Research Article

Hazard Analysis and Critical Control Point (CCP) determination in cook-chilled Beef Curry and Beef Kurma

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Dora Liyana Abd Lataf*[1]
Nor Ainy Mahyudin[2]
Ismail Fitry Mohammad Rashedi[1]
Rasiyuddin Hariri[3]
Ahmad Zaki Abdullah[3]
[1]Faculty of Food Science and Technology,
Universiti Putra Malaysia, UPM Serdang, Selangor, Malaysia
[2]Halal Products Research Institute,
Universiti Putra Malaysia, UPM Serdang, Selangor, Malaysia
[3]Felda D'Saji Sdn. Bhd. Malaysia, Kuala Lumpur, Malaysia
**dora.liyana@gmail.com*

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Abstract
The first principle of HACCP, the hazard analysis, was conducted to identify the potential hazards associated with food production at all stages, assess the likelihood of occurrence and severity of the hazards and to identify control measures. The determination of critical control point (CCP) is when control can be applied and is essential to prevent, eliminate or reduce the identified food safety hazard to an acceptable level. In this study, the hazard analysis and CCP determination for cook-chilled beef curry and beef kurma in a centralised kitchen were carried out. By using the process steps decision tree in MS1480:2007 standard, two processes were determined as CCPs, which were the boiling process and rapid chilling process.

Keywords:
Hazard Analysis, CCP, HACCP, Beef Curry, Beef Kurma, School Kitchen

1 Introduction

The hazard analysis critical control point (HACCP) system is a recognized food safety approach that addresses potential biological, chemical and physical hazards through preventive approach, rather than the traditional, cost and time-consuming end product testing. The seven principles of HACCP were developed as a preventive system for the production of food with high degree of safety precautions to cater for different types of consumers (Roberts et al., 2014)

The Malaysia Food Hygiene Regulations 2009 stated that the implementation of food safety assurance program such as Good Manufacturing Practice (GMP) and HACCP is currently regulated to only food premises involved in the manufacturing of food, mainly the commercial food service establishments. Although this does not apply to non-commercial food establishments such as boarding schools, the implementation of such systematic and preventive approach is to ensure that the food produced are safe for students' consumption since boarding school kitchens mass-produced foods approximately for 600 to 1000 students per day at five meals daily.

The purpose of this study was to examine the production of cook-chilled beef cooked in spice dishes prepared in a boarding school kitchen that also served as a centralised kitchen using the HACCP principles. Hazard analysis is to identify and analyse the hazards associated with cook-chilled food production at all stages, from receiving of raw materials to delivery of food to satellite kitchens, assessing the likelihood of occurrence and severity of the hazards and thus determining its CCPs in order to ensure food is safely prepared along the production process. Primarily, this study focused on beef dishes, which are beef curry and beef kurma. The hazard analysis were conducted using process approach, where two products which uses the same or similar ingredients and process flow were grouped together under the same hazard analysis (USDA, 2005).

2 Literature Review

Curry is a widely known spicy food originated from Indian subcontinent that is produced from curry paste that has a variety of flavourful spices in it. Its red-orange colour is contributed from the chilli and turmeric powder in the curry paste, which is also made from cumin, coriander, fenugreek and curry leaves. Kurma or korma is a Mughal cuisine which has a milder flavour compared to the curry. It is made from a mixture of chilli, cumin, coriander, and fenugreek spices. It has a pale brown to white colour due to the absence of turmeric powder in it. Meats such as chicken, fish or beef with addition of vegetables are usually cooked with curry and kurma to make it a complete dish. In Malaysia, beef curry and beef kurma are prepared in household kitchens, schools, and restaurants, and eaten with rice or bread.

The safety of food, with regard to microbiological contamination, is a very important aspect of food preparation, especially when it involves young children. Food safety needs to be monitored to avoid any occurrence of food poisoning. Many outbreaks of food poisoning and foodborne diseases have occurred in the past due to the consumption of microbiologically contaminated food (Holtby et al., 2008; Meftahuddin, 2002; Richards et al., 1993). These are the results of unacceptable practices during the preparation, storage or delivery of food. Besides, many basic food handling practices are not implemented in school foodservice. Studies have shown violations in time-temperature procedures and handwashing practices in school kitchens (Dora-Liyana, Mahyudin, Ismail-Fitry, Ahmad-Zaki, & Rasiyuddin, 2018; Henroid & Sneed, 2004; Youn & Sneed, 2003). Improvements in food safety procedures are indicated by implementing a food safety assurance program to school food operation.

HACCP, as described in many literatures, is defined as "a management system in which food safety is addressed through the analysis and control of biological, chemical, and physical hazards from raw material production, procurement and handling, to manufacturing, distribution and consumption of the finished product" (Barbut, 2015; Lohalaksandech, Wittaya, & Sujarit, 2012; Sekheta, Sahtout, Sekheta, Sharabi, & Airoud, 2010; Youn & Sneed, 2003). However, HACCP does not only depend on management commitment but also prerequisite programs such as good manufacturing practice (GMP) and other relevant food safety system that provide as the basis for the HACCP system. Prerequisite programs would include conditions such as personal hygiene, supplier control, process control, pest control, cleaning and sanitation procedures, traceability and recall procedures and documented employee training.

HACCP systems are developed through the application of seven principles which are Principle 1 (conduct a hazard analysis), Principle 2 (determine the critical control points), Principle 3 (establish critical limits), Principle 4 (establish a system to monitor control of the critical control points), Principle 5 (establish the corrective action to be taken when monitoring indicates that a particular critical control point is not under control), Principle 6 (establish procedures for verification to confirm that the HACCP system is working effectively) and Principle 7 (establish documentation concerning all procedures and records appropriate to these principles and their application) (Roberts et al., 2014; Trafiałek, Lehrke, Lücke, Kołozyn-Krajewska, & Janssen, 2015).

A centralised kitchen is the centre of commissary food service system. Ali and Akbar (2015) discussed that centralised school lunch preparation provides prospects to food safety through standards implementation and training of food handlers despite the possibility of a disease outbreak. The risk of foodborne illness is due to the time gap in food preparation and service of meal to the school children (Marzano & Balzaretti, 2011, 2013; Richards et al., 1993). Hence, stringent operating procedures are important to maintain food safety in school foodservice. It was found that centralised systems implemented more food safety procedures and practices than did conventional systems (Kim & Shanklin, 1999; Youn & Sneed, 2003). In addition to efficiencies obtained through centralised production, proponents of these systems suggest that quality and standardization of food production improves with centralisation. Not only is food quality improved but a consistent quality nutritional profile in the prepared foods may also be achieved (Ali & Akbar, 2015; Brown, 2005; Tessi et al., 2002).

Enhancing food shelf life is one way to cater mass food production and this includes food preparation using cook-chill or cook-freeze method (Man, 2008). The fact that thousands of meals are served daily requires the foods to be well prepared in advance of service. Cook-chill is considered a high risk process as it involves precise temperature and time for chilling of food for a period of time (Elansari & Bekhit, 2014; Eves & Dervisi, 2005).

The hazard analysis using process approach are usually used by foodservice establishments to enhance food safety and more timely responses to problems (Thapa, Singh, & Karki, 2010; USDA, 2005). Since foods from the centralised kitchen will be transported to satellite kitchens, cook-chill system approach was chosen. Advantages of the enhanced cook-chill system are that foods can be prepared on a 3-week menu cycle and food preparation; cooking and tray assembly are independent of mealtime. Enhanced cook-chill technology allows centralisation of food production and distribution from one source to off-site locations. The centralised production enables equipment and staff to be utilized continuously instead of just during peak hours (Langlois, Bastin, Akers, & O'Leary, 1997).

Rapid chilling was used in central kitchens that use cook-chill operation to rapidly decrease the cooked food temperature to prevent food pathogens growth which can lead to food borne diseases (Poumeyrol, Morelli, Rosset, & Noel, 2014). Food is cooked to temperature above 63^{o}C and cooled down in a blast chiller immediately after cooking. This is to prevent bacterial spores germination that survived during cooking, which can multiply when the environment became suitable for growth (Poumeyrol et al., 2014; Rodriguez et al., 2011). Hence, the time and temperature of food at the rapid chilling and cold storage process need to be monitored to ensure food safety. All chilled foods are vulnerable to temperature abuse during distribution, display, and storage. It is therefore, essential that temperature abuse be minimised. The temperature of cook-chill food should be maintained at ≤3°C throughout storage in a cold room and transported to the satellite kitchens before reheated for serving (Amezquita, Kan-King-Yu, & Le Marc, 2011; FSAI, 2014; Man, 2008).

3 Methodology

Field observation with the manager and cook of the centralised kitchen were carried out to get the basic information on the cooking process of beef curry and beef kurma. The selection of beef curry and beef kurma are because the main ingredient in these two dishes (beef) were regarded as high risk in terms of microbiological growth (Buncic et al., 2014; Ercolini, Russo, Nasi, Ferranti, & Villani, 2009). Besides, these dishes were served in boarding schools with the frequency of twice a month.

The hazard analysis and CCP determination for cook-chilled beef curry and beef kurma production were based on a comprehensive review of both Malaysian and international authoritative reports, standard requirements and data of journal articles and scholarly books.

The MS1480:2007 - Food safety according to HACCP system standard (DSM 2007) was referred for the decision tree for determination of sensitive raw materials and decision tree for determination of CCP.

The scope of HACCP for this study is from the receiving of raw materials to the delivering of finished product to satellite kitchens. The satellite kitchens are other boarding school kitchens located within 200km from the central kitchen. The assessment of the significance of food safety hazards uses the matrix of the severity and the likelihood as shown in (Mortimore & Wallace, 2013; Schmidt & Newslow, 2013; Wallace, Holyoak, Powell, & Dykes, 2014). There are five groups of severity caused by hazards which are (i) fatality occurrence, (ii) serious illness, (iii) product recall, (iv) customer complaint and (v) not significant. The likelihood of hazards is also categorised into five groups which are (i) common repeating, (ii) known to occur, (iii) could occur, (iv) not expected to occur and (v) practically impossible. A value of 1-10 indicates a significant food safety issue, which means that control measures must be put in place. Non-significant issues will have values of 11-25.

Table 1: Significance of food safety hazard matrix

	Likelihood				
Severity	A	B	C	D	E
1	1	2	4	7	11
2	3	5	8	12	16
3	6	9	13	17	20
4	10	14	18	21	23
5	15	19	22	24	25

Hazard severity:

1. Fatality occurrence
2. Serious illness
3. Product recall
4. Customer complaint
5. Not significant

Hazard likelihood:

A. Common repeating
B. Known to occur or ‘it has happened’
C. Could occur or “I’ve heard of it happening”
D. Not expected to occur
E. Practically impossible

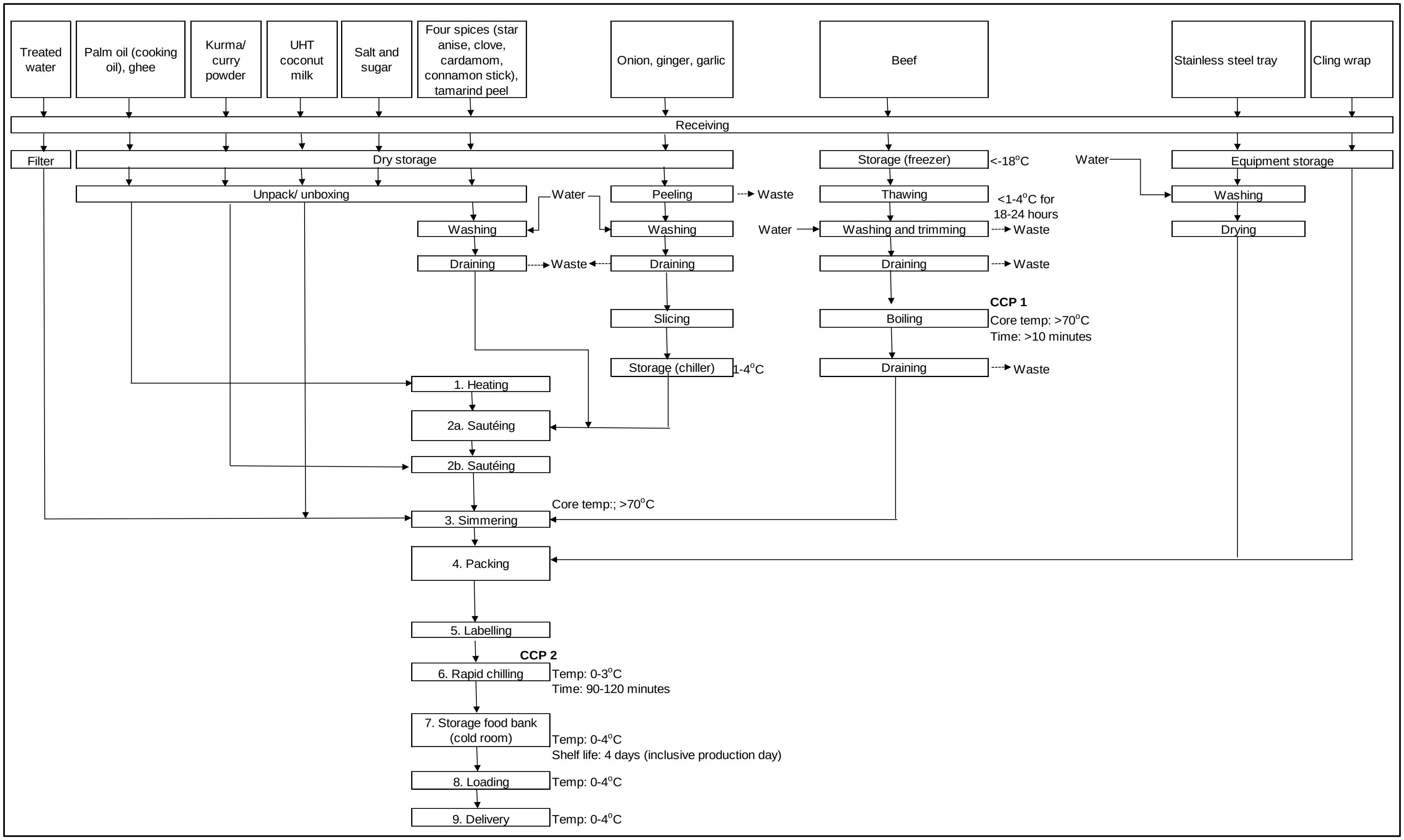
4 Findings

4.1 Process flow

HACCP process approach were applied in this hazard analysis and CCP determination because the cooking process and ingredients of the selected dishes were the same except for the spices used, where one uses curry powder, while the other uses kurma spice powder. Standard recipes for both dishes were obtained from the chef. These processes of preparing chilled beef cooked in spices dishes were observed via on-site verification at the selected boarding school and information about the production processes were collected.

Illustrates the comprehensive process flow chart for chilled beef cooked in spices dishes. The process of flow starts with the receiving of all raw materials and packaging, and ends with delivery of finished products to satellite kitchens.

Figure 1: Process flowchart for cook-chilled beef curry and beef kurma



4.2 Hazards related with raw material

Identification of hazards in Principle 1 of HACCP are categorised into two, which are hazards related to raw materials and hazards related with processes. In this step, all potential hazards associated with each raw materials and steps were listed. Besides that, hazard analysis was conducted and any measures to control identified hazards were considered. Although hazard analysis can be conducted using two approaches, this study uses scientific literature review rather than laboratory testing of the raw materials or process steps of the product. This is because the latter is costly and time-consuming.

Possible hazards related with raw materials and packaging were categorised into three hazards, which are biology, chemical, and physical hazards. Different hazards can be found in raw materials and packaging. The sensitivity of these items was also determined using the raw material/packaging material decision tree in MS1480:2007.

From the analysis, there is one raw material identified for each beef dishes that relates to sensitivity of raw material, which is the frozen beef. It is important to identify this raw material as being sensitive to prevent spoilage of the product that could compromise the food safety. Bacteria belonging to *Salmonella* spp., *Escherichia coli O157:H7* and *Listeria monocytogenes* are most commonly reported pathogens and raw beef is considered as major source of these pathogens (Shafini, Son, Mahyudin, Rukayadi, & Tuan Zainazor, 2017; Wheeler, Kalchayanand, & Bosilevac, 2014). This raw ingredient is considered as sensitive raw material because serious illnesses related to these pathogens from beef could happen and are caused by ingestion of undercooked or contaminated cooked beef (Garayoa, Vitas, Díez-Leturia, & García-Jalón, 2011; Kjeldgaard, Stormly, & Leisner, 2010). Preventive measures or controls applied to prevent this significant hazard is by ensuring product received frozen at temperature $<-18^oC$ and under the documented pre-requisite program for supplier control, process control and receiving of raw materials.

Chemical hazards related with frozen beef are veterinary drug residue (antibiotic), heavy metals (cadmium, lead, arsenic) and nitrite (Barbut, 2015; USDA, 1997) which were introduced during farming or industrial contamination. However, one of the preventive measures taken to control these hazards is by purchasing frozen beef from registered suppliers. The frozen beef received were mechanically cut into cubes. Physical hazards related with frozen beef are intrinsic (bones fragment) and extrinsic foreign objects (metal fragments from the cutting blades).

Although other raw and packaging materials were not determined as sensitive materials, preventive and control measures should be taken into consideration to prevent the presence and occurrence of possible hazards. For example, water can harbour ubiquitous bacteria such as *Enterobacteriaceae, Pseudomonas* spp., *Staphylococcus aureus, Salmonella* spp., *Vibrio cholera* and *Shigella* (Bartram, Cotruvo, Ener, Fricker, & Glasmacher, 2003). The possible chemical hazards in water are pesticide residues, chlorine and heavy metals. However, these hazards were excluded because the establishment uses potable water and water filter.

The production of beef kurma and beef curry uses palm oil and ghee as fats. Biological hazards, which are associated with these fats, includes microbial survival (fungi, *Pseudomonas* spp., *Staphylococcus aureus*) (Seiyaboh, Kigigha, Alagoa, & Izah, 2018). Chemical hazards in palm oil and ghee are pesticide residue, veterinary drug residue (antibiotic) and aflatoxin M1 (Nazir, Abdullah, Ariwahjoedi, & Yussof, 2012; Sekheta et al., 2010), while physical hazards include impurities in the raw material. Although possible hazards may be present in this raw ingredient, the hazards were not significant. The preventive measure required is to control the hazards using supplier control pre-requisite program.

Spices (kurma powder, curry powder, star anise, clove, cardamom, cinnamon stick, ginger, garlic, and onion) can be the medium for possible microbial growth which are caused by improper storage condition. Wide range microbial contamination may occur during the pre- and post-harvest handling, thus the rationality for inclusion as hazard (Banerjee & Sarkar, 2003; Lins, 2018; Sagoo et al., 2009). A study by Fogele, Granta, Valciņa, & Bērziņš (2018) found that moulds from the species *Aspergillus spp.* and *Penicillium spp*. dominates spices such as cumin, curry, cinnamon and clove. Besides moulds, the same study also found a high concentration of *Bacillus cereus* toxin in spices, as spore forming *Bacillus cereus* are resistant to drying or high heat treatment.

Chemical hazards such as the addition of food additives and level of pesticide residue and heavy metal above the permitted limit are the rationales for including these hazards. Control from a supplier such as to produce the product’s certificate of analysis (COA) or food quality assurance program by the manufacturer is one of the preventive measures taken to prevent the significant hazards. There is no cross-contamination risk to the facility or to other products, which will not be controlled as high heat treatment (sauté) was used to process the hazards out of the product.

Condiments used in the preparation of beef kurma and beef curry are sugar, salt and tamarind peel. Microbial growth in sugar is inhibited since the chemical property of the product is having very low water activity that inhibits microbial growth. In Petrová et al., (2015) and Wojtczak et al. (2012), the total bacteria count of sugar were found to be low and met the international microbiological standard. Both sugar and salt are natural anti-bacteria agents. The chemical properties of table or cooking salt are low water activity and highly salty, inhibits the growth of non-halophiles microbial. Therefore, biological hazards in salt can be eliminated. Tamarind peel or *asam keping* biological hazard may come from post-harvest of the item itself. Handling or storage at post-harvest is important to ensure minimal or no microbial growth and contamination. Chemical hazards for these condiments may be carried over from the production process or naturally present in the item.

The possible biological hazard in UHT coconut milk is microbiological survival of *Bacillus cereus* spores and *Staphylococcus aureus.* However, these hazards were excluded because this product undergoes ultra-high heat treatment to inactivate microorganisms and heat resistant enzymes (Khuenpet, Jittanit, Hongha, & Pairojkul, 2016). The chemical hazards that may be included in the hazard analysis are the presence of pesticide residue and usage of food additives. These hazards were included because there are possibilities of pesticides usage during farming and addition of food additives during production of UHT coconut milk that is above the specified limit. Hence, these hazards are controlled by producing product’s certificate of analysis (COA) which tests for pesticide residue and food additives for every batch received. As for physical hazards, it is impossible to happen because the product goes through the hot filling piping process into tetrapak, which does not allow penetration of dirt into the product.

Possible hazards can also be found in packaging (stainless-steel tray and PVC plastic wrap/stretch film). There are no identified biological hazards in both packaging materials. However, chemical hazards were included in stainless-steel tray if the supplier provides unclean or damaged trays. Therefore, the preventive measure is to control by cleaning and sanitation. As for PVC plastic wrap or stretch film, the possible chemical hazard is the presence of plasticizer in it. However, this is excluded as hazards because only food grade wrap is used. Dust is also excluded as a physical hazard for stretch film because the film comes in rolls and the surface facing the food are not exposed to dust.

Table 2: Frozen beef hazard analysis

Raw material/ packaging material	**Potential hazard biological, chemical, physical (B: Biological, C: Chemical, P: Physical)**	**Rationale for inclusion or exclusion as a hazard (In: Inclusion, Ex: Exclusion)**	**Significance of hazard**			**Preventive measure or controls applied to prevent this significant hazard**	**Is this raw material/packaging material a sensitive material? (Y: Yes, N: No)**			
			Sev.	**Like**	**Sig.**		**Q1**	**Q2**	**Q3**	**Sensitive**
Frozen beef	B: Pathogens (*Salmonella* spp., *Listeria monocytogenes*, *E. coli*)	In: Naturally present in beef	2	C	Yes	Ensure product is received in frozen condition <-18°C	Y	Y	Y	Y
	C: Veterinary drug residue (antibiotic), heavy metal (cadmium, lead, arsenic), nitrite	In: Industrial/farming cross-contamination, antibiotic given in farming to treat diseases or infections	3	D	No	Purchase from registered suppliers	-	-	-	-
	P: Foreign material (bone and metal fragments)	In: Metal fragments from cutting blade	4	D	No	Product is visually checked before use	-	-	-	-

4.3 Hazards related with processes and CCPs in the production process

Using the process flow diagram (**Error! Reference source not found.**), all potential hazards relevant to the process of cooking chilled beef cooked in spices were identified. This also includes the preparation process of cooking ingredients. Technical data was used as a guide to identify all the biological, chemical and physical hazards. For each of the hazards concluded to be significant, preventive control measures were identified to eliminate the hazard or reduce it to an acceptable level. Preventive measures related to hygiene and good manufacturing practices (GMP), were included in procedures for GMP to simplify the HACCP plan. To achieve this, the process step decision tree from MS1480:2007 was used.

There are many potential microbial hazards associated with the acceptance of raw materials or the receiving of raw materials process. In this study, the hazard analysis for receiving process was conducted for each ingredient as different ingredients may have different potential hazards. Water is the main raw material used in the preparation of this dish. It is used as both for ingredient and medium for cleaning other raw materials. As a major raw ingredient, it should meet the provisions of Malaysia Food Regulations 1985 (Drinking water quality standards). The biological and chemical hazards for receiving of dry items was excluded as products were handled properly and received at the clean and chemical-free area. As for possible physical hazards at the receiving area are the presence of dirt, dust or soil, which might be due to the use of unclean or damaged packaging material from the supplier.

The receiving process of frozen beef may pose biological hazard if temperature control of product is insufficient, hence will result in unacceptable microbial growth (Casaburi, Piombino, Nychas, Villani, & Ercolini, 2015). Although the severity and likelihood of the hazard to occur at the receiving process is significant, this step is not considered as a critical control point. From the process step decision tree, there are control measures taken for the significant hazard that is by ensuring the temperature of frozen beef is <-18^{o}C upon receiving. This step does not eliminate or reduce the occurrence of the significant hazard to an acceptable level and contamination could not increase to unacceptable level as bacteria stays at dormant stage at very low temperature (Leygonie, Britz, & Hoffman, 2012).

Microbial proliferation is possible in raw materials that is stored in high relative humidity dry storage area (>70%) (Amezquita et al., 2011; Leclercq-perlat, Sicard, Trelea, Picque, & Corrieu, 2012; Tsang et al., 2018). In such an environment, there is possible growth of fungi such as *Aspergillus* spp. in spices, which produces aflatoxin, thus compromise with food safety. However, the control measures taken to prevent this from happening is by implementing storage pre-requisite program. The stock cycle for these raw materials is by weekly. The premise will also practice the first-in, first-out (FIFO) system. Hence, the issue of storing item for a long period in the dry storage area should not arise.

Besides dry storage, raw material (frozen beef) were stored in the freezer with temperature of below -18^{o}C. Microorganisms such as *Salmonella* spp*., E. coli, Listeria monocytogenes,* and *Staphylococcus aureus* may survive and grow if there is insufficient temperature control. This is due to the increase in moisture and nutrients available when meat is exposed to high temperature, which is consequently suitable for microbial growth (Leygonie et al., 2012). These hazards were controlled by storing the raw material in a freezer with a temperature below -18^{o}C at all times.

Mis en place of the ingredients includes the unpacking or unboxing process, peeling, thawing, washing, trimming, draining and slicing of ingredients. The hazards in these processes (except thawing) were excluded from possible hazards, as there is good handling of products, food handlers practice good personal hygiene, use of clean utensils, no usage of chemicals during washing of ingredients and sealing back the packaging after usage (Dora-Liyana et al., 2018).

These rationales will prevent the possible hazards from occurring to the raw materials (Doménech, Amorós, Pérez-Gonzalvo, & Escriche, 2011).

The thawing process is as important as the storage process because it involves time and temperature variables to control the growth of bacteria in the raw ingredient. If thawing was done at room temperature, certain areas of the meat will be exposed to more favourable temperature conditions for microbial growth since thawing took much time to melt the ice crystals in meat (Leygonie et al., 2012; Panisello, Rooney, Quantick, & Stanwell Smith, 2000). For this reason, good handling practices are important as a preventive measure to prevent significant hazards from occurring. The appropriate handling is to thaw frozen meat in a chiller with temperature between 1-10^{o}C not exceeding 24 hours to prevent microbial spoilage (Manios & Skandamis, 2015).

In the preparation of chilled beef cooked in spices, the meat undergoes boiling process. This process serves to enhance the quality and safety of the meat. There are many microbial hazards associated with the cooking of meat and the possible microbial hazards at this stage are survival of *Salmonella* spp., *Listeria monocytogenes*, *Escherichia coli*, *Staphyloccous aureus* and *Bacillus cereus* (Casaburi et al., 2015; Tewari, Singh, & Singh, 2015). The rationality to include these as hazards are because insufficient temperature control and cooking time will result in unacceptable microbial growth thus resulting in foodborne illness. The control measure at this process is to cook the meat to a minimum core temperature of 70^{o}C for more than 10 minutes (Murphy, Martin, Duncan, Beard, & Marcy, 2004; Orta-Ramirez et al., 1997) to eliminate the biological hazards. Since this step of process is specifically designed to eliminate the likely occurrence of the significant hazard, this process is considered as the critical control point 1 (CCP1) (Table).

The cooking process of chilled beef cooked in spices dish starts with the heating of cooking oil. This step is then followed by sautéing of the condiments and spices. The next step is simmering with an addition of pre-cooked beef and coconut milk. The possible hazards during these stages are microbial contamination from food handlers, cleaning agent residues that are used to clean pieces of equipment and presence of foreign materials such as hair and insects. Preventive measures to prevent the hazards are by controlling the process via process control pre-requisite program. This includes ensuring that the cooking temperature achieves core temperature of more than 70^{o}C. Achieving this temperature is important as 6D log reduction of most pathogens occurs at temperature above 70^{o}C when cooked for more than 2 minutes (Horn, Olsen, Hasell, & Cook, 2015; Jarvis et al., 2016; Yousif, Ashoush, Donia, & Hala Goma, 2013). The possible hazards in sensitive raw material (frozen beef) were eliminated in the boiling process (CCP1) before undergoing this simmering process. As a result, this process step is not critical.

The next step is packing of cooked food. During this process, food is transferred from the cooking pot into a 4-inch stainless steel tray and later wrapped with PVC plastic wrap. Each tray weighs approximately 5kg. Food handlers must ensure good handling practices and use clean equipment to prevent post-handling contamination. This process is important as it protects food against physical damage and in many cases, attack by pests and prevents contamination during storage and distribution. The uses of PVC plastic wrap is acceptable in this situation and the migration of plasticizer into the food is low, as the film does not have direct contact to the food (Sekheta et al., 2010). After packing, the next step is to label the trays. Labelling is done to identify the product's name, date of production, expiry date and to inform kitchen staffs on the reheating instruction. To ensure no post-handling contamination, food handlers should practice good personal hygiene.

Rapid chilling of these foods is the step where a food core temperature is rapidly reduced to a safe temperature using blast chiller within certain time. This method was chosen as it is the most effective operational step in food processes for preventing microbial growth and toxin production after food is cooked (Choma et al., 2000). Therefore, internal food temperatures and cooling time measurements are very important. In this study, the time and temperature critical limits parameters were to chill food to core temperature of between 0-3^{o}C at time between 90 to 120 minutes using blast chiller in the presence of air (Bonne, Wright, Camberou, & Boccas, 2005; James & James, 2005; Krishnamurthy & Sneed, 2011). Probe thermometer was used to measure the core temperature of food so that it achieves <4^{o}C. After undergoing the process steps decision tree, rapid chilling step is decided to be the critical control point 2 (CCP2) as shown in Table

Chilled food is stored in the cold room food bank for a few days and made safe to be eaten. In-house preliminary study has shown that the temperature required during storage is 0-3^{o}C and consumed within 4 days (96 hours), inclusive of the production day. The storage time and temperature is in accordance with past studies related to chilled cooked foods to ensure chilled foods is stored safely for later consumption (Carlin, 2002; Langlois et al., 1997; Man, 2008; McClure & Amézquita, 2008; Ndraha, Hsiao, Vlajic, Yang, & Lin, 2018).

The potential biological hazards during the loading process are microbial growth where it could occur when food is stored for a long time at inappropriate temperature. Therefore, to prevent this from happening, the preventive measures that could be done is by ensuring cold truck temperature is ≤4^{o}C before loading process could take place. The cold truck temperature must be maintained at temperature ≤4^{o}C at all times. This is to prevent the growth of microbial as failure to maintain the chilled condition of cold truck leads to the growth of bacteria (Ndraha et al., 2018). The monitoring of temperature in cold truck is by using thermo-logger where it can record the temperature during the delivery of food from centralised kitchen to satellite kitchens. For both steps, it is not considered as a CCP since there are control measures taken to control significant hazards from occurring at unacceptable levels.

5 Conclusion

HACCP process approach in the cook-chilled beef cooked in spices dish (beef curry and beef kurma) control every stage of food processing. By using this approach, two CCPs has been identified, which are the boiling of beef process and rapid chilling of the cooked dish. These two processes have a critical limit that ensures the utmost safety for students' consumption.

Table 3: Hazards related to process step (boiling and rapid chilling)

Process step	Potential hazard biological, chemical, physical (B: Biological, C: Chemical, P: Physical)	Rationale for inclusion or exclusion as a hazard (In: Inclusion, Ex: Exclusion)	Significance of hazard			Preventive measure or controls applied to prevent this significant hazard	Is this a critical control point (CCP)?				
			Sev.	**Like**	**Sig.**		**Q1**	**Q2**	**Q3**	**Q4**	**CCP**
Boiling	B: Microbial survival (*Salmonella, Listeria monocytogenes, E.coli, Staphylococcus aureus, Bacillus cereus)*	In: Insufficient temperature control and cooking time will result in unacceptable microbial growth and result in foodborne illness	2	C	Yes	Cook product to a minimum of 70°C for >10minutes.	Y	Y	-	-	**Yes CCP1**
	C: Cleaning agent residue	Ex: Cleaning agents used for cleaning equipments at approved dosage	2	D	No	-	-	-	-	-	-
	P: Visible foreign material that could compromise product safety	Ex: Visual inspection of all products as it is processed to ensure no foreign material is present	4	D	No	-	-	-	-	-	-
Rapid chilling	B: Survival of non-spore and spore performing pathogens (*Bacillus cereus, Clostridium perfringens, Listeria monocytogenes, Staphylococcus aureus*)	In: Inappropriate blast chiller time and temperature will promote microbial growth and toxin production	2	C	Yes	Product is cooled rapidly at temperature ≤4°C within 90 to 120minutes	Y	Y	-	-	**Yes CCP2**
	C: Cleaning chemical residue	Ex: Cleaning agents used for cleaning equipments at approved dosage	2	D	No	-	-	-	-	-	-
	P: Foreign material (insects)	Ex: Food tray is wrap with stretch film and chilled storage is enclosed area	4	D	No	-	-	-	-	-	-

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7 References

Ali, J., & Akbar, M. (2015). Pupils' satisfaction with school mid-day meal program. *British Food Journal*, *117*(7), 1933–1948. http://doi.org/10.1108/BFJ-01-2015-0002

Amezquita, A., Kan-King-Yu, D., & Le Marc, Y. (2011). Modelling microbiological shelf life of foods and beverages. In D. Kilcast & P. Subramaniam (Eds.), *Food and beverage stability and shelf life* (pp. 405–458). Woodhead Publishing Limited. http://doi.org/10.1533/9780857092540.2.405

Banerjee, M., & Sarkar, P. K. (2003). Microbiological quality of some retail spices in India. *Food Research International*, *36*(5), 469–474. http://doi.org/10.1016/S0963-9969(02)00194-1

Barbut, S. (2015). Ch 12 HACCP in cooked meat operations. In *The Science of Poultry and Meat Processing* (p. 21). University of Guelph, Canada.

Bartram, J., Cotruvo, J., Ener, M., Fricker, C., & Glasmacher, A. (2003). *Heterotrophic plate counts and drinking-water safety. The Significance of HPCs for Water Quality and Human Health*. *World Health Organization*. http://doi.org/10.7717/peerj.1259

Bonne, R., Wright, N., Camberou, L., & Boccas, F. (2005). Guidelines on HACCP, GMP and GHP for ASEAN Food SMEs: A comprehensive hand-book to assess your hygiene practices and HACCP system. European Committee for Standardisation.

Brown, D. M. (2005). Prevalence of food production systems in school foodservice. *Journal of the American Dietetic Association*, *105*(8), 1261–1265. http://doi.org/10.1016/j.jada.2005.05.010

Buncic, S., Nychas, G. J., Lee, M. R. F., Koutsoumanis, K., Hébraud, M., Desvaux, M., … Antic, D. (2014). Microbial pathogen control in the beef chain: Recent research advances. *Meat Science*, *97*(3), 288–297. http://doi.org/10.1016/j.meatsci.2013.04.040

Carlin, F. (2002). *Safety of cooked chilled foods containing vegetables*. *Fruit and Vegetable Processing*. Woodhead Publishing Ltd. http://doi.org/10.1533/9781855736641.2.215

Casaburi, A., Piombino, P., Nychas, G. J., Villani, F., & Ercolini, D. (2015). Bacterial populations and the volatilome associated to meat spoilage. *Food Microbiology*, *45*, 83–102. http://doi.org/10.1016/j.fm.2014.02.002

Choma, C., Guinebretière, M. H., Carlin, F., Schmitt, P., Velge, P., Granum, P. E., & Nguyen-The, C. (2000). Prevalence, characterization and growth of Bacillus cereus in commercial cooked chilled foods containing vegetables. *Journal of Applied Microbiology*, *88*(4), 617–625. http://doi.org/10.1046/j.1365-2672.2000.00998.x

Department of Standard Malaysia (DSM). (2007). *Malaysian Standard MS 1480: 2007.* Food safety according to hazard analysis and critical control point (HACCP) system.

Doménech, E., Amorós, J. A., Pérez-Gonzalvo, M., & Escriche, I. (2011). Implementation and effectiveness of the HACCP and pre-requisites in food establishments. *Food Control*, *22*(8), 1419–1423. http://doi.org/10.1016/j.foodcont.2011.03.001

Dora-Liyana, A. L., Mahyudin, N. A., Ismail-Fitry, M. R., Ahmad-Zaki, A., & Rasiyuddin, H. (2018). Food Safety and Hygiene Knowledge , Attitude and Practices among Food Handlers at Boarding Schools in the Northern Region of Malaysia Food Safety and Hygiene Knowledge , Attitude and Practices among Food Handlers at Boarding Schools in the

Northern Region. *International Journal of Academic Research in Business and Social Sciences*, *8*(17), 238–266. http://doi.org/10.6007/IJARBSS/v8-i17/5228

Elansari, A., & Bekhit, A. E. A. (2014). Chapter 7: Processing, storage and quality of cook-chill or cook-freeze foods. In M. W. Siddiqui & M. S. Rahman (Eds.), *Minimally Processed Foods, Food Engineering Series* (pp. 125–150). Springer International Publishing Switzerland. http://doi.org/10.1007/978-3-319-10677-9

Ercolini, D., Russo, F., Nasi, A., Ferranti, P., & Villani, F. (2009). Mesophilic and psychrotrophic bacteria from meat and their spoilage potential in vitro and in beef. *Applied and Environmental Microbiology*, *75*(7), 1990–2001. http://doi.org/10.1128/AEM.02762-08

Eves, A., & Dervisi, P. (2005). Experiences of the implementation and operation of hazard analysis critical control points in the food service sector. *Hospitality Management*, *24*, 3–19.

Fogele, B., Granta, R., Valciņa, O., & Bērziņš, A. (2018). Occurrence and diversity of Bacillus cereus and moulds in spices and herbs. *Food Control*, *83*, 69–74. http://doi.org/10.1016/j.foodcont.2017.05.038

FSAI. (2014). *Validation of Product Shelf-life (Revision 2)*. *Food Safety Authority of Ireland* (Vol. 18). http://doi.org/10.3390/molecules191117078

Garayoa, R., Vitas, A. I., Díez-Leturia, M., & García-Jalón, I. (2011). Food safety and the contract catering companies: Food handlers, facilities and HACCP evaluation. *Food Control*, *22*(12), 2006–2012.

Henroid, D., & Sneed, J. (2004). Readiness to implement hazard analysis and critical control point (HACCP) systems in Iowa schools. *Journal of the American Dietetic Association*, *104*, 180–185.

Holtby, I., Tebbutt, G. M., Grant, K. A., McLauchlin, J., Kett, J., & Pinkney, S. (2008). A Clostridium perfringens food poisoning outbreak associated with consumption of chicken curry supplied by a home caterer. *Public Health*, *122*(12), 1311–1314. http://doi.org/10.1016/j.puhe.2008.05.013

Horn, B., Olsen, L., Hasell, S., & Cook, R. (2015). *Standardising D and Z values for cooking raw meat* (Vol. 4). Institute of Environmental Science and Research Limited.

James, S. J., & James, C. (2005). *Minimal processing of ready meals*. *Emerging Technologies for Food Processing*. Elsevier Ltd. http://doi.org/10.1016/B978-012676757-5/50029-3

Jarvis, N. A., O'Bryan, C. A., Dawoud, T. M., Park, S. H., Kwon, Y. M., Crandall, P. G., & Ricke, S. C. (2016). An overview of Salmonella thermal destruction during food processing and preparation. *Food Control*, *68*, 280–290. http://doi.org/10.1016/j.foodcont.2016.04.006

Khuenpet, K., Jittanit, W., Hongha, N., & Pairojkul, S. (2016). UHT Skim Coconut Milk Production and Its Quality. In *SHS Web of Conferences*. http://doi.org/10.1051/ shsconf /20162303002

Kim, T., & Shanklin, C. W. (1999). Time and temperature analysis of a school lunch meal prepared in a commissary with conventional versus cook-chill systems. *Foodservice Research International*, *11*(4), 237–249. http://doi.org/10.1111/j.1745-4506.1999.tb00169.x

Kjeldgaard, K. J., Stormly, M. L., & Leisner, J. J. (2010). Relation between microbial levels of ready-to-eat foods and the monitoring of compliance with HACCP-based own control programs in small Danish food outlets. *Food Control*, *21*(11), 1453–1457. http://doi.org/10.1016/j.foodcont.2010.03.015

Krishnamurthy, K., & Sneed, J. (2011). Cooling practices used in school foodservice. *Food Protection Trends*, *31*(12), 828–833.

Langlois, B. E., Bastin, S., Akers, K., & O'Leary, J. (1997). Microbial Quality of Foods Produced by an Enhanced Cook-Chill System in a Hospital. *Journal of Food Protection*, *60*(6), 655–666. http://doi.org/10.4315/0362-028X-60.6.655

Leclercq-perlat, M. N., Sicard, M., Trelea, I. C., Picque, D., & Corrieu, G. (2012). Temperature and relative humidity influence the microbial and physicochemical characteristics of Camembert-type cheese ripening To cite this version : HAL Id : hal-01004144. *Journal of Dairy Science, American Dairy Science Association*, *95*(8), 4666–4682.

Leygonie, C., Britz, T. J., & Hoffman, L. C. (2012). Impact of freezing and thawing on the quality of meat: Review. *Meat Science*, *91*(2), 93–98. http://doi.org/10.1016/j.meatsci.2012.01.013

Lins, P. (2018). Detection of Salmonella spp. in spices and herbs. *Food Control*, *83*, 61–68. http://doi.org/10.1016/j.foodcont.2017.05.040

Lohalaksandech, S., Wittaya, T., & Sujarit, C. (2012). Application of Hazard Analysis and Critical Control Point (HACCP) in Ready-To-Eat Tai Pla Curry. In *1st Mae Fah Luang University International Conference* (pp. 1–7).

Man, C. M. D. (2008). 19. Shelf-life of chilled foods. In M. Brown (Ed.), *Chilled Foods: A Comprehensive Guide: Third Edition* (3rd editio, pp. 1–688). Woodhead Publishing Limited. http://doi.org/10.1533/9781845694883.1

Manios, S. G., & Skandamis, P. N. (2015). Effect of frozen storage, different thawing methods and cooking processes on the survival of Salmonella spp. and Escherichia coli O157:H7 in commercially shaped beef patties. *Meat Science*, *101*, 25–32. http://doi.org/10.1016/j.meatsci.2014.10.031

Marzano, M. A., & Balzaretti, C. M. (2011). Cook-serve method in mass catering establishments: Is it still appropriate to ensure a high level of microbiological quality and safety? *Food Control*, *22*(12), 1844–1850.

Marzano, M. A., & Balzaretti, C. M. (2013). Protecting child health by preventing school-related foodborne illnesses: Microbiological risk assessment of hygiene practices, drinking water and ready-to-eat foods in Italian kindergartens and schools. *Food Control*, *34*(2), 560–567. http://doi.org/10.1016/j.foodcont.2013.05.031

McClure, P., & Amézquita, A. (2008). *Predicting the behaviour of microorganisms in chilled foods*. *Chilled Foods: A Comprehensive Guide: Third Edition* (Third edit). Woodhead Publishing Limited. http://doi.org/10.1533/9781845694883.3.477

Meftahuddin, T. (2002). Review of the trends and causes of food borne outbreaks in Malaysia from 1988 to 1997. *The Medical Journal of Malaysia*, *57*(1), 70–79.

Mortimore, S., & Wallace, C. (2013). HACCP: A practical approach. *HACCP: A Practical Approach*, 1–475. http://doi.org/10.1007/978-1-4614-5028-3

Murphy, R. Y., Martin, E. M., Duncan, L. K., Beard, B. L., & Marcy, J. A. (2004). Thermal process validation for Escherichia coli O157:H7, Salmonella, and Listeria monocytogenes in ground turkey and beef products. *Journal of Food Protection*, *67*(7), 1394–402. http://doi.org/10.4315/0362-028X-67.7.1394

Nazir, M. S., Abdullah, M. A., Ariwahjoedi, B., & Yussof, A. W. (2012). Short Communication Hazard Analysis and Critical Control Points (HACCP) in Palm Oil Processing to Improve The Productivity and Food Quality of Palm Oil Vegetation in Perak , Malaysia. *Revista Cientifica UDO Agricola*, *12*(1), 197–200.

Ndraha, N., Hsiao, H. I., Vlajic, J., Yang, M. F., & Lin, H. T. V. (2018). Time-temperature abuse in the food cold chain: Review of issues, challenges, and recommendations. *Food Control*, *89*, 12–21. http://doi.org/10.1016/j.foodcont.2018.01.027

Orta-Ramirez, A., Price, J. ., Hsu, Y. C., Veeramuthu, G. ., Cherry-Merritt, J. ., & Smith, D. . (1997). Thermal Inactivation of Escherichia coli 0157 : H7 , Salmonella senftenberg , and

Enzymes with Potential as Time-Temperature Indicators in Ground Beef. *Journal of Food Protection*, *60*(5), 471–475. http://doi.org/10.4315/0362-028X-60.5.471

Panisello, P., Rooney, R., Quantick, P., & Stanwell Smith, R. (2000). Application of food borne disease outbreak data in development and maintenance of HACCP systems. *International Journal of Food Microbiology*, *59*(3), 221–234.

Petrová, J., Juhaniaková, Ľ., Terentjeva, M., Kunová, S., Blaškovičová, H., & Kačániová, M. (2015). Microbiology of raw materials used for confectionary production. *Journal of Microbiology, Biotechnology and Food Sciences*, *4*(1), 52–56. http://doi.org/10.15414/jmbfs.2015.4.special1.52-56

Poumeyrol, G., Morelli, E., Rosset, P., & Noel, V. (2014). Probabilistic evaluation of Clostridium perfringens potential growth inorder to validate a cooling process of cooked dishes in catering. *Food Control*, *35*(1), 293–299. http://doi.org/10.1016/j.foodcont.2013.07.008

Richards, M. S., Rittman, M., Gilbert, T. T., Opal, S. M., DeBuono, B. A., Neill, R. J., & Gemski, P. (1993). Investigation of a staphylococcal food poisoning outbreak in a centralized school lunch program. *Public Health Reports*, *108*(6), 765–771. http://doi.org/10.1016/j.elerap.2004.02.002

Roberts, K. R., Sauer, K., Sneed, J., Kwon, J. H., Olds, D., Cole, K., & Shanklin, C. W. (2014). Analysis of school food safety programs based on HACCP principles. *Journal of Child Nutrition and Management*, *38*(1).

Rodriguez, M., Valero, A., Carrasco, E., Pérez-Rodríguez, F., Posada, G. D., & Zurera, G. (2011). Hygienic conditions and microbiological status of chilled Ready-To-Eat products served in Southern Spanish hospitals. *Food Control*, *22*(6), 874–882.

Sagoo, S. K., Little, C. L., Greenwood, M., Mithani, V., Grant, K. A., McLauchlin, J., … Threlfall, E. J. (2009). Assessment of the microbiological safety of dried spices and herbs from production and retail premises in the United Kingdom. *Food Microbiology*, *26*(1), 39–43. http://doi.org/10.1016/j.fm.2008.07.005

Schmidt, R. H., & Newslow, D. (2013). Hazard Analysis Critical Control Points (HACCP) – Prerequisite Programs. *Food Science and Human Nutriiton 07-03*, (February), 1–4. Retrieved from http://edis.ifas.ufl.edu/fs138

Seiyaboh, E. I., Kigigha, L. T., Alagoa, C. T., & Izah, S. C. (2018). Microbial Quality of Palm Oil Sold in Amassoma , Bayelsa State , Nigeria. *International Journal of Public Health and Safety*, *3*(2), 1–4.

Sekheta, M. A. F., Sahtout, A. H., Sekheta, A. H. F., Sharabi, R. O., & Airoud, K. A. (2010). The Group of Hidden Hazards in Enhanced HACCP and ISO-22000 Based Quality Systems. *Internet Journal of Food Safety*, *12*, 146–157.

Shafini, A. B., Son, R., Mahyudin, N. A., Rukayadi, Y., & Tuan Zainazor, T. C. (2017). Prevalence of Salmonella spp. in chicken and beef from retail outlets in Malaysia. *International Food Research Journal*, *24*(1), 437–449.

Tessi, M. A., Aringoli, E. E., Pirovani, M. E., Vincenzini, A. Z., Sabbag, N. G., Costa, S. C., … Moguilevsky, M. A. (2002). Microbiological quality and safety of ready-to-eat cooked foods from a centralized school kitchen in Argentina. *Journal of Food Protection*, *65*, 636–642. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/11952212

Tewari, A., Singh, S. P., & Singh, R. (2015). Incidence and enterotoxigenic profile of Bacillus cereus in meat and meat products of Uttarakhand, India. *Journal of Food Science and Technology*, *52*(3), 1796–1801. http://doi.org/10.1007/s13197-013-1162-0

Thapa, P., Singh, A., & Karki, T. B. (2010). Assessment of Hazard Analysis Critical Control Point (HACCP) of Fast Food (Momo) from Restaurants of Kathmandu City. *Nepal Journal of Science and Technology*, *9*(0), 49–56. http://doi.org/10.3126/njst.v9i0.3164

Trafiałek, J., Lehrke, M., Lücke, F. K., Kołozyn-Krajewska, D., & Janssen, J. (2015). HACCP-based procedures in Germany and Poland. *Food Control*, *55*, 66–74. http://doi.org/10.1016/j.foodcont.2015.01.031

Tsang, Y. P., Choy, K. L., Wu, C. H., Ho, G. T. S., Lam, H. Y., & Tang, V. (2018). An intelligent model for assuring food quality in managing a multi-temperature food distribution centre. *Food Control*, *90*, 81–97. http://doi.org/10.1016/j.foodcont.2018.02.030

USDA. (1997). *Meat and poultry products hazards and control guide*. *United States Department of Agriculture, Food Safety and Inspection Service*. Retrieved from http://www.haccpalliance.org/sub/haccpmodels/hzrdcontrolguid.pdf

USDA. (2005). *Guidance for School Food Authorities : Developing a School Food Safety Program Based on the Process Approach to HACCP Principles*.

Wallace, C. A., Holyoak, L., Powell, S. C., & Dykes, F. C. (2014). HACCP e The dif fi culty with Hazard Analysis, *35*. http://doi.org/10.1016/j.foodcont.2013.07.012

Wheeler, T. L., Kalchayanand, N., & Bosilevac, J. M. (2014). Pre- and post-harvest interventions to reduce pathogen contamination in the U.S. beef industry. *Meat Science*, *98*(3), 372–382. http://doi.org/10.1016/j.meatsci.2014.06.026

Youn, S., & Sneed, J. (2003). Implementation of HACCP and prerequisite programs in school foodservice. *Journal of the American Dietetic Association*, *103*(1), 55–60. http://doi.org/10.1053/jada.2003.50002

Yousif, E. I., Ashoush, I. S., Donia, A. A., & Hala Goma, K. A. (2013). Critical control points for preparing chicken meals in a hospital kitchen. *Annals of Agricultural Sciences*, *58*(2), 203–211.