Processed Foods and *Bacillus Cereus* Poisoning

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ABSTRACT

Despite advances in food science and technology, foodborne illness is an important cause of morbidity as well mortality both in developing and under developing countries of the world. It is estimated that about one third of the population of industrialized nations are affected from foodborne diseases each year. Microbes can contaminate the food any stage of food chain. In many types of food and feed, the soil can be considered as the initial contamination source for spore forming organisms. Due to the complexity of the food chain, particular spore-forming species may encounter niches where proliferation occurs. This can happen on the primary production level, in the processing or in the final product .These proliferation steps enable the endospore former B. cereus, either to enter as a contaminant into a next step of the production chain or to provoke food quality or safety problems in the final product. It causes two types of food poisoning known as the emetic and the diarrhoeal types. The widespread distribution of B. cereus and the ability of the spores to survive long-term storage in food products, and the thermal resistance of spores help to explain that a wide variety of foods have been implicated in B. cereus foodborne illness outbreaks. It is not surprising that B. cereus is a major concern of the food industry, because it seems impossible to avoid its presence in foods completely. Therefore, sanitation, HACCP and good hygienic practices should be followed to prevent growth of this bacterium during food handling. In addition, it is recommended to monitor the presence of B.cereus in foodborne outbreaks.

***Key words**: Bacillus cereus, Food poisoning, Processed foods, Public health, Soil,Toxin*

INTRODUCTION

Currently, more than 250 foodborne diseases of multiple etiologies have been identified. These diseases can occur in sporadic as well as in epidemic form resulting into high morbidity and mortality in developed and developing nations. Among these, *Bacillus cereus* is an important cause of food poisoning and is reported from many countries of the world (Suksuwam, 1983; Kramer and Gilbert, 1989; TeGiffel *et al.*,1997; Granum *et al.*, 2003 ;Derick *et al.*, 2005). *Bacillus* species are Gram positive, aerobic heterotrophs, mesophilic ubiquitous bacteria, characterized by their ability to produce heat-resistant endosopores with a growth range of 10°C to 48°C, with optimal growth at 28°C to 35°C (Jay *et al.*, 2005). In addition, they can grow in a broad pH range of 4.9 to 9.3.There are about 48 known species in the genus *Bacillus* but only *B. anthracis* and *B. cereus* are associated with human disease. *Bacillus cereus* was isolated from the air in a cowshed by Frankland and Frankland in 1887. Since 1950, many outbreaks from a variety of foods including meat and vegetable soups, cooked meat and poultry, fish, milk and ice cream were described in Europe (Mehrdad, 2007). The food poisoning is a result of either a thermostable emetic enterotoxin or a thermosensitive diarrhoegenic enterotoxin (Schneider *et al.,* 2004).

The authors wish to dedicate this paper in the memory of Swami Vivekanand, a reverend saint and philosopher who made India's greatness known to the world.

The organism is widespread in the soil and the food industry. As a soil bacterium, *B. cereus* can spread easily into many types of foods such as plants, eggs, meat, fish, milk, and dairy products, and is known for causing 25 % of foodborne intoxications due to its secretion of emetic toxins and enterotoxins (Christiansson, 1993; Pal, 2012). Food poisoning occurs when food is left without refrigeration for several hours before it is served. Remaining spores of contaminated food from heat treatment grow well after cooling and are the source of food poisoning (Wijnands *et al.*, 2006).Transmission of this disease results not only from contaminated foods, but improper food handling/storage and improper cooling of cooked foodstuffs . *Bacillus cereus* can infect all persons, since illness may result from ingestion of contaminated foodstuffs, however, the immuno compromised, very young and old may suffer from more serious side effects. Its potential to cause systemic infections is of current public health and biomedical concerns. Hence, this communication highlights the significance of *Bacillus cereus* in processed foods.

Mode of Transmission

The primary mode of transmission is via the ingestion of *B. cereus* contaminated food . Emetic type of food poisoning has been largely associated with the consumption of starchy foods such as rice, potato, cheese and pasta, while the diarrheal type is transmitted mostly by milk products, fish, casseroles, pastries, sauces, vegetables and meat. The bacterium forms spores and spreads easily (Kotiranta *et al.,* 2000). In hospitals, *B. cereus* can be transmitted via contaminated linen (Barrie *et al.,* 1992).

Nature of Illnesses

Bacillus cereus is responsible of two types of food poisoning in humans including diarrhoeal syndrome and emetic illness. The most common is a diarrhoeal illness that is caused by the ingestion of B.cereus cells with the food, and the symptoms such as abdominal pain, watery diarrhoea, rectal tenesmus, moderate nausea, seldom, and vomiting develop within 5 -16 hours and can persist for 24 hours. This syndrome is rather mild and mimic the symptoms of *Clostridium perfringens* food poisoning (Mehrdad, 2007). The dosage of ingested *B. cereus* spores leading to diarrhoeal syndrome is 10^5–10^7 g of ingested food, and 10^5–10^8 g of ingested food for emetic syndrome (Wijnands *et al.,* 2006). The second type is an emetic syndrome caused by heat stable toxin and is characterized by nausea and vomiting. Also, abdominal cramps and/or diarrhea may occur. The incubation period is about 1–5 hours. The symptoms of this illness mimic those of *Staphylococcus aureus* food poisoning (Mehrdad, 2007).

Diarrhoeal poisoning is most probably due to *B. cereus* cells ingested with the food .Most foods will be contaminated with spores of *Bacillus cereus* and whenever conditions are not favorable to spore germination and growth *B. cereus* would be ingested as spores. In contrast, whenever conditions in the food permit germination and growth, *B. cereus* would be ingested as vegetative cells. In particular, refrigeration, considering a mean temperature of refrigerators of 4-7°C would select the psychtrotrophic strains of *B. cereus* (Notermans *et al.* 1997).

Public Health Hazards

Bacillus cereus , being an ubiquitous bacterium*,* is known to affect humans by causing food poisoning and infections as an opportunistic pathogen .Although *B. cereus* is commonly known to cause foodborne intoxications (Jay *et al*., 2005), it has been reported to cause local and systemic infections, as an opportunistic pathogen, especially among immunocompromised patients, newborns, and patients with surgical wounds. The organism can cause ocular infections such as keratitis, endophthalmitis, and panophthalmitis .In addition, *B. cereus* can produce gangrene, bovine mastitis, pyogenic infections, cellulitis, infant death, meningitis, periodontal disease, lung abscesses, osteomelitis, and endocarditis (Barrie *et al*.,1992; Kotiranta *et al*.,2000).

Bacillus Cereus in Processed Foods

The organism is found in about 25 % of food products sampled, including dry milk, cream, rice, meat, fish, pudding, rice, vegetables, spaghetti sauces, etc. Many food mixtures such as soups, sauces, pastries, puddings, salads, and casseroles have been frequently implicated in food poisoning outbreaks (Kotiranta *et al*., 2000).Heat resistance, germination and outgrowth capacity of *Bacillus cereus* spores in processed foods are major factors in producing the disease. Dried milk products and infant foods are known to be frequently contaminated with *Bacillus cereus* (Jensen *et al*., 2003).

The soil, together with air, is probably the primary source of food contamination. Being a soil resident, *B. cereus* is part of the microbiota of plant raw materials, attached as vegetative cells or spores. At harvest, this plant raw material can be used for direct human consumption as fresh produce, as ingredients for food or feed production, or directly as animal feed. Dairy cows consuming such feed will excrete *B. cereus* spores in the faeces, and these spores will contaminate the raw milk causing potential safety or shelf-life problems.Specific endospore formers have become important contaminants in industrial food processing. The direct or indirect soil route of contamination or dispersal is the start of events or processes in the agro-food chain that eventually leads to important problems or concerns for food safety and/or quality. Problems of *B. cereus* food poisoning and/or spoilage are mainly restricted to pasteurized or dried products manufactured in food processing units (Kramer and Gilbert,1989; Kotiranta *et al.,* 2000).

In the ready-to-eat food sector, *B. cereus* is introduced via vegetables, fruits, or herbs and spices and pose safety and spoilage risks in chilled packaged. *B. cereus* spores, which are introduced into the food production chain via plant ingredients or via milk or milk powder, can efficiently adhere to equipment surfaces and pipelines because of the hydrophobic character of the exosporium and the presence of appendages on the spore surface .*B. cereus* biofilm may particularly develop in a partly filled industrial storage or a piping system, and such a biofilm acts as a nidus for formation of spores that can subsequently be dispersed by release into the food production system. The spores of the bacterium embedded in biofilms are protected against disinfectants (Pal *et al*., 2013).

There is use of extended refrigeration in food production and distribution, as well as in the kitchen, to increase the shelf life of processed foods. An important feature of *B. cereus* strains, especially diarrhoeal and food-environment strains (but, however, virtually none of the emetic strains), is psychrotolerance; growing at temperatures d"7°C. Moreover, it is important to note that the majority of *B. cereus* strains are able to start growing from 10°C, which represents mild temperature abuse conditions (Carlin *et al.,* 2006).The level of *B. cereus* in raw foods and in processed foods before storage is usually very low (<100 spores/g or ml) and poses no direct health or spoilage concern. However, upon storage of processed foods or the use of contaminated ingredients in complex foods, conditions may allow germination and outgrowth of spores to levels that present hazards for consumers (Stenfors-Arnesen *et al*., 2008).

Growth of *B. cereus* in pasteurized milk is considered the main limiting factor determining the shelf life of this food product (Pal *et al*., 2012). High level of *B. cereus* in pasteurized milk before the end of its shelf life or prolonged refrigerated storage causes common structural defects known as sweet curdling and bitty cream (Bassett and McClure, 2008). *B. cereus* diarrhoeal cases or outbreaks associated with milk or dairy products are scarce, although *B. cereus* is commonly isolated from pasteurized milk (Pal *et al*., 2012).

Prevention and Control

The heat treatments used for canning of low acid foods can ensure a complete destruction of spores of *B. cereus*. The number of spores in other processed foods must be kept as low as possible by proper cleaning and disinfection of equipments. Rapid cooling is necessary to prevent germination and growth of *B. cereus* spores. Low pH (below 4.5), reduction in water activity (aw) (below 0.92) would inhibit *B. cereus*. In other cases, refrigeration below 4°C is necessary to prevent growth of all types of *B. cereus*, including psychrotrophic strains.The steaming under pressure, roasting, frying and grilling foods can destroy the vegetative cells and spores and a rapid cooling process to prevent the spores from germinating. Foods infested with the diarrheal toxin can be inactivated by heating for 5 minutes at 133°F. Foods infested with the emetic toxin need to be heated to 259°F for more than 90 minutes. Reheating foods until they're steaming is not enough to kill the emetic toxin. In meat processing facilities, to prevent contamination and toxin formation, it has to be assured that good manufacturing practices (GMP) are being used in the slaughterhouses and processing units, apply approved treatments of carcasses to remove fecal bacteria, use proper cleaning and disinfection of food contact surfaces with hypochlorite or other approved sanitizers. It is important to keep hot foods above 60°C and cold foods below 4°C to prevent the formation of spores. It is emphasized that workers must wash hands, utensils, and food contact surfaces with hot soapy water after they touch raw meat or poultry, or before food preparation, and after using the bathroom. Cooking of the beef and beef products thoroughly and properly refrigeration of leftovers are highly imperative to prevent the food poisoning due to *B.cereus* (Schneider *et al.,* 2004).

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