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Clostridium botulinum

What is *Clostridium botulinum*?

Clostridium botulinum is an anaerobic, spore-forming bacterium that can produce a neurotoxin which is one of the most poisonous naturally occurring substances on earth. The toxins of *C. botulinum* are the causative agent for the food poisoning called botulism. This serious illness results in weakness or paralysis of the muscles which can lead to difficulty breathing and even death. The onset of food poisoning by *C. botulinum* toxin usually occurs within 18 to 36 hours after ingestion.

C. botulinum is found throughout the environment, in water, soil and in the intestinal tract of animals therefore any food products that have encountered these could possibly be a hazard. Almost any type of food with:

- A pH value above 4.6
- Salt value below 10%
- Water activity above 0.85

can support the growth and toxin formation of *C. botulinum* in an anaerobic environment (little to no available oxygen). The strains of *C. botulinum* can be divided into two groups based on the type of toxins they produce.

Type of strain	Minimum pH for growth	Minimum water activity for growth	Minimum T for growth /toxin production	Minimum processing temperature (time depends on product)
**Proteolytic A, B, F	4.6	0.94	10°C	121°C
**Non-proteolytic B, E, F	4.7	0.97	3°C	80°C

* Proteolytic – toxin has ability to break down proteins; non-proteolytic – cannot break down proteins
**Human botulism is caused by Types A, B, E
*** Types A and B are primarily found on land. Type E is usually found in freshwater and marine environments

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How to Prevent *Clostridium botulinum* Toxin Formation with Food Processing

C. botulinum cells can be present on raw food products and can survive within foods when safe food processing techniques are not applied correctly. The growth of *C. botulinum* must be controlled when producing foods that are packaged in hermetically sealed (airtight) containers. If the pH of an unrefrigerated, hermetically sealed food product is above 4.6 and thermal treatment is not adequate, *C. botulinum* cells can grow and produce spores and toxins. Spores do not necessarily cause noticeable spoilage in the food so it may appear and smell normal.

To prevent the growth of *C. botulinum*, there are a variety of methods that can be utilized alone or in combination, including:

- High temperatures
- Acidification
- Dehydration
- Salination
- Preservatives

Dried foods that have a water activity of 0.85 or less are considered to be safe from the growth of *C. botulinum* and other pathogenic bacteria. High levels of salt can also be used to keep some foods safe. Freezing and maintaining strict refrigeration temperatures can also be used to keep some foods safe from *C. botulinum*.

Otherwise, in order for low-acid foods in airtight containers to be considered shelf stable at room temperature, they need to achieve "commercial sterility" by reaching temperatures of 121°C for a sufficient time in the coldest spot in the package to destroy *C. botulinum* spores. Potential processing techniques include

- Retorting (in-container sterilization under pressure)
- Ultra-high temperature (UHT) processing with aseptic (sterile) filling

Note: these techniques require specialized equipment which can be expensive. Acidifying to below pH below 4.6 or keeping the product refrigerated/frozen are simpler options when access to this equipment is limited.

How to Prevent *Clostridium botulinum* Toxin Formation with Storage

In some cases where acidification or commercial sterility cannot be achieved for low acid foods, products can be pasteurized and chilled. Proper storage and handling of chilled low-acid food products in hermetically sealed containers is essential to control the growth of *C. botulinum*. Cooling must be done rapidly to avoid extended periods within the growth temperature range of *C. botulinum* (4°C to 48°C). Strict temperature control at or below 4°C throughout storage, distribution, and display are critical for safety. For uncooked, refrigerated seafood, packaging that allows some oxygen transmission (at least 10,000 cc/m2/d at 24°C) will prevent anaerobic conditions and reduce risk.

DEFINITIONS:

Low-acid foods "a food of which any component has a pH that is greater than 4.6 and a water activity … greater than 0.85" (CFIA)

Commercial sterility: The condition achieved in a food that has been processed by the application of heat, alone or in combination with other treatments, to render the food free from viable forms of microorganisms, including spores, capable of growing in the food at temperatures at which the food is designed normally to be held during distribution and storage." (Canadian Food and Drug Regulations)

Acid foods are foods that have a natural pH of 4.6 or below and are considered safe from *C. botulinum* cell growth. These products can be made shelf stable with proper pasteurization, filling, and cooling (USFDA)

Acidified Foods are low-acid foods to which acid(s) or acid food(s) are added, and which have a water activity greater than 0.85 and a finished equilibrium pH of 4.6 or below (USFDA)

Finished Equilibrium pH is the pH of a finished food once all components have reached a uniform pH (can take up to 48 hours for acidified foods).

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What types of food products are at risk?

Some examples of foods that have been implicated in botulism outbreak include under-processed vegetables, soups, meat, and seafood as well as sauces, cheese, yogurt, bean paste and olives. Often home canned products have been implicated.

Case Study: Bolthouse carrot juice

In 2006, six people (Georgia, Florida, and Ontario) contracted botulism from drinking carrot juice produced by Bolthouse Farms. One victim died from the illness and others suffered long-term effects. Investigators determined that this product likely had a breach in refrigeration (despite "keep refrigerated" labelling), allowing production of botulism toxin. Due to this outbreak, in 2007 the US Food and Drug Administration modified its guidance for refrigerated low-acid juices, recommending acidification or appropriate thermal treatment to lower the risk of C. botulinum should refrigeration not be reliable. In Canada, the Safe Foods for Canadians Regulations state that low acid foods may be kept refrigerated or frozen, but they must indicate "Keep Refrigerated" / "garder réfrigéré," or "Keep Frozen" / "garder congelé" on the principal display panel of the package.

Case Study: La Stimpson's clams

In January 2022, La Stimpson's surf clams were recalled from the Moncton Fish Market due botulism risk because of lack of refrigeration and insufficient thermal processing. No one reported illness from this product.

Case study: Garlic-in-oil

Garlic-in-oil products has been linked to several botulism outbreaks; one incident in Vancouver in 1985 affected 37 people and one in New York in 1989 affected 3 people. In both cases the garlic was not acidified or heat-treated, and was not kept refrigerated, which allowed spores to germinate and produce the botulism toxin. Commercially, garlic for garlic-in-oil is now pre-treated (e.g. acidified or dried) or the product is kept frozen.

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