

Bad Bug Book

Foodborne Pathogenic Microorganisms and Natural Toxins

***Bacillus cereus* and other *Bacillus* species**

1. Organism

Bacillus cereus is a Gram-positive, facultatively anaerobic, endospore-forming, large rod. These and other characteristics, including biochemical tests, are used to differentiate and confirm the presence of *B. cereus*, although these characteristics are shared with *B. mycooides*, *B. pseudomycooides*, *B. thuringiensis* and *B. anthracis*. Differentiation of these organisms depends on:

- determination of motility (most *B. cereus* strains are motile)
- presence of toxin crystals (*B. thuringiensis*)
- hemolytic activity (*B. cereus* and others are beta hemolytic, whereas *B. anthracis* usually is non-hemolytic)
- rhizoid growth, which is characteristic of *B. cereus* var. *mycooides*.

B. weihenstephanensis, also a member of this group, is a psychrotrophic strain, and thus can grow at refrigerated temperatures.

Production of the enterotoxin associated with the vomiting form of *B. cereus* food poisoning (cereulide, described below) has been detected in other bacilli, including *B. weihenstephanensis*. This suggests that the plasmid carrying the emetic toxin can undergo lateral transfer, conferring the same properties to otherwise non-pathogenic strains.

B. cereus is widespread in the environment and often is isolated from soil and vegetation. The optimal growth temperature is 28°C to 35°C, with a

For Consumers: A Snapshot

Bacillus cereus might cause many more cases of foodborne illness than is known. One reason it's under-reported may be that most people have fairly mild, brief symptoms, so they don't seek medical attention. But it can cause serious illness in some people, as described below. Often called "*B. cereus*," this bacterium can cause two different types of sickness. (1) In the first type, after contaminated food is eaten the bacteria make a toxic substance in the small intestine. This can lead to diarrhea, cramps, and, sometimes, nausea (but usually not vomiting). Many kinds of contaminated foods have been linked to this illness. Symptoms start in about 6 to 15 hours and usually clear up within a day or so. (2) The second type occurs if *B. cereus* makes a different kind of toxin in contaminated food. It most often affects rice and other starchy foods. It causes nausea and vomiting in a half-hour to 6 hours and usually clears up in about a day. Both kinds of illness generally go away by themselves, but can cause serious complications, although rarely in otherwise healthy people. As with all infections, people who have weak immune systems (because they have certain other diseases or take medications that weaken the immune system) are much more likely to suffer serious consequences. One of the most important things you can do to protect yourself from infection with *B. cereus* is to keep your food refrigerated at 40°F or lower. The reason is that, at higher temperatures, *B. cereus* can form spores – a survival mode in which they make an inactive form that can exist without nutrition and that develops very tough protection against the outside world – that grow and turn into more *B. cereus* bacteria. The more bacteria, the more toxin, and the greater the chance that you'll get sick. Cooking may kill the bacteria, but it might not disable the toxin that causes the vomiting type of illness. And don't stop at refrigeration, because a related *Bacillus* bacterium can survive and grow at refrigerator temperature. Add other [food-safety measures](#) – good hygiene, like washing your hands, foods and utensils, and cooking setting; and keep raw and cooked foods separate.

minimum growth temperature of 4°C and a maximum of 48°C. Growth can occur in pH ranges from 4.9 to 9.3, and the organism tolerates 7.5% salt concentration.

2. Disease

B. cereus food poisoning is the general description of illness associated with this organism, although two recognized types of illness are caused by two distinct metabolites (toxins):

The **diarrheal type** of illness is caused by a large-molecular-weight protein.

The **vomiting (emetic) type** of illness is associated with cereulide, an ionophoric low-molecular-weight dodecadepsipeptide that is pH-stable and heat- and protease-resistant. The non-antigenic peptide is stable after heating at 121°C for 30 minutes, cooling at 4°C for 60 days, and at a pH range of 2 to 11.

- **Mortality:** Albeit rare, the emetic enterotoxin of *B. cereus* foodborne illness has been implicated in liver failure and death in otherwise healthy individuals. Similarly, a newly identified cytotoxin has been isolated from a *B. cereus* strain that caused a severe outbreak and three deaths.
- **Infective dose:** The presence of large numbers of *B. cereus* (greater than 10^6 organisms/g) in a food is indicative of active growth and proliferation of the organism and is consistent with a potential human health hazard. The number of organisms most often associated with human illness is 10^5 to 10^8 ; however, the pathogenicity arises from preformed toxin.
- **Onset:**

Diarrheal type: 6 to 15 hours after consumption of contaminated food.

Emetic type: 0.5 to 6 hours after consumption of contaminated foods.

- **Disease / complications:** Although both forms of foodborne illness associated with the diarrheal and vomiting toxins produced by *B. cereus* are generally mild and self-limiting, more severe and fatal forms of the illness have been reported. Other clinical manifestations of *B. cereus* invasion and infection that have been observed include severe systemic and pyogenic infections, gangrene, septic meningitis, cellulitis, panophthalmitis, lung abscesses, infant death, and endocarditis, and, in cows, bovine mastitis.
- **Symptoms:**

Diarrheal type: The symptoms of *B. cereus* diarrheal-type food poisoning include watery diarrhea, abdominal cramps, and pain, mimicking those of *Clostridium perfringens* food poisoning. Nausea may accompany diarrhea, but vomiting (emesis) rarely occurs.

Emetic type: The symptoms of the emetic type of food poisoning include nausea and vomiting, paralleling those caused by *Staphylococcus aureus* foodborne intoxication.

- **Duration of symptoms:** The symptoms usually subside after 24 hours of onset.

- **Route of entry:** Consumption of food contaminated with enterotoxigenic *B. cereus* or with the emetic toxin.
- **Pathway:** Cereulide has been shown to be toxic to mitochondria by acting as a potassium ionophore. Using a house musk shrew animal model, researchers have found that a serotonin5-HT₃ receptor-mediated mechanism is associated with the emetic syndrome. Two of the diarrheal enterotoxins are composed of multicomponent proteins that have dermonecrotic and vascular permeability activities and cause fluid accumulation in ligated rabbit ileal loops. The third type of enterotoxin is a member of the β -barrel toxin family and is similar to the β -toxin of *Clostridium perfringens*.

3. Frequency

In a recent Centers for Disease Control and Prevention (CDC) [report](#) on domestically acquired foodborne illness in the United States, the estimated number of episodes of *B. cereus* illness annually was given as 63,400. The numbers of confirmed outbreaks reported to the CDC in 2005, 2006, and 2007 were 4, 3, and 6 and affected 69, 35, and 100 people, respectively. However, an average of 37.6 suspected outbreaks occurred during this same period, affecting more than 1,000 people. Foods that were associated with outbreaks included beef, turkey, rice, beans, and vegetables. Other outbreaks may go unreported or are misdiagnosed because of symptomatic similarities to *Staphylococcus aureus* intoxication (*B. cereus* vomiting type) or *Clostridium perfringens* food poisoning (*B. cereus* diarrheal type).

4. Sources

A wide variety of foods, including meats, milk, vegetables, and fish, have been associated with the diarrheal-type food poisoning. The vomiting-type outbreaks generally have been associated with rice products; however, other starchy foods, such as potato, pasta, and cheese products, also have been implicated. Food mixtures, such as [sauces](#), puddings, soups, casseroles, pastries, and salads, frequently have been linked with food-poisoning outbreaks.

5. Diagnosis

Confirmation of *B. cereus* as the etiologic agent in a foodborne outbreak requires either (1) isolation of strains of the same serotype from the suspect food and feces or vomitus of the patient, (2) isolation of large numbers of a *B. cereus* serotype known to cause foodborne illness from the suspect food or from the feces or vomitus of the patient, or (3) isolation of *B. cereus* from suspect foods and determination of their enterotoxigenicity by serological (diarrheal toxin) or biological (diarrheal and emetic) tests. The rapid-onset time to symptoms in the emetic form of the disease, coupled with some food evidence, is often sufficient to diagnose this type of food poisoning.

6. Target Populations

All people are believed to be susceptible to *B. cereus* food poisoning.

7. Food Analysis

A variety of methods have been recommended for the recovery, enumeration, and confirmation of *B. cereus* in foods. More recently, a serological method has been developed for detecting the

putative enterotoxin of *B. cereus* (diarrheal type) isolates from suspect food sources. Recent investigations suggest that the vomiting-type toxin can be detected through animal models (cats, monkeys) or, possibly, by cell culture.

8. Examples of Outbreaks

CDC OutbreakNet [Foodborne Outbreak Online Database](#)

9. Other Resources

- Loci index for genome [Bacillus cereus](#)
- GenBank [Taxonomy database](#)
- ["Produce Handling and Processing Practices"](#) (1997) Emerging Infectious Diseases 3(4).
- [Surveillance for Foodborne Disease Outbreaks](#) – U.S., 2006