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Bacillus cereus foodborne outbreaks in mass catering

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ABSTRACT

Bacillus cereus is the causative agent of two gastrointestinal diseases that cause emesis and diarrhea. As evidenced by the reviewed literature published between 2002 and 2016, the contribution of the catering industry to the spread of *B. cereus* foodborne intoxications is evident. The reported settings included banquettes, a prison facility, clinics, a wedding, pubs and clubs, a take-away restaurant, a kindergarten, and a hotel restaurant. Many of the reported outbreaks were related to the consumption of rice-based products and starchy foods, together with vegetable-based dishes, with an attack rate that varied between 22.2% and 95.0%. Epidemiological and microbiological investigations allowed the common risk factors to be identified, including incorrect temperature maintenance of the foods and improper cleaning of food production equipment. Hence, to prevent microbial growth and toxin formation, appropriate training of the staff involved in food production and management must be pursued.

1. Introduction

Bacillus cereus is a gram-positive or gram-variable, rod-shaped, aerobic-to-facultative, spore-forming bacterium. Its bacterial spores do not swell the sporangium and sporulate only under aerobic conditions (Bottone, 2010; Tewari and Abdullah, 2015). *B. cereus* is generally considered a mesophilic microorganism, with a temperature range for growth between 10 and 50 °C (with an optimum between 28 and 37 °C). Furthermore, only a few strains can multiply below 7 °C and above 45 °C. The pathogen can grow at pH values from 4.3 to 9.3 (with an optimum between 6.0 and 7.0) and at a minimum of water activity (a_w) of 0.92. *B. cereus* spores are moderately heat-resistant and survive freezing and drying. Some strains require heat activation for spores to germinate and outgrow (Forsythe, 2010; Tewari and Abdullah, 2015, WHO, 2008).

B. cereus is ubiquitous in nature, and living cells can be found in soil (where toxins can persist), water, vegetables, decaying matter, the intestinal tract of animals, and insects (Bottone, 2010; Garofalo et al., 2017; Osimani et al., 2017).

The *B. cereus* group includes seven species (*Bacillus anthracis*, *B. cereus sensu stricto*, *Bacillus cytotoxicus*, *Bacillus mycoides*, *Bacillus pseudomycoides*, *Bacillus thuringiensis* and *Bacillus weihenstephanensis*) that are genetically correlated. All species are known as *B. cereus sensu lato* (Guinebretiere et al., 2008). *B. cereus sensu stricto* is the causative agent of two gastrointestinal diseases: i) an intoxication (emetic syndrome) that occurs approximately 5 h after ingestion due to a heat-stable toxin (cerulide) preformed in the food, and ii) an infection (diarrheal syndrome) due to the ingestion of viable cells, which produce enterotoxins in the small intestine. This latter pathogenic effect is linked to two enterotoxin complexes, namely hemolysin BL (HBL) and non-hemolytic enterotoxin (NHE). Together with single proteins (cytotoxin K and enterotoxin T), it usually manifests 8–16 h after ingestion of contaminated food (Forsythe, 2010; Guinebretiere et al., 2006; Kumari and Sarkar, 2016). In more detail, among the diarrhea-causing toxins, hemolysin BL (HBL) is the best studied. This toxin possesses hemolytic and dermonecrotic activities and has the capacity to cause fluid accumulation in rabbit ileal loops (Ghelardi et al., 2002). Moreover, the non-hemolytic enterotoxin (NHE) is also responsible for foodborne poisoning. Although the action mechanisms of both the HBL and NHE toxins are not completely understood, Sastalla et al. (2013) reported that the *B. cereus* ATCC 10876 strain harbors not only genes encoding NHE but also two copies of HBL genes.

Generally, infections caused by *B. cereus* have a short duration and are self-limiting without recognized post-illness (Schmid et al., 2013).

Abbreviations: AFSSA, Agence Française de Sécurité Sanitaire des Aliments; BIOHAZ, Panel on Biological Hazards; BSE, Bovine Spongiform Encephalopathy; CAC, Codex Alimentarius Commissio; CIP, cleaning-in-place; DGHM, Deutsche Gesellschaft für Hygiene und Mikrobiologie; ECDC, European Centre for Disease Prevention and Control; EFSA, European Food Safety Authority; EU, European Union; FSAI, Food Safety Authority of Ireland; GMP, Good Manufacturing Practices; HACCP, Hazard Analysis and Critical Control Points; HBL, hemolysin BL; MS, Member State; HPA, Health Protection Agency; MPRRR, Ministarstvo Poljoprivrede Ribarstva i Ruralnog Razvoja; NHE, non-hemolytic enterotoxin; NMA, Normas Microbiológicas por Alimentos; PCM, Presidenza del Consiglio dei Ministri; WHO, World Health Organization

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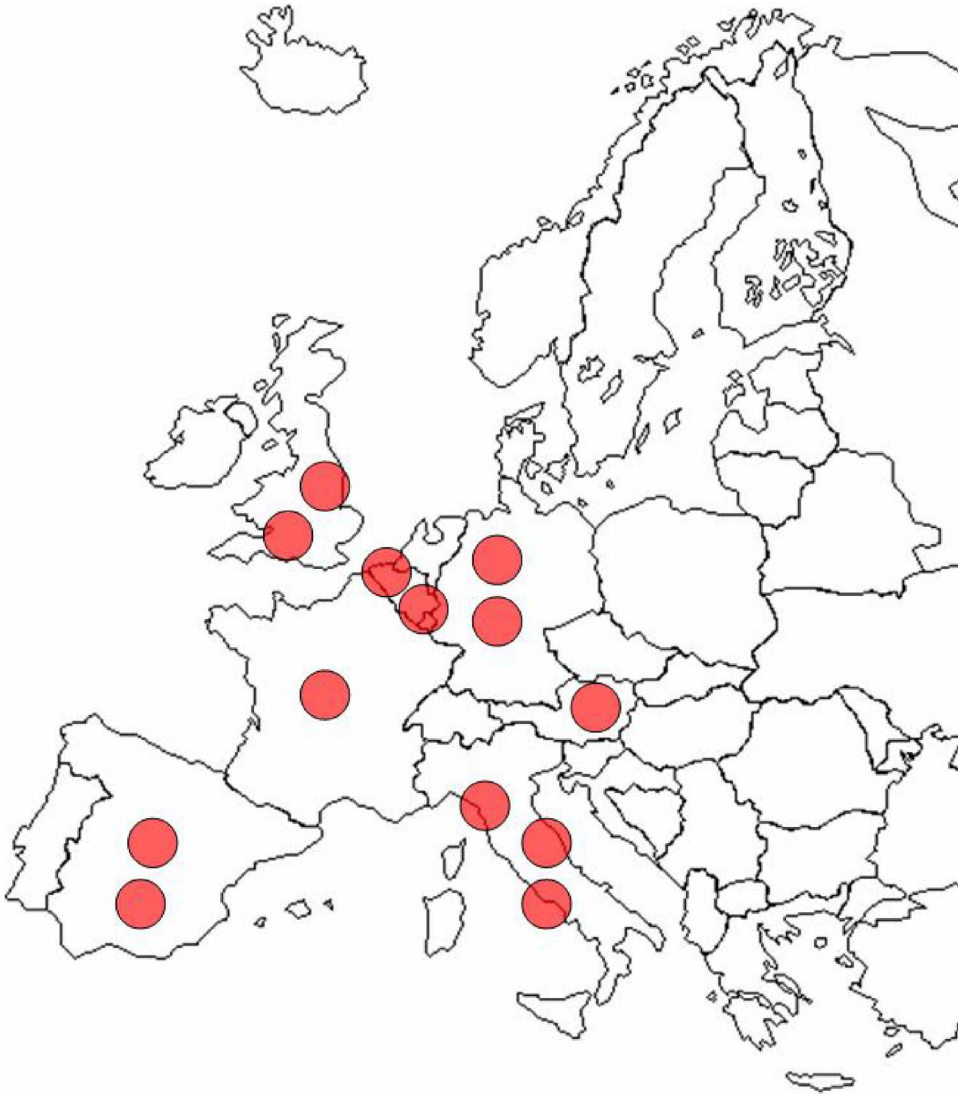

Fig. 1. Geographical location of *Bacillus cereus* outbreaks related to catering service in the European Union between 2000 and 2013. Each dot represents the location of the each reported outbreak in Table 2.

The European Union summary report on trends and sources of zoonoses, zoonotic agents and food-borne outbreaks reported a total of 287 outbreaks caused by *B. cereus* toxins involving 3073 cases (about 8% hospitalization) in European Member States (MSs) in 2014 (EFSA and ECDC, 2016), whereas 291 outbreaks involving 3131 cases (with 3% hospitalization) were reported by nine MSs in 2015. Moreover, in the same year, other outbreaks were reported by Norway (4 outbreaks affecting 17 cases) and France (including 15 strong-evidence outbreaks). With strong-evidence that these outbreaks are caused by *B. cereus* toxins, mixed foods were generally implicated (8 outbreaks), followed by cereal-based foods, almonds and nuts (2 outbreaks) (EFSA and ECDC, 2016).

The present review focuses on reported *B. cereus* outbreaks in the catering sector in the European Union (EU). The review describes the framework of the current EU legislation on food safety, followed by an overview of documented outbreaks of *B. cereus* in the EU related to the catering sector between 2000 and 2013 (Fig. 1). Finally, once again considering the available literature, the authors analyze and discuss the possible risk factors that could have contributed to the presence of *B. cereus* and its toxins in food preparations.

2. The European legislative framework on food safety

The protection of consumers' health represents the main aim of the European regulatory framework on food safety.

Since the biggest European food scandal involved bovine spongiform encephalopathy (BSE) in 1996, the EU underwent a heavy reorganization of the legislative framework inherent in food safety issues and public health.

The key act of this regulatory overhaul was represented by Regulation (EC) No 178/2002 that laid down general principles and requirements of food law based on risk analysis and management. As reported in Article 1, "*This Regulation provides the basis for the assurance of a high level of protection of human health and consumers' interest in relation to food, taking into account in particular the diversity in the supply of food including traditional products, while ensuring the effective functioning of the internal market*".

One of the most impacting provisions of Regulation (EC) No 178/2002 was undoubtedly represented by the establishment of the European Food Safety Authority (EFSA). Among its activities, the EFSA provides independent scientific and technical support for the Community's legislation and undertakes action to identify and characterize emerging risks.

Within the regulatory framework drawn up by Regulation (EC) No 178/2002, in 2004, the European legislation on food safety was further expanded by issuing the "Hygiene Package" composed of four legislative acts, namely Regulation (EC) No 852/2004, Regulation (EC) No 853/2004, Regulation (EC) No 854/2004, and Regulation (EC) No 882/2004. In particular, Regulation (EC) No 852/2004 on the hygiene of foodstuffs established that food businesses are responsible for the safety