MICROBIAL FACTSHEET SERIES

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Bacillus cereus

1. What is *Bacillus cereus*?

Bacillus cereus is a Gram-positive, rod shaped bacterium belonging to the genus Bacillus. It is a spore forming bacterium capable of facultative aerobic metabolism. It causes two kinds of foodborne disease: i) an intoxication due to a toxin preformed in the food and ii) an infection due to the ingestion of cells which produce enterotoxins in the small intestine.

2. Sources of *B. cereus* and its Importance in Foods

B. cereus is widely distributed in nature and is readily isolated from soil, dust and vegetation. Low levels of *B. cereus* cells or spores are found on virtually every raw agricultural commodity, e.g. herbs, spices, vegetables, milk, meat etc. These levels are generally too low to cause foodborne poisoning; however, the ability of *B. cereus* to form spores ensures its survival through all stages of food processing and subsequent time/temperature abuse enables low levels of *B. cereus* to multiply to dangerous levels.

3. *B. cereus* Food Poisoning

Almost all types of foods have been associated with *B. cereus* food poisoning; however, the majority of cases have been linked to heat treated foods which have been subjected to temperature abuse during storage and handling, e.g. cooked rice. Temperature abuse can result in spore germination and multiplication of the vegetative cells, leading to hazardous levels of vegetative cells or toxins in the food at the time of consumption.

B. cereus causes two kinds of foodborne disease:

1) An emetic (vomiting) intoxication due to the ingestion of a toxin preformed in the food. This toxin known as cereulide may be formed by certain strains of *B. cereus* if the vegetative cell count exceeds 10^5 cfu/g. The toxin is extremely stable and cannot be inactivated by reheating the food. Symptoms can appear within five hours and include nausea and vomiting. The duration of illness is usually 6 to 24 hours
2) A diarrhoeal infection due to the ingestion of bacterial cells which produce enterotoxin in the small intestine. This infection occurs when *B. cereus* levels exceed 10^6 cfu/g in the food and sufficient amounts of the enterotoxin are formed in the small intestine of the host. Symptoms usually appear within 24 hours and include abdominal pain, watery diarrhoea and nausea. The duration of illness is usually 12 to 24 hours

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4. Growth and Survival Characteristics

Table 1. Factors affecting the growth of *B. cereus* (vegetative cells)

CONDITIONS	MINIMUM	OPTIMUM	MAXIMUM
Temperature (°C)	4	30-40	55
pH	4.3	6.0-7.0	9.3
Water activity (a_w)	0.93	–	–

The effect of heat on the number of viable cells is represented by the D-value (i.e. the time in minutes at a given temperature to achieve a 90% reduction in the number of viable cells). D-values for *B. cereus* are presented in Table 2:

Table 2. D-values for *B. cereus* spores in certain foods (at 100°C)

FOOD TYPE	D-VALUE (MIN) FOR *B. CEREUS* SPORES AT 100°C*
Pumpkin pie	40
Distilled H_20	5.5
Rice broth	4.2 – 6.3

* ICMSF 1996 provides an extensive list of D-values for *B. cereus* under different conditions and food types.

B. cereus spores are variable in their resistance to heat. Most are moderately heat resistant ($D_{121°C}$ of 0.03 minutes) but some are extremely heat resistant ($D_{121°C}$ of 2.35 minutes). The cereulide toxin is extremely heat resistant and can survive at 126°C for 90 minutes. In contrast, the diarrheal toxin is heat sensitive and can be inactivated by heating at 56°C for five minutes.

5. Incidence of the Disease in Ireland

Bacillus cereus foodborne infection/intoxication has been a notifiable disease in Ireland since 1st January, 2004 (S.I. No. 707 of 2003). According to this legislation, medical practitioners and clinical directors of diagnostic laboratories are requested to transmit a written or electronic notification to a Medical Officer of Health. In 2009, one case of *B. cereus* foodborne infection/intoxication was notified. No cases were notified between 2010 and 2014 inclusive; however, it is possible that this illness is under-reported because the symptoms are generally not severe enough for the patient to visit their GP.

6. Outbreaks of *B. cereus* Food Poisoning

In 2014, 12 Member States of the European Union (EU) reported 287 outbreaks caused by *Bacillus* toxins resulting in 89 hospitalisations and no deaths. This represented 5.5% of all outbreaks reported within the EU and is a small increase (3.2%) compared with 2013, when nine Member States reported 278 *Bacillus* toxin outbreaks. The overall reporting rate in the EU was 0.1 per 100,000 population.

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7. Legislation

All food business operators have a legal responsibility to produce safe food (Regulation 178/2002)[1]. The safety of foodstuffs is ensured by a preventative approach, i.e. the implementation of a food safety management system based on the principles of Hazard Analysis and Critical Control Point (HACCP). This system enables hazards to be identified and controlled before they threaten the safety of food. All food business operators, with the exception of primary producers, are legally obliged to put in place, implement and maintain, a permanent procedure or procedures based on HACCP principles (Article 5 of Regulation 852/2004)[2]. Furthermore, all food business operators, including primary producers, are legally obliged to implement good hygiene practices (GHP). Regulation 852/2004 lays down hygiene requirements for all foodstuffs; while Regulation 853/2004[3] lays down more specific hygiene requirements for foods of animal origin.

Regulation 2073/2005[4] lays down microbiological criteria for various combinations of food commodities and microorganisms, their toxins or metabolites. It requires food business operators to take measures as part of their procedures based on GHP and HACCP principles to ensure compliance with the relevant microbiological criteria. Food business operators should test against these criteria, as appropriate, when validating and verifying the correct functioning of these procedures.

The Regulation differentiates microbiological criteria into:

1) **Process hygiene criteria:** These criteria indicate if the production process is operating in a hygienic manner. A process hygiene criterion is established in Commission Regulation (EC) No 2073/2005 for presumptive *B. cereus* in dried infant formulae and dried dietary foods for special medical purposes intended for infants below six months of age. The criterion is applicable at the end of the manufacturing process
2) **Food safety criteria:** These criteria define the acceptability of a foodstuff in terms of its microbiological safety. They are applicable to foodstuffs placed on the market during their shelf-life. To date, no food safety criterion has been established for *B. cereus*

Please note: Food business operators should be aware of their obligations in these and other pieces of legislation. It is the responsibility of the food business operator to keep up-to-date with all amendments to legislation. For further information on the legislation, please consult the FSAI website: http://www.fsai.ie/legislation/food_legislation.html.

[1] Regulation (EC) No 178/2002 of The European Parliament and of The Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety

[2] Regulation (EC) No 852/2004 of The European Parliament and of The Council of 29 April 2004 on the hygiene of foodstuffs

[3] Regulation (EC) No 853/2004 of The European Parliament and of The Council of 29 April 2004 laying down specific hygiene rules for food of animal origin

[4] Commission Regulation (EC) No 2073/2005 of 15 November 2005 on Microbiological Criteria for Foodstuffs

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8. Control of *B. cereus* in the Food Chain

B. cereus food poisoning is principally associated with temperature abuse during the storage of cooked foods. The following control measures should be employed to control this pathogen:

- All foods should be cooked to a core temperature of 75°C or equivalent, e.g. 70°C for two minutes
- After cooking, foods should be cooled as quickly as possible to ensure they can be refrigerated within two hours
- Hot food should be kept hot, i.e. maintained at a temperature greater than or equal to 63°C, and cold food should be kept cold, i.e. maintained at a temperature less than or equal to 5°C. Particular attention should be paid to pre-cooked rice as *B. cereus* spores can survive the cooking process. These spores can lead to bacterial growth and toxin production if the rice isn't cooled rapidly and stored at the correct temperature
- Low pH foods (less than pH 4.3) and dry foods will not support the growth of *B. cereus*; however, particular care should be paid to dried foods which are rehydrated and stored prior to consumption
- Food handlers must be aware of the microbiological risks and implement good handling and hygiene practices
- A food safety management system based on the principles of HACCP must be implemented (this is a legal requirement for all food businesses)

References/Further Reading

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