

# Preventing Foodborne Illness: *Bacillus cereus*<sup>1</sup>

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This is one in a series of facts sheets discussing common foodborne pathogens of interest to food handlers, processors, and retailers.

## What is *Bacillus cereus*?

*Bacillus cereus* is a Gram positive, facultatively anaerobic bacteria characterized by large rod-shaped cells and its ability to form heat-resistant endospores. Since this bacterium is commonly found in soil, it is naturally present in a wide range of food products of both plant and animal origin. Growth of *B. cereus* takes place at a temperature range of 4°C to 55°C and a pH range of 4.9 to 10.0. Optimal growth occurs within the narrower temperature range of 30°C to 40°C and pH range of 6.0 to 7.0 (FSANZ 2013).

While there are numerous known species in the genus *Bacillus*, only two, *B. anthracis* and *B. cereus*, are associated with human diseases. *Bacillus anthracis*, though pathogenic, is rarely linked to foodborne illness. However, *Bacillus cereus* is the known source of two distinct types of foodborne illness. Both illnesses are associated with the ingestion of a distinct toxin produced by the bacteria. The first form is emetic, which is characterized by nausea, vomiting, and abdominal cramps. The emetic form has a short onset time of about 1 to 6 hours. It is caused by the ingestion of a pre-formed toxin that has been produced by *B. cereus* on the food prior to eating. The second form is diarrheal and has a longer onset time of about 6 to 15 hours. The diarrheal form is characterized by diarrhea lasting up to 24 hours. This form of the illness is caused

by diarrheagenic enterotoxins (the toxins produced by *B. cereus* that cause diarrhea) produced by *B. cereus* inside the host after ingestion (FSANZ 2013; Naranjo et al. 2011).

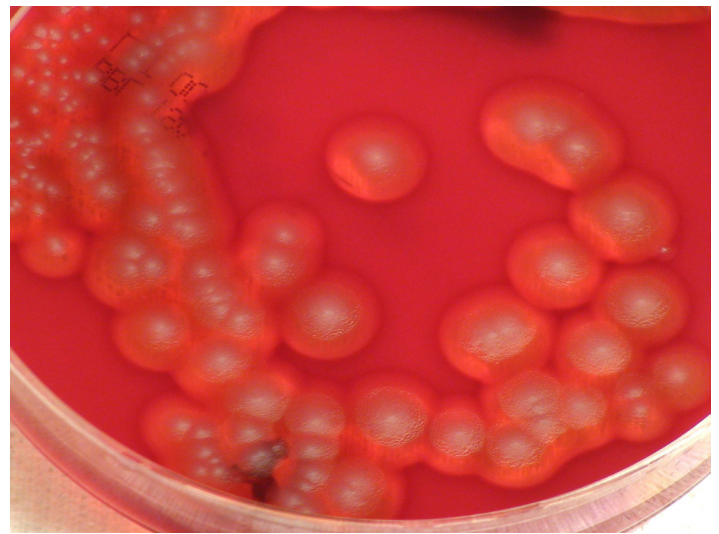


Figure 1. A colony of *Bacillus cereus*.

Credits: CDC/Amanda Moore, MT; Todd Parker, PhD; Audra Marsh

## Transmission of Foodborne Illness

Due to its ubiquity in the environment, *B. cereus* is easily spread to many types of fresh and processed food products. It is a natural component of the normal microflora in foods including meat, vegetables, milk, and other dairy products, but it does not usually pose a health risk. Illness usually occurs when food improperly cooked.

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Transmission of the diarrheal form of the illness is caused by ingestion of bacterial cells or spores at a concentration of greater than 100,000 cells/g. The emetic form is caused by the ingestion of food contaminated with the pre-formed toxin (OAHPP 2015; FSANZ 2013). These instances are almost exclusively the result of improper food handling, storage and cooling that allow for growth of *B. cereus* and production of emetic toxins.

Cooking of contaminated food at recommended temperatures will destroy cells of *B. cereus*. However, heat-resistant endospores produced by the bacteria are more likely to survive cooking and grow well when the food is allowed to cool gradually over a period of time (FSAI 2011). If stored at improper temperatures for several hours before serving (above 41°F or 5°C for cold food; below 135°F or 57°C for hot food), hazardous concentrations of bacterial cells or toxins could be present in the food at the time of consumption (HPSC 2012). The temperature range between 135°F (57°C) to 41°F (5°C) is known as the danger zone of food storage and thus should be avoided to prevent foodborne illnesses.

Additional sources of foodborne illness outbreak could be improper hygiene during food canning and inadequate re-heating of food in congregate settings such as restaurants and schools (HPSC 2012).

## What foods have been commonly associated with *Bacillus cereus*?

A broad range of foods have been implicated as vehicles of *B. cereus*. These include boiled or fried rice, cooked vegetables and meats, pasta, vanilla sauce, custards, casseroles, pastries, salads, soups, ice cream, and herbs and spices (FDA 2012). The emetic form of illness (vomiting) is most frequently associated with improperly refrigerated starch dishes, whereas the diarrheal form of illness is associated with foods containing meat and vegetables (Todar 2012).

There are many examples of outbreaks caused by this organism. In China, 2014, 139 people reported nausea, vomiting, and diarrhea after consuming fermented black beans. Three *B. cereus* strains were isolated from the outbreak, including two known to produce the emetic toxin and one known to produce the diarrheal enterotoxin (Zhou et al. 2014). Another severe outbreak occurred in 2003 when five children in one family became ill after consuming pasta salad that contained the emetic toxin. The pasta was stored in a refrigerator set to 57.2°F, much higher than the proper storage temperature of 41°F. The youngest child, a 7 year-old girl, died in the hospital only 13 hours after

consuming the pasta (Dierick et al. 2005). The Centers for Disease Control and Prevention (CDC) estimates that *B. cereus* was responsible for 63,000 cases of foodborne illness and 20 hospitalizations in the US each year between 2000 and 2008 (CDC 2012). However, many cases are never reported or diagnosed in a clinical setting because the associated symptoms are usually mild and/or short-lasting in nature. Table 1 outlines recent *B. cereus* foodborne outbreaks.

## What methods are used to prevent the contamination of foods?

Because *B. cereus* endospores are extremely heat resistant, they are likely to survive cooking at temperatures that would otherwise destroy foodborne pathogen cells. Heat resistance increases with increasing salinity (presence of salt) and decreases with increasing acidity. *Bacillus cereus* spores can germinate when exposed to heat or improper handling; therefore the 2013 Food Code recommends that hot foods be maintained at a temperature of 135°F (57°C) or above and cold foods be maintained at a temperature of 41°F (5°C) or below (FDA 2013a).

According to the National Institutes of Health (NIH), the National Institute of Allergy and Infectious Diseases (NIAID), and the National Food Processors Association (NFPA), the suggestions below are good methods and practices that destroy *B. cereus*:

- Steaming under pressure, roasting, frying, and grilling foods can destroy the vegetative cells and spores.
- Foods containing the emetic toxin need to be heated to 259°F (126°C) for more than 90 minutes. Reheating foods until they are steaming is not enough to inactivate the emetic toxin.
- Heating (i.e., cooking) will destroy the vegetative (actively growing) cells. Once cooked, the rapid cooling of the product will prevent any spores present from germinating.
- Keep hot foods above 135°F (57°C) and cold foods below 41°F (5°C) to prevent the formation of spores.
- Refrigerate leftovers properly by cooling rapidly to 41°F (5°C) or below. Make sure leftover containers are not stacked close together, thus allowing for adequate airflow around the food and ensuring rapid cooling.

## Good Practices for Food Product Receiving, Handling, Processing and Storage

The FDA defines Current Good Manufacturing Practices (cGMPs) in the Code of Federal Regulations, Title 21, Part 110.5 (FDA 2012a). These cGMPs outline minimal sanitation requirements in FDA-inspected food handling and processing facilities. 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 FDA 2009 Food Code were adopted as law by sixteen states, including Florida's, as of August 2013 (FDA 2013b). The FDA updated the 2009 Food Code with the release of the 2013 Food Code. Since the adoption of new versions of the Food Code varies by state, it is important that each facility check with the appropriate state or local regulatory authority to make sure they are using the guidelines required by their jurisdiction. The Florida statutes can be found at <http://www.leg.state.fl.us/statutes>, Title 33: Chapter 509.

In addition to setting and adhering to strict sanitation requirements in the facility, a retail establishment should also develop SOPs for the receiving and storing of food products and ingredients. If food processing is being performed, appropriate controls and requirements should be established and strictly adhered to. The FDA 2013 Food Code outlines appropriate processing and cooking requirements for food service.

### Processing

One of the easiest ways to prevent foodborne illness associated with *B. cereus* is by ensuring that foods are cooked thoroughly and cooled rapidly. One of the leading causes of foodborne infections and intoxications by *B. cereus* is the improper hot holding of prepared food items. Refer to sections 3-401.11 to 3-401.14, and 3-403.11 of the 2013 Food Code.

- Raw animal foods should be cooked to an internal temperature of 145°F (63°C) or above, and be held for a minimum of 15 seconds at that temperature.
- Fruits and vegetables cooked for hot holding should be cooked to an internal temperature of 135°F (57°C).
- Hold hot food at a temperature of 135°F (57°C) or higher.
- Chill foods promptly. Cooked food should not be left out at room temperature for more than 2 hours, especially meat.

- Reheating previously cooked material such that all parts of the food reach an internal temperature of at least 165°F (74°C) for 15 seconds will inactivate existing toxins. (Note: Contaminated food should never knowingly be served, even if reheated properly. If a food is thought to be contaminated it should be disposed of. When in doubt, throw it out!)

### Storage

Once a product has been received or processed, it should be properly displayed or stored. There are some general guidelines governing these practices as well. Refer to sections 3-501.13 and 3-501.14 of the 2013 Food Code.

- 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 41°F (5°C) or below.
- Frozen food should be thawed at a temperature of 41°F (5°C) or below or under running water at a temperature of 70°F (21°C) or below.
- The product can be thawed as part of the cooking process.
- Food should be cooled from 135°F (57°C) to 70°F (21°C) over a period of two hours.
- Overall, the cooling process from 135°F (57°C) to 41°F (5°C) should take no more than six hours.
- Cooked product should be maintained above 140°F while displayed and stored at or under 41°F.
- Properly label all stored product.

For recommendations that are more specific consult the 2013 Food Code: <http://www.fda.gov/downloads/Food/GuidanceRegulation/RetailFoodProtection/FoodCode/UCM374510.pdf>

### Resources

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Table 1. Significant *Bacillus cereus* Foodborne Outbreaks.<sup>1</sup>

| Year | Location  | Cases | Deaths | Toxin           | Food/Source                            |
|------|-----------|-------|--------|-----------------|--|
| 1985 | US        | 11    | 0      | ND <sup>2</sup> | Hibachi steak                          |
| 1988 | Canada    | 37    | 0      | ND              | Milkshake                              |
| 1989 | US        | 55    | 0      | ND              | Cornish game hens                      |
| 1989 | Canada    | 74    | 0      | ND              | Milk                                   |
| 1991 | US        | 139   | 0      | Diarrheal       | Barbecued pork                         |
| 1993 | US        | 14    | 0      | Emetic          | Fried rice                             |
| 1998 | France    | 44    | 3      | Diarrheal       | Vegetable puree                        |
| 2000 | Italy     | 173   | 0      | Diarrheal       | Cake                                   |
| 2003 | Belgium   | 5     | 1      | Emetic          | Pasta salad                            |
| 2005 | US        | 26    | 1      | ND              | Turkey                                 |
| 2006 | US        | 26    | 0      | Emetic          | Fried rice                             |
| 2007 | Australia | 1     | 1      | ND              | Asparagus sauce                        |
| 2008 | Belgium   | 1     | 1      | Emetic          | Spaghetti                              |
| 2010 | US        | 103   | 0      | Emetic          | Rice                                   |
| 2010 | US        | 17    | 0      | ND              | Pork/Chicken                           |
| 2011 | US        | 58    | 0      | ND              | ND                                     |
| 2012 | Belgium   | 20    | 0      | Emetic          | Rice, cucumber, chicory                |
| 2013 | UK        | 93    | 0      | ND              | Rice                                   |
| 2014 | England   | 14    | 1      | ND              | Intravenous liquid (TPN <sup>3</sup> ) |
| 2014 | Canada    | 44    | 0      | Emetic          | Fried rice                             |
| 2014 | China     | 139   | 0      | Emetic          | Fermented black beans                  |

<sup>1</sup>Delbrassinne et al. 2015; Zhou et al. 2014; FSANZ 2013; DOH 2011; Naranjo et al. 2011; Dierick et al. 2005; BCCDC 2002; CDC 1994; CDC 1986  
<sup>2</sup>Not Determined;  
<sup>3</sup>Total Parental Nutrition