

Preventing Foodborne Illness: *Bacillus cereus*¹

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

What is *Bacillus cereus*?

Bacillus cereus is a Gram-positive, facultative anaerobic bacterium characterized by large rod-shaped cells and the ability to form heat-resistant endospores. Since this bacterium is widely distributed in the environment and often found in soil, it is naturally present in a wide range of food products from both plant and animal origins. *B. cereus* can grow in a temperature range of 39 to 118°F (4 to 48°C). Optimal growth occurs within the narrower temperature range of 82 to 95°F (28 to 35°C) and a pH range of 4.9 to 9.3 (FDA 2012).

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 a 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 is the emetic form, which is characterized by nausea, vomiting, and abdominal cramps. The emetic form has a short onset time of about one to six hours after consumption of contaminated foods and is caused by the ingestion of a pre-formed toxin. The temperature range for emetic toxin (cereulide) production is 77–86°F (25–30°C) (FDA 2022b). The second, the diarrheal form, causes diarrhea, has a longer onset time of about 6 to 15 hours, and can last approximately 24 hours. This illness is caused by enterotoxins (toxins that specifically affect the intestinal mucosa) produced by *B. cereus* in the intestine following ingestion (FSANZ 2013; Naranjo et al. 2011).



Figure 1. A colony of *Bacillus cereus*.
Credit: Pete Seidel [PHIL #12378]

Transmission of Foodborne Illness

Due to its ubiquity in the environment, *B. cereus* can easily contaminate a wide range of fresh and processed food products. It is found in the environment and on many foods, including meat, cereal dishes, vegetables, milk products, puddings, and soups, but it does not usually pose a health risk. Illness typically occurs when food is improperly cooked and stored in the danger zone (41 to 135°F) (FDA 2022b) for extended periods (Marriot and Gravani 2006).

Transmission of the diarrheal form of the illness occurs through ingestion of viable cells or spores. These cells grow in the body and secrete toxins (whereas the emetic form involves ingestion of a preformed toxin present in the food) (Bottone 2010). The diarrheal form typically requires a concentration of 100,000 or more cells/g to cause illness (FDA 2012). In most instances, illnesses associated with *B. cereus* result from improper food handling, storage, and cooling that allow the growth of *B. cereus* and/or the production of emetic toxins.

Cooking contaminated food at recommended temperatures destroys the vegetative cells of *B. cereus*. Heat-resistant endospores from this organism are more likely to survive cooking and germinate and grow when the food is cooled gradually over an extended period. The emetic toxin is heat-stable up to 250°F (121°C) (Rajkovic 2014). If stored at improper temperatures for several hours before serving, > 41°F (5°C) for cold food;

< 135°F (57°C) for hot food, hazardous concentrations of bacterial cells or toxins may develop prior to consumption (HPSC 2012). The temperature range between 135°F (57°C) and 41°F (5°C) is known as the danger zone for food storage and should be avoided (FDA 2022b).

Additional sources of foodborne illness outbreaks include improper hygiene during food canning and inadequate reheating 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 identified as vehicles for *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, such as fried rice, whereas the diarrheal form is more commonly associated with foods containing meat and vegetables (Todar 2012).

There are many examples of outbreaks caused by this organism. In 2014 in China, 139 people reported nausea, vomiting, and diarrhea after consuming fermented black beans. Three strains of *B. cereus* were isolated from the outbreak, including two emetic-toxin-producing strains and one strain producing the diarrheal enterotoxin (Zhou et al. 2014). Another severe outbreak occurred in 2003 in Leuven, Belgium, where five children in one family became ill after consuming pasta salad that contained the emetic toxin. The pasta was stored in a refrigerator set at 57°F (14°C), which is significantly higher than the proper storage temperature of 41°F (5°C). 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* caused 63,400 cases of foodborne illness and 20 hospitalizations in the United States each year between 2000 and 2008 (Scallan et al. 2011; CDC 2012). In addition, a 2012 CDC surveillance annual report lists two outbreaks and 24 illnesses involving *B. cereus* in the United States (Bennett et al. 2014). However, many cases are never reported or diagnosed because the associated symptoms are usually mild and/or short-lasting. Table 1 outlines recent *B. cereus* foodborne outbreaks.

Preventing Contamination by *B. cereus*

Because *B. cereus* endospores are extremely heat-resistant, they can survive cooking temperatures that would otherwise destroy the cells of foodborne

pathogens. Additionally, *B. cereus* spores' heat resistance increases with salinity (salt presence) and decreases with increasing acidity. Although there is no single temperature that kills *B. cereus* endospores in all food products, their growth and further contamination can be prevented. *Bacillus cereus* spores can germinate when exposed to heat or improper handling; therefore, the 2022 Food Code recommends that hot foods be maintained at temperatures 135°F (57°C) or above and cold foods kept at 41°F (5°C) or below (FDA 2022b).

Further research has shown that specific thermal exposure can inactivate *B. cereus* spores in foods such as rice during cooking (Juneja et al. 2020). To achieve thermal inactivation of *B. cereus* spores in rice, it must be heated to 195°F (90.5°C) for approximately 256 minutes or to 210°F (99°C) for about 44 minutes. The thermal exposure applied to contaminated rice resulted in a 4-log reduction (99.99% inactivation) of spores. Such cooking temperatures and times may be useful for retail food services to prevent *B. cereus* spores in cooked rice while minimizing risk to consumers (Juneja et al. 2020). However, the level of heating required can affect rice quality and energy consumption; thus, further research is needed to more precisely target *B. cereus* spores and their heat resistance.

According to the National Institutes of Health (NIH), the National Institute of Allergy and Infectious Diseases (NIAID), the National Food Processors Association (NFPA), and the FDA 2022 Food Code, the suggestions below represent effective practices to prevent *B. cereus* growth:

- Steaming under pressure, roasting, frying, and grilling foods can destroy the vegetative cells if temperatures reach at least 145°F (63°C).
- Since foods containing the emetic toxin need to be heated to 249°F (121°C) for more than 80 minutes, reheating foods until they are steaming is not enough to inactivate the emetic toxin, and efforts should be devoted to prevention (Rajkovic 2014).
- Heating (i.e., cooking) to 145°F (63°C) and reheating to 165°F (74°C) for 15 seconds can destroy the vegetative (actively growing) cells. Once cooked, rapid cooling will prevent any present spores from germinating. However, foods cannot be made safe to eat if toxins have already been formed.
- Keep hot foods above 135°F (57°C) and cold foods below 41°F (5°C) to prevent spore germination and bacterial growth (FDA 2022).
- Refrigerate leftovers properly by cooling rapidly to 41°F (5°C) or below. Avoid stacking containers tightly so that air can circulate and cooling occurs quickly (FDA 2022).

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

The FDA defines current Good Manufacturing Practices (GMPs) in Title 21, Part 117 of the Code of Federal Regulations (FDA 2022a). These GMPs outline minimum sanitation requirements for FDA-inspected food-handling and processing facilities. It is recommended that more specific, stringent standard operating procedures (SOPs) be developed for each facility. In addition, the sanitation recommendations for food service and retail food facilities outlined in the FDA 2022 Food Code were adopted as law by 7 states (11 state agencies), excluding Florida, as of December 2025 (FDA 2025). The FDA updated the 2017 Food Code with the release of the 2022 Food Code. Since the adoption of updated Food Code versions varies by state, it is important that each facility consult the appropriate state or local regulatory authority to ensure they are using the guidelines required by their jurisdiction. The Florida statutes can be found at <https://www.leg.state.fl.us/statutes>, Title XXXIII, Chapter 509.

In addition to setting and adhering to strict sanitation requirements, a retail establishment should also develop SOPs for the receiving and storing of food products and ingredients. If food is being processed, appropriate controls and requirements should be established and strictly followed. The FDA 2022 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 to ensure that foods are cooked thoroughly and cooled rapidly. One of the leading causes of foodborne infections and intoxications from *B. cereus* is the improper holding of cooked foods, such as cooked meats, eggs, rice, vegetables, pasta, sauces and gravies, and starchy foods, as identified in the FDA's Food Code and FSMA Preventive Controls. Refer to sections 3-401.11 to 3-401.14 and 3-403.11 of the 2022 Food Code.

- Raw intact animal foods (such as fish, intact cuts of beef, pork, lamb, and eggs for immediate service) should be cooked to an internal temperature of 145°F (63°C) and held for a minimum of 15 seconds.
- Raw nonintact animal foods (such as ground, minced, or mechanically tenderized meat; ratites (ostrich, rhea, emu); eggs not for immediate service; and comminuted fish or commercially raised game animals) should be cooked to an internal temperature of 155°F (68°C) and held for a minimum of 17 seconds.

- Wild game animals, poultry, stuffed fish, meat, pork, pasta, ratites and poultry, or stuffing containing any meat or poultry should be cooked to an internal temperature of 165°F (74°C).
- Plant foods (such as fruits, vegetables, grains, and legumes) prepared for hot holding should be cooked to an internal temperature of 135°F (57°C).
- Spore-containing foods, such as rice, should be heated to 210°F (99°C) for approximately 44 minutes or to 195°F (90.5°C) for approximately 256 minutes to achieve a 4-log reduction (99.99% inactivation) of *B. cereus* spores (Juneja 2020).
- Hold all hot food at 135°F (57°C) or higher.
- Chill cooked foods promptly. Cooked food, especially meat, should not be left out at room temperature for more than 2 hours.
- Reheating previously cooked food so that all parts reach an internal temperature of at least 165°F (74°C) for 15 seconds can kill most harmful bacteria but may not inactivate existing toxins (Rajkovic 2014). Note: Contaminated food should never be knowingly served, even if properly reheated. If a food is suspected to be contaminated, it should be discarded. When in doubt, throw it out.

Storage

Once a product has been received or processed, it should be properly displayed or stored. There are several general guidelines governing these practices to ensure safety and quality. Refer to sections 3-501.13 and 3-501.14 of the 2022 Food Code, as the requirements are designed to prevent the growth of *B. cereus*, *C. perfringens*, and other spore formers.

- Frozen food should remain frozen until ready for use.
- If frozen food is displayed in a refrigerated case and allowed to thaw, the food should remain at 41°F (5°C) or colder.
- Frozen food should be thawed at 41°F (5°C) or below, or under running water at no more than 70°F (21°C).
- Products may also be thawed as part of the cooking process.
- Food should be cooled from 135°F (57°C) to 70°F (21°C) within two hours.
- Food should be cooled from 70°F (21°C) to 41°F (5°C) within four hours.
- Overall, the cooling process from 135°F (57°C) to 41°F (5°C) should take no more than 6 hours.
- Cooked product should be maintained above 135°F (57°C) while displayed and held at or below 41°F (5°C) for no more than seven days.
- Properly label all stored food products to ensure traceability and safe use.
- Always remember, when in doubt, throw it out.

For more specific recommendations, consult the 2022 Food Code:
<https://www.fda.gov/media/164194/download>.

<https://web.archive.org/web/20240428062156/http://www.cdc.gov/foodborneburden/PDFs/pathogens-complete-list-01-12.pdf>

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Table 1. Significant *Bacillus cereus* Foodborne Outbreaks¹

Year	Location	Cases	Deaths	Toxin	Food/Source
1985	US	11	0	ND	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 (TPN3)
2014	Canada	44	0	Emetic	Fried rice
2014	China	139	0	Emetic	Fermented black beans
2015	US	22	0	ND	Enchilada, cheese, salsa
2015	US	3	0	ND	Rice
2016	US	179	0	ND	Refried beans
2017	US	105	0	ND	Tortilla
2018	US	106	90	ND	Ham
2019	US	116	0	ND	Rice
2020	US	280	0	ND	Coleslaw
2021	US	324	0	ND	Chicken, beans, chili
2022	France	1486	ND	Emetic	Rice, pasta, vegetables
2023	France	474	2	Emetic	Milk/dairy products, nosocomial infection
2024	Norway	23	0	Emetic	Porridge
2024	Germany	2	1	Emetic	Pre-cooked tortellini
2025	Switzerland	27	0	Emetic	Macaroni with béchamel sauce

¹ Sources: Delbrassinne et al. (2015); Zhou et al. (2014); FSANZ (2013); Williams (2011); Naranjo et al. (2011); Dierick et al. (2005); BCCDC (2002); CDC (1994); CDC (1986); CDC (2017); Carroll et al. (2019); CDC (2024); French National Public Health Agency (2022); Manin et al. (2026); Whitworth (2023); Whitworth (2024); Schiel (2026); Biggel et al. (2026)

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