A Review on *Bacillus Cereus* in Africa's Locally Produced Foods

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Abstract

Bacillus cereus (B. cereus) is known to be responsible for food borne infections in humans and it is attributable to several foods. However, in developing countries, particularly in Africa, the prevalence of food borne infections attributable to this bacterium is difficult to assess accurately. This is because illness cases are nearly officially not reported. This paper focuses on foods contamination by *B. cereus* in Africa. A large number of foods, including street, fermented and children's foods, with a high rate of *B. cereus* have been revealed. Some of this *B. cereus* produces the emetic toxin, which is capable of causing fatal infections. Although this toxin seems to be less accumulated in acidified foods as well as in foods with low pH and low water activity, concern should be raised about the frequently poor sanitary conditions around the production and vending sites in the urban areas of developing countries. These conditions can increase *B. cereus* multiplication and toxin production, as well as infecting cereal-based infant food formulas, which support significant cereulide levels.

Keywords: *Bacillus cereus*, street foods, fermented foods, Africa

Introduction

Bacillus cereus is a ubiquitous Gram-positive, facultative anaerobic and rod-shaped bacterium. It is increasingly recognized as an important food borne pathogen causing diarrhea, an emetic food poisoning with even fatal outcomes (Malher *et al*., 1997; Schulz *et al*., 2015; Glasset *et al*., 2016). In 2016, the existence of a discrete clade of the *B. cereus* group was found within tropical Africa, capable of causing anthrax-like disease which has been reported and it shows the dangerousness of this bacterium (Antonation *et al*., 2016). Furthermore, the existence of bacteria is suspected to be a highly pathogenic *B. cereus* in Zambia, and the possibility of an outbreak caused by highly pathogenic *B. cereus* has been identified (Ogawa *et al*., 2015)**.**

The diarrhea syndrome is due to a combination of various toxins (Michelet & Mahillon, 2003). However, emesis is caused by a single heat-stable toxin, which is the cereulide produced in the food (Agata *et al*., 1995; Ehling-Schulz *et al*., 2004; Rajkovic *et al*., 2008).

Several death cases related to the emetic *B. cereus* have been reported in developed countries (Dierick *et al*., 2005; Shiota *et al*., 2010; Naranjo *et al*., 2011). Indeed, the prevalence of food borne poisoning outbreaks related to *B. cereus* is documented in these countries (EFSA, 2005). However, in developing countries, particularly in Africa, the actual number of food borne infections attributable to *B. cereus* is difficult to assess accurately. This is because, illness cases are nearly officially not reported.

Starchy foods like rice and pasta are mostly associated with emetic food poisoning (Naranjo *et al*., 2011). Rice is implicated in 95 % of the *B. cereus* emetic food poisoning cases (Altayar & Sutherland, 2006; Ehling-Schulz *et al*., 2004). Furthermore, many other foods such as beef, poultry, vanilla sauce, pasteurized cream, milk pudding, milk product, pasteurized milk, and dairy products can support the *B. cereus* emetic toxin production (Kroten *et al*., 2010; Schoeni & Wong, 2005; Delbrassinne *et al*., 2011). It must be noted that most of these foods implicated in food poisoning or which allowed the *B. cereus* emetic toxin production are consumed in different parts of African countries. In sub-Saharan Africa for example, cereals are considered one of the most important sources of nutrients, and young children below 5 years often receive some cereal-based gruels as complementary foods for breast feeding. These foods are produced in traditional production units under poor sanitary conditions (Honfoga *et al*., 2003; Mouquet-Rivier *et al*., 2008; Humblot *et al*., 2012).

According to Cissé *et al*. (2018), sorghum and millets constitute the main source of nutrition in diets of people living in the semi-arid regions of Africa and flour is one of the most consumed foods in Cameroon (Engle-Stone *et al*., 2012). Furthermore, in 2014, Ghosh *et al*. reported the

implementation of small infant flour production companies, in many developing countries, to make locally produced infant flours available.

Since several food poisoning have been associated to *B. cereus*, and the health of infants and young children is at stake, it is relevant to have an overview of the prevalence of this bacterium in different foods in Africa.

Bacillus Cereus in African Fermented Foods

Some food condiments produced by alkaline fermentation constitute an important source of protein and are an essential part of the diet in West African countries, such as Burkina Faso and Benin (Kabore´ *et al*., 2013; Kpikpi *et al.,* 2014; Thorsen *et al*., 2015; Qian *et al*., 2015).

Many fermented foods are known, while some serve as main course meals, others serve as beverages and almost all humans are exposed to fermented foods in many forms.

Several studies have been reported on the health-promoting properties of fermented foods such as anti-inflammation, anticancer, and antioxidant properties. Also, fermented foods may improve intestinal and extra intestinal health. Furthermore, the folates, essential vitamins (B9) could be increased in foods during fermentation (Sivamaruthi *et al*., 2018; Kok *et al*., 2018).

However, most fermented foods have health-promoting benefits, bacterial species belonging to *Bacillus cereus* "sensu lato" (sl) group may occur in high numbers, or even be dominant in traditional fermented African foods (Oguntoyinbo & Oni, 2004; Azokpota *et al*., 2007; Agbobatinkpo *et al*., 2013; Park *et al*., 2016).

Thus, after investigating fermented African locust bean-based condiments (Parkia biglobosa) produced in Benin, Thorsen *et al*. (2010) isolated Nineteen *B. cereus* group strains and seven of them produced cereulide. According to these authors, no reports on food poisoning from the consumption of the fermented condiments exist. Also, in 2012, Humblot *et al*. isolated high count of *Bacillus cereus* from cereal-based fermented slurries, which is used to prepare infant foods in an African context. *B. cereus* virulence genes were characterized in 60 isolates from 26 traditional cereal-based foods. Seventy-two and 38% of isolates were positive for the complete set of genes coding for hemolysin BL and nonhemolytic enterotoxin, respectively. This suggested a high enterotoxigenic potential for these foodborne isolates. Authors, however, suggested an inadequately controlled fermentation, resulting in conditions that would permit growth in some instance of pathogenic bacteria such as *B. cereus*. Fortunately, no potentially emetic toxin–producing strains were detected in this case.

In the same vein, Thorsen *et al*. (2015) isolated fifty-three *B. cereus* sensu lato from traditional West African food condiment. The number among them has been identified as cereulide producers. Within these conditions,

those foods represent a major risk factor in emetic food poisoning. On another note, *Bacillus cereus* was detected in 95% of 50 tested samples of Nigerian traditional fermented dairy foods (Oguntoyinbo & Kintum, 2015) and in fermented alcoholic beverages (Jeon *et al*., 2015).

The high incidence of detection (20%) of possibly pathogenic *B. cereus* strains in a traditional fermented soup condiment from Nigeria, and this brings to light the potential health risk incurred by consumer (Oguntoyinbo *et al*., 2010).

In the knowledge that *Bacillus* species are among the common microorganisms involved in the fermentation process, the modernization process which involves developing appropriate steps such as starter culture production, controlled multi-step fermentation, and fermented functional foods production is recommended to obtain an enhanced health beneficial fermented product (Gadaga *et al*., 2004; Marco *et al*., 2017; Sivamaruthi *et al.,* 2018).

Furthermore, the importance of fermented foods in African's eating habits and the frequently used cereal-based fermented foods as complementary foods for infants and young children in Africa should be taken in consideration (Tou *et al.,* 2006). Also, the preparation of these foods should be carried out under appropriate hygienic conditions.

Bacillus Cereus in Africa's Street Foods

Ready-to-eat foods that are prepared and/or sold by vendors in public places or informal sector, commonly known as "street foods" (Hanashiro *et al*., 2005; Steyn *et al*., 2011; Alimi, 2016), are very popular in developing countries where a nutrition transition is underway in urban areas.

For many people with limited means, street foods are the most accessible way of obtaining a nutritionally balanced meal outside the home as long as the consumer is informed and capable of choosing an appropriate combination of foods (FAO, 2009). Even if these street foods ensure food security for low-income group urban populations and make an important contribution to employment (Kharel *et al*., 2010; Ekanem *et al*., 1998; Kharel *et al*., 2016), their cooking and sales operations are often unhygienic, particularly in developing countries. Thus, in 2016, the microbiological analysis of Soy wara, a common ready-to-eat food products and sale in Nigeria, highlighted the contamination of this food by different pathogens, including *B. cereus* (Akanbi & Usoh, 2016). The determination of microbial load and pathogenic organisms in street meat by Haileselassie *et al.* (2013) showed mean values of 4.3×10^6 cfu / g, and bacteria. *B. cereus* was one of the main isolated pathogens. Furthermore, after analyzing 148 point-of-sale composite street food samples in Gaborone, Botswana between June 2001 and May 2002, the *B. cereus* levels is as high as 9.1 log CFU/g and 59.6% of

enterotoxigenic *B. cereus* was determined (Murindamombe *et al*., 2005). This bacterium was also isolated from 511 menu items, classified as breakfast/snack foods, main dishes, sauces, and cold dishes sold on streets of Accra, as part of an investigation on food quality and factors predisposing to their contamination. According to the authors, street foods can be sources of enteropathogens (Mensah *et al*., 2002). It must be noted that the risk of food poisoning from street food remains a threat in many parts of the world, especially microbiological contamination. *Bacillus cereus* contamination of raw milk produced on traditional dairy farms in Abidjan (Ivory Coast) from farm to retail was estimated at 27% and 41% respectively, for the udder milk samples and from seller's pooled milk (Yobouet *et al*., 2013). Given the high degree of milk consumption, there is a risk of exposure to *B. cereus* and therefore the probability of food poisoning caused by this bacterium is high. Also, it showed that "the attiéké", a popular food in Ivory Coast, could be a source of contamination by *B. cereus* given the presence of a high rate of this bacterium in the "Attiéké" (Yobouet *et al*., 2016). The temperatures used in cooking this food are high enough to kill the vegetative cells, but the resistant *B. cereus* spores can survive. Thus, handling after cooking, predisposes the latter to recontamination (Umoh & Oddoba, 1999; Yobouet *et al*., 2016; Buliyaminu, 2016).

Conclusion

In this review, the presence of *B. cereus* in fermented foods and street foods in Africa was highlighted. Even if no reports on food poisoning from the consumption of the fermented condiments exist, most of these foods often contain high level of *B. cereus* and some of them produce emetic toxin. Although this toxin seems to be less accumulated acidified foods, concern should be raised as regards to cereal-based infant food formulas, which support significant cereulide levels. Furthermore, fatal cases of infection due to the *B. cereus* emetic toxin which occurred in Europe and Asia in the last two decades should be taken into consideration, and the contamination of food by this bacterium needs more attention in Africa. This study also contributes to the understanding of the risk associated with the presence of *B. cereus* in traditional fermented foods, as well as in street foods produced in poor conditions, in Africa.

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