.

Type C strains cause botulism in birds, turtles, cattle, sheep and horses. Type D is associated with forage poisoning of cattle and sheep in Australia and South Africa. No outbreaks of type G have been reported; however, type G has been isolated in cases of sudden and unexpected death in humans.

Inactive *Clostridium botulinum* spores are found in soil and water throughout the world. In the spore form, these bacteria are relatively harmless. The problem occurs when the spores **germinate into vegetative** or actively growing cells. As the vegetative cells grow they become overpopulated and begin to die. As they do, they produce the deadly neurotoxin that causes botulism.

Type A toxin is more lethal than types B and E. The toxin is a protein which can be inactivated by heating at 180 degrees F for 10 minutes. The toxin can be absorbed into the blood stream through the respiratory mucous membranes as well as through the wall of the stomach and intestine.

Several conditions must be present for the germination and growth of *Clostridium botulinum* spores. Acid level is a primary factor. Acidity is measured on a pH scale of 0 to 14, with 7 considered neutral, 0 to 7 acidic and 7 to 14 alkaline. A pH near 7 or neutral favors the growth of *Clostridium botulinum*, while growth is inhibited at a pH of 4.6 or lower. The pH of a food also has an influence on the amount of heat necessary to kill the spores of *Clostridium botulinum*. The higher the pH (lower the acid level), the greater the amount of heat needed to kill the spores.

A second important factor affecting the growth and toxin production of *Clostridium botulinum* is temperature. Proteolytic types grow between temperatures of 55 and 122 degrees F, with most rapid growth occurring at 95 degrees F. Nonproteolytic types grow between 38 and 113 degrees F, with an optimum for growth and toxin production at about 86 degrees F. For these types, refrigeration above 38 degrees F may not be a complete safeguard against botulism.

Another important condition affecting the growth of *Clostridium botulinum* is the presence of oxygen. These organisms can't grow if air or free oxygen is present in their microenvironment (the area immediately next to them). This area is so small that it is not readily observed. Therefore, it is possible to have conditions develop in a food system or wound whereby it appears that lots of air is available, but in reality there are areas where no air is present and anaerobic organisms, such as *Clostridium botulinum*, can develop. Anaerobic conditions develop when food is canned. If the food is not heated enough to kill the spores of *Clostridium botulinum*, the spores will germinate and grow during subsequent storage of the food.

Canning is not the only condition in the manufacture and preservation of foods in which anaerobic conditions can develop. Smoked fish can develop anaerobic conditions in the visceral cavity and under the skin. The interior of sausage also may become anaerobic during the preservation process. Anaerobic conditions capable of supporting the growth of *C. botulinum* also have developed in such foods as chopped garlic in oil, foil-wrapped baked potatoes, sauteed onions, turkey loaves, meat stews and pot pies left at room temperature or in a warming oven overnight. In these cases the original baking killed competing organisms and eliminated much of the oxygen in the micro-environment under the crust, foil or buttery coating. Subsequent storage at warm temperatures created an ideal environment for the germination and growth of botulinum spores. For these types of foods, growth of *Clostridium botulinum* is inhibited by storage at a low temperature (below 38 degrees F) and/or the use of a preservative, such as sodium nitrite.

## Food-Borne Botulism

Food-borne botulism was first identified in Europe during the 1800s as a problem in sausages. The sausages probably were slightly preserved with salt and smoke. Refrigeration was nonexistent or dependent on seasons of the year. Because of the great problem with sausages, the disease was named botulism after the Latin word for sausage, *botulus*.

In the 1900s, refrigeration practices improved and sausages no longer caused a major problem with botulism. However, at this same time, the technology and containers for canning became available. Almost immediately, botulism became a problem in canned foods. By 1926, most of the problems in the commercial canning industry had been solved. Since that time, most of the outbreaks of food-borne botulism in the United States have been caused by improperly home-canned foods, mostly fish and vegetables, such as string beans, corn, beets, spinach, asparagus and chili peppers.

Although low-acid vegetables and fish have been the chief culprits, tomatoes, tomato-based mixtures and such fruits as figs, apricots, pears, peaches,

### Infant Botulism

*Unlike food-borne botulism, which is caused by ingestion of pre-formed botulinum toxin, infant botulism is presumed to be caused by ingestion of viable spores that later grow and produce toxin in susceptible infants, mostly under 6 to 8 months of age. Because C. botulinum spores are found in the soil everywhere, the probability of ingesting the spores from garden soil, dust in the air, and such sources as vacuum cleaner dust is quite high. The only food item thus far associated with cases of infant botulism has been honey, although the possibility exists for contamination with the spores from any raw or unprocessed food, especially if it has not been carefully washed.*

applesauce, persimmons and mangoes also have been involved. In some cases inadequate processing permitted the growth of molds, yeasts or bacteria, which in turn raised the pH of the food sufficiently to permit the growth of *C. botulinum*.

In some of these cases, molds or bacteria grew due to poor processing and reduced acidity. In others, reduced acidity may have been due to differences in variety or in the degree of ripeness, pointing up the fact that overripe tomatoes and fruits should not be selected for home canning. With fruits, the syrup added before processing does not become acidic until acid diffuses out of the food. This may take some time if the fruit is not heated (processed) enough.

Colorado and other states in the West have higher per capita rates of food-borne botulism than other parts of the United States. One contributing factor is that the soil in the western U.S. from the Rocky Mountains to the Pacific Ocean contains a particularly high count of Type A *Clostridium botulinum* spores, the type of spores that produce the toxin most dangerous to humans.

A second factor is the higher altitude. **The temperature of boiling water decreases as the altitude increases.** Thus, the temperature at which foods are processed is lower. To compensate, the canning pressure for low-acid foods must be increased by 1/2 pound for every 1,000 feet rise in elevation. For example, at 5,000 feet vegetables must be pressure canned at 12-1/2 pounds pressure per square inch rather than the usual 10 pounds recommended in canning instructions designed for sea level canning. Forgetting to make these changes leads to underprocessing and an increased risk of botulism.

## Symptoms

Symptoms of food-borne botulism usually appear within 18 to 36 hours after the contaminated food is eaten, but the time can vary from six hours to 10 days. The most significant symptoms are blurred double vision and difficulty in swallowing and speaking. Fever is absent early in the disease.

For some types of the disease, early symptoms may be gastrointestinal (nausea, vomiting, abdominal pain, constipation, cramps, headache, fullness) and lead to a false diagnosis of appendicitis, bowel obstruction or heart attack.

Symptoms of infant botulism include constipation, followed by general weakness, feeding and swallowing problems, weak or altered cry, loss of motor tone and poor head control. The syndrome can evolve in anywhere from 6 hours to one week or more and ranges in severity from only minimal constipation to sudden death. In cases of the latter, infant botulism is thought to account for at least some of the reported cases of Sudden Infant Death Syndrome.

## Treatment

Unless treatment of food-borne botulism is initiated promptly at the onset of the symptoms, death may result within three to seven days. Improved detection methods and the ready availability of antitoxins have reduced the high death rate to around 10 percent in recent years.

Most state health departments offer 24-hour assistance in diagnosing and obtaining antitoxin for treatment of botulism. In Colorado, contact the State Health Department at (303) 692-2000 weekdays or (303) 370-9395 weekends and evenings if botulism is suspected.

Treatment of food-borne botulism consists primarily of 1) removing any unabsorbed toxin in the digestive tract, 2) neutralizing the circulating toxin with an antitoxin as quickly as possible, and 3) keeping a patient breathing by a mechanical respirator (iron lung) as necessary. Recovery may take several weeks to months.

Treatment of infant botulism is somewhat different than that of food-borne botulism. Antitoxin generally is not used because of potentially hazardous

## References

CDC. 1998. *Botulism in the United States. 1899-1996: Handbook for Epidemiologists, Clinicians, and Laboratory Workers*. Atlanta, GA: Centers for Disease Control and Prevention.

Sobel, J., Tucker, N., Sulka, A., McLaughlin, J., and Maslanka, S. 2004. Foodborne Botulism in the United States, 1990-2000. *Emerging Infectious Diseases*, 10:1606-1611.

Summary of Notifiable Diseases, United States, 2000. Morbidity and Mortality Weekly Report, 49 (53) 1-100, June 14, 2002.

side effects on young infants. Rather, comprehensive supportive care in the hospital for the course of the disease, usually three to four weeks, is the usual treatment.

## Prevention

Botulism can be controlled if consumers are aware of the dangers and take steps to prevent spoilage in home-canned and home-cooked foods. Here are some important tips to remember:

- Clean foods well before cooking or processing. This reduces but does not remove all bacteria. Bacteria are still present in nearly every pint or unit of food to be cooked or canned.
- Be sure all home canning methods are up-to-date with current research-based recommendations and are properly adjusted for altitude.
- Process all home-canned meats and vegetables, with the possible exception of tomatoes, in a steam pressure canner at 240 degrees F for the time recommended in a current USDA research-based publication. At sea level, a pressure of 11 pounds per square inch (psi) is necessary to reach 240 degrees F. With each 1,000 feet rise in altitude an additional 1/2 psi is needed to achieve 240 degrees F. When using a weighted pressure gauge, the 15 pound weight must be used at all altitudes in Colorado.
- Acid foods, such as tomatoes and fruits, if properly selected and processed, do not support the growth of *Clostridium botulinum* and may be canned in a boiling water bath if current, research-based instructions are followed. The addition of acid in the form of lemon juice or citric acid is recommended in all tomato products canned in a boiling water bath as a precautionary measure.
- Before using home-canned food, critically examine the product and container. A bulging lid or leaking jar are signs of spoilage. When you open the jar, look for other signs of spoilage such as spurting liquid, an off odor or mold.
- As an added precaution, boil all home-canned vegetables and meats without tasting for 10 minutes plus one minute per 1,000 feet above sea level (15 minutes at 5,000 feet). Boil home-canned spinach and corn 20 minutes before tasting. If the food looks spoiled, foams or has an off odor during heating, discard it.
- Dispose of all spoiled food in a place where it will not be eaten by children or pets. One sure way to prevent the spread of toxin is to boil suspect foods 30 minutes before disposing. This will ensure destruction of any toxin that might be present and prevent its spread.
- See 9.300, *Bacterial Food-Borne Illness*, for more tips on avoiding food spoilage.
- Given the widespread nature of *C. botulinum* spores in the soil, especially in the western part of the United States, complete prevention of infant botulism is probably not possible. However, measures that can reduce the incidence include avoidance of honey and protection from excessively dusty or muddy conditions among infants under 1 year of age.