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RESEARCH ARTICLE

Bacillus cereus Contamination in Selected Home-based Food Products Sold Throughout Malaysia

Muhammad Amirun Che Hassan, Muhammmad Nur Shazwan Jamzuri, Fisal Ahmad, Amir Izzwan Zamri, Tuan Zainazor Tuan Chilek*

Faculty of Fisheries and Food Science, Universiti Malaysia Terengganu, 21030 Kuala Nerus, Terengganu, Malaysia

Abstract Home-based food was a new trend in food business industry where the sellers' or the owners' fully prepared and handled food for sale from their home. This online food business had start blooming since the beginning of the Covid-19 Pandemic due to various factors. Almost every Malaysian can produce and sell foods from their home, even without proper training and knowledge regarding food safety. These products were usually sold on online shopping platform or social media as marketing and ordering tools. The purpose of this research was to evaluate the status of *Bacillus cereus* that present in the selected home-based food products. *Sambal belacan* and *sambal bilis*, both packed in retort pouch and glass jar were chosen as representative samples. A total of 40 samples was purchased through online shopping platform, Shopee, with a pre-determined and appropriate screening. The method was set to simulate the real-life situation of how the home-based food purchasing were made by most peoples. The purchased samples were subjected to the enumeration of *Bacillus cereus* and total plate count (TPC). From the analysis, it was found that the *B. cereus* count of 8 out of 40 samples had exceeded the acceptable limit set by the Guidelines for Assessing the Microbiological Safety of Ready-to-Eat Foods, 2009, which is >1x10^4 CFU/g. This study indicated that the home-based food products still possess a threat regarding the presence of pathogenic anaerobic bacteria. More data and studies were still needed to validate the food safety status of home-based food products in the market.

Keywords: Home-based food, anaerobic bacteria, hermetically sealed packaging, online shopping platform, *Bacillus cereus.*

Introduction

Food industries in Malaysia have been playing a major role in sustaining the everyday life of Malaysian. This industry is also contributed to Malaysia's economy rapidly. Food industries in Malaysia were very diverse, ranging from small scale street hawkers to large scale multinational food companies [18]. Regardless of their scale, all of them have their own importance and impacts toward sustainability and lifestyle. In order to manage their operation properly, different type of food premises will require different needs in terms of facilities, infrastructures, equipment and else. Food industry was a very dynamic industry and very susceptible to changes as the generation shifts [45]. Following the global food trends, food industry must adapt to supply and provide demanded food to consumers. One of the trends that were gaining more popularity recently is the home-based food business.

Home-based food products can be defined as the operation of food business that been fully conducted in the sellers' home. This business has been increasing significantly since the start of the Covid-19 Pandemic due to several key factors [43]. In Malaysia, during the peak of the pandemics, the government issued a Movement Control Order (MCO) to restricted the movement of peoples and to contained the disease's spread. Because of this, most business and industries had to be shut down to follow this order. This scenario had caused massive dismissal dan unemployment among Malaysian [61]. People who were affected needs a new source of income to sustain themselves. By preparing and selling food from

***For correspondence:**
t.zainazor@umt.edu.my

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home, they can obtain some income, while still be comply with the MCO. However, the downside was many of the newly emerged sellers/owners were untrained and lacking in knowledge regarding basic food safety management. If it was not controlled properly, foodborne illness outbreak could easily occur. This matter had been a concern for Malaysia Ministry of Health (MOH). Recently, on March 2021, MOH have endorsed a new guideline and certification regarding the home-based food.

Most home-based food products can be considered as ready-to-eat (RTE) and be packed in hermetically sealed packaging (air-tight packaging). Hermetically sealed package was quite effective at extending the shelf-life of most high-risk food. The packaging method allows foods to be packed and preserved without the use of any chemical, but will solely utilized the vacuum and airtight condition of the package [36]. However, its open a new way for anaerobic bacteria growth. Anaerobic bacteria can survive and even grow in low oxygen concentration medium [6]. Out of all anaerobic bacteria, *Bacillus cereus* are some of the main concerns. *Bacillus cereus* had been proved to be able to alter their metabolic pathway in the event where oxygen concentration were low, making them able to grow in anaerobic condition [54]. It also a spore-forming bacteria, making it very easy to spread and very resistant to heat [47]. Hence, this study was designed to evaluate the contamination status of *Bacillus cereus* in selected home-based food products sold throughout Malaysia and to discuss the possible risk and factors which might contribute to the contamination.

Materials and Methods

Sample Collection and Screening

The home-based food product representatives (*sambal belacan* and *sambal bilis* packed in retort pouch and glass jar) was purchased using online shopping platform, Shopee. The method used was randomized sampling. The samples were delivered by manufacturers/sellers via third-parties courier services, following the standard procedure of most online shopping. This method was self-developed and designed to simulate the real-life situation for most home-based food products purchasing. A total of 40 samples from 4 different groups were purchased and subjected to analysis. The samples were; 10 samples for *sambal belacan* in retort pouch, 10 samples for *sambal bilis* in retort pouch, 10 samples for *sambal belacan* in glass jar and 10 samples for *sambal bilis* in glass jar.

All samples that were purchased came from different brands. The screening for the samples' purchasing had been done thoroughly, and the elements that been considered were; 1) The sales amount for the products (samples) must be more than 500 units sold and the star rating for the products should be 4 stars or more. This indicate that many purchased had been done for the products (samples); 2) The location of the production for the samples; 3) The "home-made' claim for the products – 'made at home', 'home-made', 'made with traditional recipe', etc. This indicate that the products were indeed made at home (home-based food products); 4) The products should be ready-to-eat products (RTE); 5) The critical claim on processing and shelf-life of the products. For example, the products were subjected to retort processing, sterilization and so on.

The samples were subjected to enumeration of *Bacillus cereus* and total plate count (TPC) for evaluation of microbial contamination. Visual inspection for the samples were also done.

Enumeration of *Bacillus cereus*

A total of 25g of the samples were weighted inside a stomacher bag and then been homogenized for 60 seconds in 250ml of 0.1% peptone water using a stomacher. The homogenate was further diluted in another 0.1% peptone water for serial dilution process. A 1ml of the homogenate was diluted with 9ml 0.1% peptone water inside a universal bottle. Serial dilution was repeated until 10^{-3} were obtained. After that, 0.1ml amounts of the 10^{-1} and higher homogenate dilutions was inoculated on the *Bacillus cereus* agar (BCA) surface. The agar was incubated at 37°C for 24 hours. If no colonies present, it was further incubated for another 24 hours. The colonies presented was counted and reported. *Bacillus cereus* colony was represented by a blueish area on green agar surface [20].

Total Plate Count (TPC)

A total 25g of samples were weighted and added with 225ml 0.1% peptone water in a stomacher bag before been homogenized using stomacher for 60 seconds. Next, 1ml of homogenate was transferred to 9ml 0.1% peptone water inside a universal bottle to obtain 10^{-2} dilution. A serial dilution was continued until 10^{-3} was obtained. 0.1ml from all the dilutions was pipetted and spread onto plate count agar (PCA) plates. The plate was incubated at 37ºC for 24 - 48 hours. Plates was examined and the number for suspected colonies was calculated according to rules applicable for colony counting [57].

Results and Discussion

Home-based food products can be defined as the operation of food business that been fully conducted in the sellers' home. This business has been increasing significantly since the start of the Covid-19 Pandemic due to several key factors [43]. Most home-based food products can be considered as RTE products. A preliminary survey through web search on various platform was done before selecting the samples in terms of brand, type of packaging, product weight and place of manufacturing. The limit for unsatisfactory level of *Bacillus cereus* was set to be 1.0 x 10^4 CFU/g as stated in the Guidelines for Assessing the Microbiological Safety of Ready-to-Eat Foods, 2009. This guideline was endorsed by the Health Protection Agency (HPA), London. The expected level for toxin production of *Bacillus cereus* was >1.0x10^5 CFU/g [42]. The samples were delivered via third parties courier service and all the related information during deliveries and arrival were recorded. The complete results for this study were shown on Table 1, 2, 3 and 4.

Table 1. *Bacillus cereus* and total plate count in home-based food (*sambal belacan* packed in retort pouch) – Group 1

Sample number	Samples (packaging, weight)	Microbiological status (CFU/g)		Claimed shelf-life	Remarks
		Bacillus cereus	Total Plate Count (TPC)		
1	*Sambal belacan* (Retort pouch, 50g)	<1.0x10^2	2.0x10^2	5 months	- 3 days delivery time - Product has MeSTi certification - No defect on arrival
2	*Sambal belacan* (Retort pouch, 100g)	<1.0x10^2	2.0x10^2	Not stated	- 3 days delivery time - Product has Halal logo - Package a little crumpled on arrival - Labelling uncompliant to Food Act 1983
3	*Sambal belacan* (Retort pouch, 70g)	3.2x10^2	2.5x10^2	1 year	- 5 days delivery time - Package crumpled but no leakage - Labelling uncompliant to Food Act 1983
4	*Sambal belacan* (Retort pouch, 150g)	1.0x10^2	2.0x10^3	8 months	- 4 days delivery time - No defect on arrival - Product have Halal logo - Labelling uncompliant to Food Act 1983
5	*Sambal belacan* (Retort pouch, 220g)	<1.0x10^2	<1.0x10^2	2 months	- 4 days delivery time - No defect on arrival
6	*Sambal belacan* (Retort pouch, 200g)	1.2x10^2	5.0x10^2	6 months	- 5 days delivery time - Product have MeSTi and Halal logo - No defect on arrival - Labelling uncompliant to Food Act 1983
7	*Sambal belacan* (Retort pouch, 100g)	<1.0x10^2	<1.0x10^2	1 year	- 5 days delivery time - Product have MeSTi and Halal logo - No defect on arrival
8	*Sambal belacan* (Retort pouch, 200g)	<1.0x10^2	<1.0x10^2	10 months	- 4 days delivery time - No defect on arrival - Labelling uncompliant to Food Act 1983
9	*Sambal belacan* (Retort pouch, 200g)	<1.0x10^2	<1.0x10^2	1 year	- 5 days delivery time - No defect on arrival - Labelling uncompliant to Food Act 1983
10	*Sambal belacan* (Retort pouch, 150g)	<1.0x10^2	<1.0x10^2	6 months	- 3 days delivery time - Package crumpled on arrival - Labelling uncompliant to Food Act 1983

A total of ten samples of *sambal belacan* in retort pouch were analysed and out of 10 selected samples, only 3 samples were detected for *Bacillus cereus* presence with a level between 1.0 x 10^2 CFU/g to 3.2 x 10^2 CFU/g, which still considered as the satisfactory level (Table 1). The delivery time for each sample taken between 3 to 5 days, a rather fast delivery service. On samples arrival, 3 out of 10 samples have defect as the package were crumpled. For the labelling, 7 samples do not follow the labelling specification stated in the Malaysian Food Regulation 1985. Apart from that, 5 samples claimed to have the MeSTi and Halal certification by the logo printed on the packaging. The samples' shelf-life claimed to be between 2 months and 1 year, with one sample does not state its shelf-life.

Table 2. *Bacillus cereus* and total plate count in home-based food (*sambal bilis* packed in retort pouch) – Group 2

Sample numbers	Samples (packaging, weight)	Microbiological status (CFU/g)		Claimed shelf-life	Remarks
		Bacillus cereus	Total plate count (TPC)		
1	*Sambal bilis* (Retort pouch, 50g)	$3.0x10^2$	$5.2x10^2$	Not stated	- 4 days delivery time - Package crumpled on arrival - Labelling uncompliant to Food Act 1983
2	*Sambal bilis* (Retort pouch, 200g)	$<1.0x10^2$	$1.5x10^2$	1 year	- 2 days delivery time - Package crumpled on arrival - Labelling uncompliant to Food Act 1983
3	*Sambal bilis* (Retort pouch, 2000g)	$<1.0x10^2$	$<1.0x10^2$	1 year	- 3 days delivery time - No defect on arrival - Labelling uncompliant to Food Act 1983
4	*Sambal bilis* (Retort pouch, 120g)	$<1.0x10^2$	$1.0x10^2$	10 months	- 2 days delivery time - No defect on arrival
5	*Sambal bilis* (Retort pouch, 70g)	$2.0x10^4$	$1.0x10^5$	3 months	- 5 days delivery time - Product crumpled on arrival - Labelling uncompliant to Food Act 1983
6	*Sambal bilis* (Retort pouch, 140g)	$2.0x10^2$	$<1.0x10^2$	2 years	- 5 days delivery time - Product have MeSTi and Halal logo - No defect on arrival
7	*Sambal bilis* (Retort pouch, 150g)	$1.0x10^3$	$2.0x10^3$	1 year	- 4 days delivery time - No defect on arrival
8	*Sambal bilis* (Retort pouch, 150g)	$2.1x10^3$	$2.0x10^3$	2 years	- 7 days delivery time - Package crumpled on arrival but no leakage - Labelling uncompliant to Food Act 1983
9	*Sambal bilis* (Retort pouch, 150g)	$1.0x10^2$	$3.0x10^3$	5 months	- 3 days delivery time - No defect on arrival - Labelling uncompliant to Food Act 1983
10	*Sambal bilis* (Retort pouch, 100g)	$1.5x10^4$	$4.3x10^5$	10 months	- 7 days delivery time - Package bloated on arrival - Labelling uncompliant to Food Act 1983

Based on the Table 2, 7 out of 10 samples were detected for *Bacillus cereus* contamination, and 2 of them had exceeded the unsatisfactory level with 2.0×10^4 CFU/g and 1.5×10^4 CFU/g *B. cereus* count respectively. The delivery time takes about 2 to 7 days and from 10 samples, 5 were damaged on arrival, with 1 of them had been bloated. This indicated that there was microorganism growth in the package. For the labelling, 7 samples do not follow the labelling specification from Food Regulation 1985 and one (1) sample have MeSTi and Halal logo on their packaging. The claimed shelf-life for samples were between 3 months and 2 years, which quite a very long period.

Table 3. *Bacillus cereus* and total plate count in home-based food (*sambal belacan* packed in glass jar) – Group 3

Samples number	Samples (packaging, weight)	Microbiological status (CFU/g)		Claimed shelf-life	Remarks
		Bacillus cereus	Total plate count (TPC)		
1	*Sambal belacan* (Glass jar, 200g)	$3.5x10^3$	$8.0x10^3$	Not stated	- 3 days delivery time - No sealing on cap, no leakage - Labelling uncompliant to Food Act 1983
2	*Sambal belacan* (Glass jar, 220g)	$1.2x10^4$	$2.6x10^3$	1 year	- 4 days delivery time - No defect on arrival - Labelling uncompliant to Food Act 1983
3	*Sambal belacan* (Glass jar, 340g)	$1.5x10^3$	$2.1x10^4$	3 months	- 3 days delivery time - No defect on arrival - Labelling uncompliant to Food Act 1983
4	*Sambal belacan* (Glass jar, 150g)	$2.2x10^3$	$2.1x10^4$	2 years	- 2 days delivery time - No defect on arrival - Product have Halal logo

Samples number	Samples (packaging, weight)	Microbiological status (CFU/g)		Claimed shelf-life	Remarks
		Bacillus cereus	Total plate count (TPC)		
5	*Sambal belacan* (Glass jar, 300g)	$2.9x10^3$	$4.4x10^3$	Not stated	- 4 days delivery time - No defect on arrival - Labelling not follow specification by Law - Product have Halal logo
6	*Sambal belacan* (Glass jar, 200g)	$1.0x10^2$	$1.0x10^3$	1 year	- 2 days delivery time - No defect on arrival
7	*Sambal belacan* (Glass jar, 200g)	$2.5x10^3$	$5.0x10^3$	5 months	- 4 days delivery time - No defect on arrival - Labelling uncompliant to Food Act 1983
8	*Sambal belacan* (Glass jar, 180g)	$1.3x10^5$	$8.8x10^4$	5 months	- 7 days delivery time - No sealing and leakage on cap - Labelling uncompliant to Food Act 1983
9	*Sambal belacan* (Glass jar, 240g)	$2.2x10^4$	$6.5x10^4$	2 months	- 6 days delivery time - No sealing on cap, no leakage - Labelling uncompliant to Food Act 1983
10	*Sambal belacan* (Glass jar, 180g)	$1.5x10^2$	$2.2x10^2$	Not stated	- 5 days delivery time - Labelling not follow specification by Law - No defect on arrival

All samples that were evaluated shows the growth of *Bacillus cereus* with 3 samples exceeded the satisfactory level. The *Bacillus cereus* level ranging from 1.0 x 10^2 CFU/g and 1.3 x 10^5 CFU/g. The samples take about 2 – 7 days to be delivered by courier services. Three (3) samples do not have additional plastic sealing on cap and, on arrival, there were leakage on 2 of the samples. All samples were wrap in bubble wrap during deliveries to safeguard the glass jar integrity. As for shelf-life, 3 samples did not state any date, while the others claimed the shelf-life of 2 months up to 2 years. Meanwhile, for packaging, 9 out of 10 samples does not follow the labelling specification and 2 of them have Halal logo printed on its packaging.

Table 4. *Bacillus cereus* and total plate count in home-based food (*sambal bilis* packed in glass jar) – Group 4

Sample numbers	Samples (packaging, weight)	Microbiological status (CFU/g)		Claimed shelf-life	Remarks
		Bacillus cereus	Total plate count (TPC)		
1	*Sambal bilis* (Glass jar, 220g)	$5.0x10^3$	$3.0x10^3$	1 year	- 3 days delivery time - No defect on arrival - Labelling uncompliant to Food Act 1983
2	*Sambal bilis* (Glass jar, 475g)	$2.1x10^3$	$4.0x10^3$	Not stated	- 4 days delivery time - No defect on arrival - Product have Halal and MeSTi logo - Labelling uncompliant to Food Act 1983
3	*Sambal bilis* (Glass jar, 200g)	$2.0x10^3$	$4.0x10^3$	1 year	- 5 days delivery time - No sealing on cap, no leakage - Labelling uncompliant to Food Act 1983
4	*Sambal bilis* (Glass jar, 230g)	$1.0x10^2$	$3.0x10^2$	Not stated	- 5 days delivery time - No defect on arrival - Labelling uncompliant to Food Act 1983
5	*Sambal bilis* (Glass jar, 200g)	$1.4x10^4$	$3.0x10^3$	1 year	- 4 days delivery time - No sealing on cap, no leakage - Labelling uncompliant to Food Act 1983
6	*Sambal bilis* (Glass jar, 300g)	$<1.0x10^2$	$<1.0x10^2$	1 year	- 3 days delivery time - No defect on arrival
7	*Sambal bilis* (Glass jar, 300g)	$7.0x10^3$	$4.1x10^3$	5 months	- 4 days delivery time - No sealing and leakage on cap - Labelling uncompliant to Food Act 1983
8	*Sambal bilis* (Glass jar, 140g)	$2.0x10^2$	$2.5x10^2$	1 year	- 7 days delivery time - No defect on arrival - Product have Halal logo - Labelling uncompliant to Food Act 1983

Sample numbers	Samples (packaging, weight)	Microbiological status (CFU/g)		Claimed shelf-life	Remarks
		Bacillus cereus	Total plate count (TPC)		
9	*Sambal bilis* (Glass jar, 180g)	$3.5x10^4$	$1.5x10^5$	4 months	- 7 days delivery time - No sealing on cap, no leakage - Labelling uncompliant to Food Act 1983
10	*Sambal bilis* (Glass jar, 180g)	$2.1x10^4$	$4.5x10^4$	Not stated	- 5 days delivery time - No sealing and product leakage on cap - Labelling uncompliant to Food Act 1983

Sambal bilis packed in glass jar showed that only one out of 10 sample free from *Bacillus cereus* contamination (Table 4). Other samples had growth between 1.0 x 10^2 CFU/g to 1.3 x 10^5 CFU/g and 3 samples had been exceeded the satisfactory level. The samples' delivery takes about 3 – 7 days. Upon receiving of sample, 5 samples were found that the capping without plastic sealing and 2 of them are leaked. The products' claimed shelf-life ranging from 4 months to 1 year. Nine of the products do not follow the labelling specification and 2 of them have Halal and MeSTi logo on packaging.

Bacillus cereus was one of the most opportunistic and resistant bacteria that can be associated with foodborne illness and it had been proved to be presented not only in most food products but also in the environment. It was a spore former, making it very resistant towards technological processing in food and environmental impacts (drought, heat, radiation). In Malaysia, some of the mass outbreak of *Bacillus cereus* occur in 15 February 2012 in Sabah [26] and on 6 October 2019 in Selangor [41]. There were also cases where fatal infection of *Bacillus cereus* been reported [11, 49]. This signifies that *Bacillus cereus* can cause mass outbreak if not controlled and monitored.

Sambal belacan and *sambal bilis* were one of the traditional South East Asia condiments that usually been consumed with rice and rice products. As time goes by, there were also wide variation of *sambal* emerge with variations of ingredients used. However, same as other food products, *sambal* also susceptible towards foodborne pathogen contamination. According to SNI 01-2976-2006 (Indonesian National Standard), it specifically declares that the maximum bacterial contamination for sambal was 1.0 x 10^4 CFU/g for total plate count (TPC) [57], while for the *Bacillus cereus* it was set to be 1.0 x 10^4 CFU/g as stated by the Guidelines for Assessing the Microbiological Safety of Ready-to- Eat Foods, 2009 [44]. Based on the overall results in Table 1, 2, 3 and 4, a total of 8 samples out of 40 samples were redeemed unsatisfactory for *Bacillus cereus* count (0 from Group 1, 2 from Group 2, 3 from Group 3 and 3 from Group 4). For total plate count (TPC), 8 samples out of 40 were unsatisfactory (0 from Group 1, 2 from Group 2, 4 from Group 3 and 2 from Group 4).

The prevalence of microorganism in sambal had been studied by Hasimah *et al*., [17]; Pepiana *et al*., [40]; Sharif *et al*., [48]; and Wardhani *et al*., [57]. All of them conclude that various microorganisms were present in some of their samples, which ranging from >1.0 x 10^2 CFU/g and up to 2.2 x 10^4 CFU/g for total plate count (TPC) value. The results from previous studies were in agreement with the results from this study. However, no previous publications can be found on prevalence of *Bacillus cereus* in sambal, indicating that this was a new study for this particular matters. For ready-to-eat food (RTE), a study by Yu *et al*., [60], shows that 302 out of 860 samples (35%) were detected for *Bacillus cereus,* and some strains isolated were very resistant towards various antimicrobial. They conclude that *B. cereus* possess a very high risk towards RTE foods, in addition to their resistance to antimicrobial.

Sambal belacan's main ingredients were fresh red/green chilli while for *sambal bilis,* it was dried chilli and anchovies. All of above ingredients were susceptible towards bacterial contamination. Jeong *et al*., [27], studies the microorganism contamination on freshly picked red pepper from farm. They found that 3 out of 37 samples were positive for *B. cereus*, while all samples (37 out of 37 samples) were positive for coliforms and *Enterobacteriaceae.* Another study from Swagato *et al*., [52], stated that the fresh green chilli from wet market can harbour various pathogenic bacteria. The numbers reported were; *Staphylococcus aureus* (7.91 log CFU/g), total coliforms (8.39 log CFU/g), total plate count (11.43 log CFU/g), while *Salmonella spp., Vibrio cholerae* or *V. parahaemolyticus* also positive in several samples. For dried chilli, Choo *et al*., [10], proved that *B. cereus* can also be found in it. The bacteria were present in about 84.3% of the samples with the numbers can be up to 1.9 x 10^4 CFU/g. Hernández *et al*., [20], also showed that ampicillin-resistant *Bacillus cereus* can be found in dried red chilli powder.

A comparison study of microorganism contamination between fresh red pepper and dried red pepper were done by Jeong *et al*., [27]. They found that the microorganism contamination was higher in the dried red pepper compare to fresh red pepper. This might occur due to human intervention during

processing, transportation and the environment in storage areas. There were also evidences that bacterial spores can be presented in chili pepper. Several studies had quantified *B. cereus* spores present in chilli pepper, with the highest value can be up to 5.3 log spores/g [33]. Both *B. cereus* vegetative cells and spores were higher in the dried pepper due to its drying process. In Malaysia, the pepper was left to dry in the sun, exposing it to the environments, where *B. cereus* were abundant. The spores were dormant and doesn't need water nor nutrient to thrive, making it very suitable to resides dry food. Kim *et al*., [29], had study the reduction of *B. cereus* spore in chilli pepper using various methods. They found that *B. cereus* spores can be reduce from 6 log CFU/g to 4.8 log CFU/g, about 1.2 log CFU/g reduction. But, by using chlorine dioxide (ClO_2) and sodium hypochlorite (NaOCl) as sanitizer agents at 200 µg/mL concentration, *B. cereus* spore can be reduced up to 3.0 log CFU/g from 6.0 log CFU/g (about 3.0 log CFU/g reduction). This indicate that *B. cereus* spore can be very hard to get rid of even on raw ingredients.

Based on the tables, the contamination of *B. cereus* was higher in glass jar compared to retort pouch (6 glass jar and 2 retort pouches had unsatisfactory *B. cereus* level). This might occur due to the differences in processing steps of both products. Products packaged in retort pouch were subjected to retort processing as additional heat treatment to kill off most bacteria and spores [31]. Previous study by many group of researchers [2, 30, 57], proved that their respective samples namely soy-peas curry, egg curry and Indian pancakes had achieved commercial sterility after been packed in retort pouch and subjected to retort processing. However, this not always been the case. Frediansyah *et al*., [14] and Nalini *et al*., [37], shows that their products (beef rendang and pepper chicken, respectively) can still retain small numbers of bacteria inside the retort pouch even after retort processing. This can occur due to various factors such as equipment (retort) faulty, sealing failure, not enough time/temperature for processing and poor heat penetration of foods. While for *sambal* package in glass jar, the hot-filling methods was maybe the safest methods that can be implemented.

Hot filling was a method where any products were packaged and capped immediately after processing while it's still hot. This will ensure that the bacteria will not have any chance to grow (at temperature danger zone) and its was proved to be effective in prolonging the shelf-life of products [16]. Other precautions that can be taken was to put additional plastics seal in the cap of the glass jar. The sealing area possess the most troublesome role in food packaging as it was the most vulnerable part where gases and foreign substance can penetrate if not properly done [22]. The results from this study also support the statement. Form the tables, 8 out of 20 samples package in glass jar doesn't have additional sealing on cap. A total of 3 samples have leakage on sealing, resulting in unsatisfactory level *B. cereus* count. Furthermore, all samples in glass jar with no sealing shows a higher *B. cereus* growth inside them in comparison to the one with additional sealing.

Most home-based food business owners sold their products via online shopping platforms, and to compensate with the logistic needs, they usually utilised various third-parties courier delivery services to deliver their products straight from their home to consumers. The global courier market value was summed to be about 306 billion dollars in 2018, and it was expected to keep increasing, with anticipated value of 8 – 10% value increases annually [15]. However, even with the significant increase in value, there will always be a cases where customers will received a damaged courier upon arrival [28, 50]. Upon arrival, 4 out of 40 (10%) samples were considered damaged (products with leakage and bloating). The damage of parcels/packages can occur due to improper parcels' packing, unsatisfactory warehouse environment, bad weather conditions (rain, snow, etc.), improper handling of courier, poor road conditions (bumpy, pot-holes, etc.) and human mistakes [59].

The damaged courier was particularly important to be avoided if the packages was food products. It can affect the food safety integrity of the food products. The evidence for these matters can be seen from the results above. All of the samples that were damaged upon arrival (leaked and bloated) had harboured high level of *B. cereus* count and TPC ($7.0 \times 10^3 – 1.3 \times 10^5$ CFU/g and $4.1 \times 10^3 – 4.4 \times 10^5$ CFU/g, respectively). Three (3) out of 4 of the samples were redeemed unsatisfactory in terms of *B. cereus* level. The leakage on glass jar and bloated condition of retort pouch signifies the presence of 'pin-hole' on the packaging. The presence of pin-hole on packaging could permitted the entrance of oxygen and even microorganisms into the products, contaminating the foods [21]. These also compromised the sealing of the packaging, which design to be hermetic and airtight. Although *B. cereus* were facultative anaerobe, it was observed that it can grow faster aerobically (with presence of oxygen), which signify the higher number of *B. cereus* on damaged products. Furthermore, oxygen will also support the growth of other aerobic bacteria, which contribute to higher level of TPC value.

However, it was also observed that a perfectly fine couriers (no defect on delivery) can harbour high level of *B. cereus* and TPC. These samples do not have any leakage or bloated upon arrival. The growth

of *B. cereus* might occur due to the germination of spores that still reside inside the products. The duration of the couriers' delivery might play an important factor here. It was observed that the samples with unsatisfactory level of *B. cereus* takes longer time to arrive (4 days duration – 2 samples; 5 days duration – 2 samples; 6 days duration – 1 sample; 7 days duration – 3 samples). It was speculated that the fluctuate of temperature cause the germination of *B. cereus* spore. The temperature at the couriers' warehouse and transit point cannot be controlled, whether it was air-conditioned or open-spaced were unknown to us and it was outside of our study reaches. However, we can confidently speculate that there will be temperature fluctuated during the couriers' sorting, processing and also during transporting. It also worth noting that the temperature inside the couriers' transportation (trucks, vans, cars, etc.) were also unstable and can deviated [25]. In recent cases, The Guardian, US reported that a couriers cargo driver had recorded a temperature of over 100°F (38°C) inside the courier's truck without air-conditioning, signifying that the temperature inside the trucks were much higher than outside. A study by Ubong *et al*., [53], shows that the germination and growth of *B. cereus* spore were faster at higher temperature of 35°C compared to room temperature of 25°C. It was also proved that *B. cereus* can survive and even grow in higher temperature of 45°C for several days, with the colony increase each days up to 8 log CFU/g on the third days [55]. They also proved the production of emetic and enterotoxin at higher temperature (25 – 45°C) by *B. cereus*.

The usage of the domestic kitchen itself possess several risks for commercial food preparation. Most consumers worried about the hygiene and food safety concerns regarding the public dining location and kitchen, but little do they aware that a notable amount of foodborne illness were actually originated from homes [38]. Several previous study by many researchers [12, 19, 34] had evaluated the microbiological contamination and hygiene status in common domestic kitchens. They conclude that the prevalence of pathogenic foodborne pathogens was very high in domestic kitchen and the hygienic status of the kitchen was unsatisfactory. These matters could lead to various food safety issues emerged from domestic kitchen. The microbiological contamination was usually high in the workspace area, the sink area and the refrigerator area. In a study by Chen *et al*., [9] and Evans & Redmond [12], reveal that extra precaution should be taken during cleaning and sanitation of domestic kitchen. They reported that the dishcloth and sponges used for the cleaning itself had one of the highest microbiological counts in the kitchen. By using the contaminated dishcloth to wipe and dry various kitchens' space could lead to unnoticed cross-contamination and reintroduced the microorganism back during or after the cleaning process. They also reported that the microbiological count in the domestic kitchen were still high even after cleaning, which means that the cleaning process were not sufficiently and properly done. Haysom & Sharp, [19], in their 24-hours study in domestic kitchen had observed that there were varieties of undesirable activities been done in the domestic kitchen such as repairing equipment, pets' cleaning and children playing. All of this could compromise food safety integrity in the domestic kitchen if not avoided.

Another important factors that can compromise food safety at domestic kitchen was arrangement, segregation and zoning. In most food industries establishment, facility design was the first key factors to be considered. Having a good facilities design that can safeguard food safety were one of the main elements in MeSTi and GMP implementation [24]. However, for domestic kitchen level, segregation can also be done with several simples but important steps. This can be done by; 1) segregating the chemical detergent/cleaning agents, waste stockpile and pesticides from food storage and preparation area (refrigerator, food shelves, preparation table, etc.), by placing it as far apart as possible or using barrier; 2) Avoid placing any hazardous materials and equipment in kitchen. It was a common practice in Malaysian households that treat the kitchen area as 'secondary storage' area. All manners of equipment, materials and even vehicles been stored in kitchen; 3) Ensure that there was segregation between kitchen and toilet. It was common in most household that toilet was located near kitchen area. Always make sure the toilets' door stay closed during food preparation and it needs to be cleaned and sanitize regularly. 4) Proper materials arrangement in refrigerator. Placing the finished products and ready-to-eat food on top and raw materials below to avoid dripping; 5) Proper segregation between sink and preparation area, as sink harbour very high amount of bacteria [38]. The main purpose for segregation was to avoid cross-contamination between elements in the food processing area and it was possible to be done in domestic kitchen.

Pets and pests possess a significant threat towards food safety in domestic kitchen. It can be said that almost all household have both or either one these organisms. The role of pests in harbouring and transferring various foodborne pathogen have been widely documented [46] and the prevalence of pests in food premises can be a direct correlation towards the sanitation and hygiene level of those food establishments. However, most food establishment have their own Integrated Pest Management program (IPM), as it was a compulsory elements stated in the food safety laws and regulations to control pests prevalence [5]. Things were different for domestic kitchens as there were no regulations that emphasizes the pest management system. Pest control in domestic kitchen usually been done by the

owners solely based on their awareness and knowledge regarding the hazards of pest towards food safety, whether it was sufficient or not. Out of all pests present in domestic kitchen, houseflies (*Musca domestica*) were the most dominant. The presence of various pathogenic bacteria in houseflies had been discussed by many group of researchers [3, 4, 23, 56] in their publications. Houseflies were a nuisance towards food safety as they: both attracted to waste and food products and can be present in most domestic kitchen [58], very hard to control and had been resistant to certain pesticides [32] and can developed in large number and travel quite a far distance [39].

Apart from pests, the pets itself can also possess a certain threat towards food safety in domestic kitchen. Differ from pests, pets were a 'wanted' animals and usually been allowed to roam freely in most households. Buma *et al*., [8], proved that pets can harboured various pathogenic bacteria that were significant towards food safety such as *Staphylococcus spp., Micrococcus spp., Bacillus spp., Escherichia spp.* and *Pseudomonas spp.* Various bacteria had been isolated from the skin, urine, diarrheal stool and even from respiratory of a pets [35]. There was also evidences that cross contamination of foodborne pathogen can be associated with pet foods [7]. Active prevention must be taken to avoid bacterial cross-contamination between pets and food, such as: 1) Putting barriers in the kitchen to prevent pets' entrance; 2) Frequent cleaning and bathing time for pets, including their cage/pen/enclosure; 3) Vaccination and immediate medical treatment for sick pets; 4) Cautions in choosing pets food as raw meat/fish can harbour various pathogen.

The legal issue and law statement regarding the food business in Malaysia were all stated in the Food Act 1983, Food Regulation 1985 and Food Hygiene Regulation 2009. However, the laws and regulations for home-based food business were not specifically stated in any either of these laws. The legal issues regarding Home Based Food Business (HBFB) were thoroughly discussed in a study by Abd Razak *et al*., [1]. They stated that there was 'loophole' in the Food Hygiene Regulation 2009 that doesn't include HBFB as the food establishments that need to comply to the regulations. This had caused the HBFB owners to operate their businesses without the surveillance from Ministry of Health Malaysia (MOH) and potentially ignoring the food safety requirement as the HBFB owners are not obligated to follow the Regulations. However, on March 2021, the Ministry of Health Malaysia (MOH) had taken it first step in regulating the HBFB. The authorities had announced a specific guideline for HBFB and encouraged it owners to register their business under MOH [13]. As stated in the guideline, HBFB owners were advised to register their business with MOH and Suruhanjaya Syarikat Malaysia (SSM), to attend and acquire food handlers' certificate (Latihan Pengendali Makanan), to obtain the Typhoid vaccination injection, to properly label their products and to provide the photo of their domestic (operation) kitchen to MOH. This was all done to safeguard the integrity of food safety for the community.

Conclusions

The home-based food business had found their footing in the society during the pandemic of Covid-19. Although the pandemic were been considered had passed, the home-based food business were still here to stay. Many peoples had made this kind of business as their main or secondary source of incomes due to its flexibility and high profit turnover. However, this study had proved that the contamination of *B. cereus* was possible to occur in high level inside the home-based food products. This contamination occurs due to various factors such as the natural contamination of raw ingredients, the condition and storage during third-parties courier deliveries, the incompatibility of domestic kitchen to be used as commercial food preparation and the 'missing' of law and regulation for home-based food business. However, the guidelines and recommendations endorsed by Malaysia Ministry of Health indicated the first crucial efforts in regulating and monitoring the HBFB in Malaysia.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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