Imported food risk statement
Bean curd and *Bacillus cereus*

Commodity: Bean curd, also referred to as tofu. This includes fresh and preserved bean curd, such as fermented bean curd, made from soy milk. Bean curd made from non-soy products are not covered by this risk statement.

Microorganism: *Bacillus cereus*

Recommendation and rationale

Is *B. cereus* in bean curd a medium or high risk to public health:

☐ *Yes*

☑ *No*

☐ *Uncertain, further scientific assessment required*

Rationale:

- *B. cereus* is a moderate hazard which generally causes illness of short duration and usually presents no sequelae. Also, large numbers of *B. cereus* are required for toxin production to occur.
- There is no evidence of *B. cereus* illness attributed to consumption of bean curd, despite the non-compliance reported for analyses under the Australian Imported Food Inspection Scheme.
- *B. cereus* vegetative cells are inactivated by the heating process applied during the production of bean curd.
- *B. cereus* spores can survive the heating process, however implementation of good manufacturing practices and good hygienic practices will minimise *B. cereus* contamination of bean curd.
- If post-heating conditions are suitable, *B. cereus* spores can germinate and vegetative cell growth can occur.
- International and Australian compliance and recall data have shown detections of *B. cereus* in bean curd, however levels of *B. cereus* from the Australian Imported Food Inspection Scheme compliance testing are generally significantly lower than levels associated with the production of *B. cereus* toxins.

General description

Nature of the microorganism:

B. cereus is a facultative anaerobic Gram-positive, spore-forming, rod shaped bacteria. It is widespread in the environment and is often isolated from soil and vegetation (FDA 2012; FSANZ 2013).

B. cereus produces two types of toxins – emetic (vomiting) and diarrhoeal – which cause different types of illness. The emetic syndrome is caused by an emetic toxin produced by the bacteria during the growth phase in the food. The diarrhoeal syndrome is caused by diarrhoeal toxins produced during growth of the bacteria in the small intestine (Ehling-Schulz et al. 2006; FSANZ 2013).

Growth of *B. cereus* can occur at temperatures ranging between 4 – 55°C, pH of 4.9 – 10.0 and a minimum water activity of 0.93 when other conditions are near optimum. Normal cooking conditions will generally kill vegetative cells. However, spores are heat resistant; resistance to increased temperatures is enhanced in high fat and oily foods. Cooking to temperatures ≤ 100°C can allow spore germination and growth of *B. cereus* will occur if the food is then held at temperatures between 10 – 50°C. The emetic toxin is heat stable and can

withstand normal cooking procedures (ICMSF 1996; FSANZ 2013; Granum and Lindback 2013).

Adverse health effects:

B. cereus is a moderate hazard as both forms of illness are generally of short duration and usually have no sequelae (ICMSF 2002). All population sub-groups may be susceptible to *B. cereus* food poisoning. However some individuals, especially young children, are particularly susceptible and may be more severely affected (ICMSF 1996).

Food poisoning from food containing the emetic toxin has a short incubation period of 1 – 5 hours with recovery usually occurring within 6 – 24 hours. Symptoms include nausea, vomiting and abdominal cramping. The diarrhoeal syndrome has an incubation period of 8 – 16 hours with illness lasting 12 – 14 hours, although it can continue for several days. Symptoms are usually mild with abdominal cramps, watery diarrhoea and nausea. In a small number of cases both emetic and diarrhoeal symptoms occur (Schoeni and Wong 2005; Senesi and Ghelardi 2010; FSANZ 2013; Granum and Lindback 2013).

The number of organisms most often associated with human illness is 10^5 to 10^8 CFU/g. However, exposure to the bacteria *per se* does not cause illness, rather exposure to the emetic toxin or diarrhoeal toxins causes illness (FDA 2012).

Consumption patterns:

In the 2011 – 2012 Nutrition and Physical Activity Survey (part of the 2011 – 2013 Australian Health Survey) <1% of children (aged 2 – 16 years), <1% of adults (aged 17 – 69 years) and <1% of people aged 70 and above reported consumption of bean curd (Australian Bureau of Statistics 2011). Mixed foods that contained bean curd were excluded from the analysis. The survey derived data from one day of dietary recall data.

Key risk factors:

Key risk factors on the farm during the growing and harvesting of soybeans include contact with the soil (as *B. cereus* is commonly found in soil) and quality of the irrigation water. Risk factors associated with bean curd production include contaminated raw ingredients (soybeans) and water quality during production. The heating process used during bean curd production will kill any *B. cereus* vegetative cells which may be present; however *B. cereus* spores and the emetic toxin are heat resistant. If the conditions are suitable (i.e. warm and moist) spores can germinate, leading to the growth of vegetative cells in the food (this growth can occur after the heating process used in the manufacture of bean curd) (FSANZ 2013; MPI 2016).

Risk mitigation:

Good agricultural practices on the farm during soybean primary production will minimise *B. cereus* contamination of the raw ingredients for bean curd production. Good manufacturing practices and temperature control in food manufacturing will limit the potential for growth of *B. cereus* during bean curd production. The heating step during production is lethal to *B. cereus* vegetative cells. Good handling practices post-processing and temperature control will minimise spore germination and subsequent growth of vegetative cells within the bean curd.

Large numbers of *B. cereus* cells are required for toxin production to occur. Studies have shown that 10^6 to 10^8 CFU/g of *B. cereus* was required for the formation of emetic toxin in various foods (Agata et al. 2002; Finlay et al. 2002).

Compliance history :

Under the Imported Food Inspection Scheme of the Australian Department of Agriculture and Water Resources, the test applied to bean curd for *B. cereus* is n=5, c=2, m=10^2 CFU/g, M=10^3 CFU/g. The test limit applied is significantly lower than the level of *B. cereus* associated with the production of toxin. The imported food compliance data sourced from the Imported Food Inspection Scheme for January 2007 – May 2016 showed that of the 489 *B. cereus* tests applied to bean curd there were 89 fails (an 18.2% failure rate). The failed samples were from multiple Asian countries; the majority of failed samples were fermented or

preserved bean curd.

There were 15 notifications on the European Commission's Rapid Alert System for Food and Feed (RASFF) for *B. cereus* in bean curd from China and Taiwan during the period January 2007 – May 2016. There were an additional two notifications for *Bacillus* spp. in bean curd from China.

There have been four food recalls in Australia of bean curd due to the presence of *B. cereus* from 2007 – May 2016. These recalls were for product imported from China and Taiwan. There have been no recalls of domestic product.

Surveillance information:

Infection with *B. cereus* is not a notifiable disease in Australia. There was one reported outbreak in Australia in 2011; the outbreak was associated with multiple foods (OzFoodNet 2015). No Australian outbreaks were reported in the OzFoodNet reports for 2012 and 2013.

Illness associated with consumption of bean curd contaminated with *B. cereus*

A search of the scientific literature via Web of Science, PubMed, Scopus, the US CDC Foodborne Outbreak Online Database and other publications during the period 1990 – February 2016 failed to identify any outbreaks associated with *B. cereus* and consumption of bean curd.

Data on the prevalence of *B. cereus* in bean curd

A search of the scientific literature via Web of Science, PubMed, Scopus and other publications during the period 1990 – February 2016 identified limited data on the prevalence of *B. cereus* in bean curd:

- Survey in Thailand in 2010/2012 – *B. cereus* was isolated from 40% of unpackaged tofu collected at open markets (n=74) and 41% of packaged tofu (n=59) collected at supermarkets. Of the 54 *B. cereus* isolates, four isolates were of the type able to produce diarrhoeal enterotoxin (Ananchaipattana et al. 2012).
- Survey in Hong Kong in 2008 – unsatisfactory levels of *B. cereus* (ranging from 2.9×10^5 – 2×10^6 per gram) were detected in 12.5% of bottled fermented bean curd cubes collected from restaurants and retail stores (n=32) (CFS 2008).

Other relevant standards or guidelines

- FSANZ compendium of microbiological criteria for food categorises food as satisfactory if *B. cereus* levels are $<10^2$ CFU/g. Food is deemed potentially hazardous if *B. cereus* levels are $>10^5$ CFU/g.
- Codex general principles of food hygiene *CAC/RCP 1 – 1969* follows the food chain from primary production through to final consumption, highlighting the key hygiene controls at each stage (Codex 2003).

Approach by overseas countries

Many countries and regions, such as New Zealand and the European Union, require food manufacturers (including bean curd production) to have HACCP based measures in place.

Other considerations

Biosecurity restrictions apply to products under this commodity classification. Refer to the BICON database.

This risk statement was compiled by FSANZ in: November 2016

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