CHAPTER 2

LITERATURE REVIEW

2.1 Inflight Food

History recorded that as early as in the year 1981, on regular flights from London-Paris, the world's first in-flight catering was provided to the passengers with sandwiches, fruits, and chocolates packed in paper boxes (Seon Hee Ko & Joo Eun Lee, 2016). Today, airlines are striving to improve the quality and quantity of in-flight food as a study has shown that catering is a key factor for a customer's satisfaction with airline service quality (Wolfgang, 2016). Onboard, food and beverage (F&B) service is used by companies to attract passengers. Studies showed that an inflight meal is the primary means by which an airline company differs from others, especially on long-haul flights passengers' expectations and demands vary compared to short-haul flights. Because of this, many airline companies serve various meals for passengers with restrictive diets such as halal, kosher, gluten-free, diabetic, JAIN (a strictly vegan meal that excludes all animal products and does not contain any onion, garlic or other root vegetables), vegetarian and many more (Dolekoglu, Vezigrolu & Keiyinci, 2017). Nasi lemak is a popular Malaysian heritage food and it consists of rice, chicken rendang, chili-onion paste (*sambal*), fried groundnuts and anchovies and half of a hard-boiled egg.

2.2 Preparation of Inflight Food

The production process of in-flight meals is done in the central kitchen on the ground. The cooked meals are stored in the chiller before being uplifted into the aircraft (Seon Hee Ko & Joo Eun Lee, 2016). Hot foods use the cook-chill method where the high temperature, 75°- 90° Celsius of newly cooked meals is cooled down as low as 4°Celsius or below within two hours using a blast chiller before storing it in the refrigerator. Additionally, there is also an alternative method of cook-freeze technique when the hot cooked meals with high temperature are drastically cooled down to frozen temperature; -18°Celsius and below within two hours by using a blast freezer before it is kept in a freezer. All of the methods are used to maintain the overall quality and safety of the meals. The type of meal uplifted in the aircraft depends on the duration of the flight journey either short or long-haul. This is due to the food safety and shelf life concerns. Many of inflight hot meals including Nasi Lemak uses the cook-chill method. All the ambient, chilled or frozen meals are transported from the dedicated storage area at inflight airline warehouse by using hi-lift trucks before downloading to each of the aircraft at a scheduled time. The particular central kitchen will produce Nasi Lemak early in the morning and deliver the meals to the inflight airline warehouse on the same day at around 10 am, daily. The meals are then stored in the chiller before being arranged in the inflight cart. The process of cart setting at Inflight Warehouse, uplifting meals in the hi-lift trucks, and a short journey of the hi-lift trucks from the inflight airline warehouse to the dedicated scheduled aircraft at the hangar, will take about two hours before all meals are transferred into the particular aircraft.

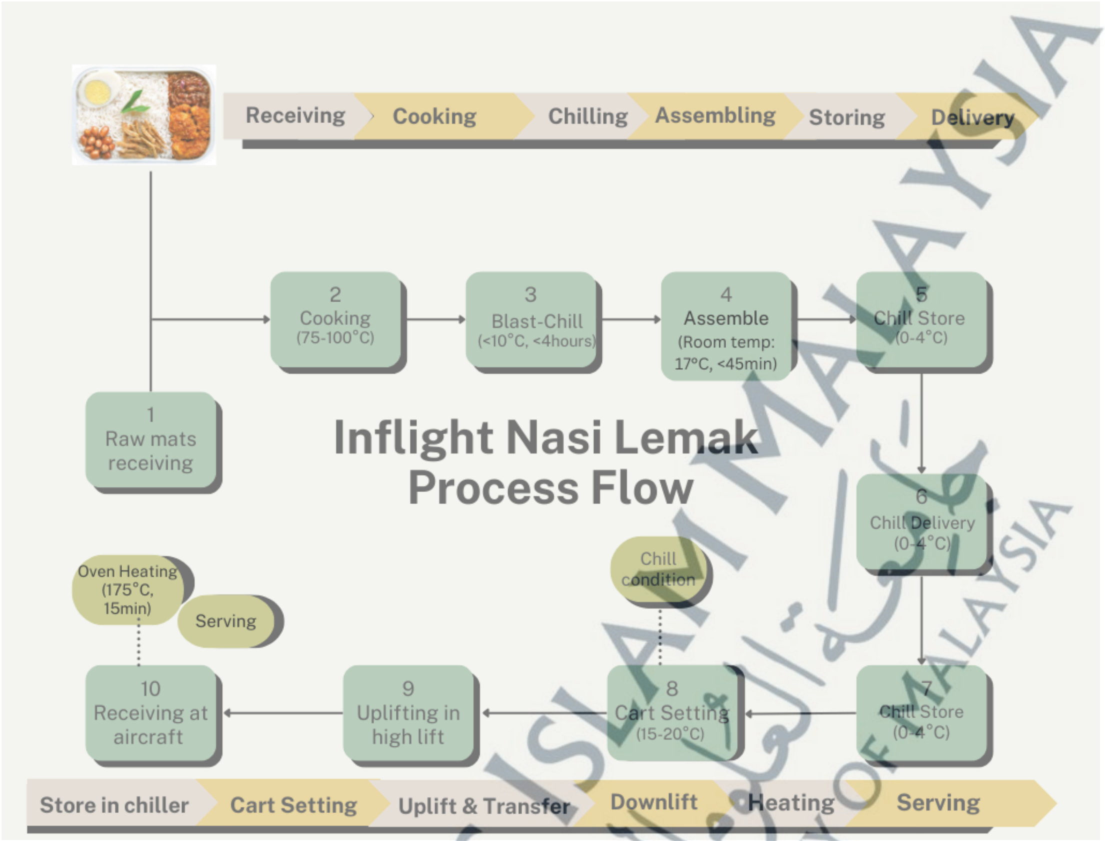

Figure 2.2: The process flow of the overall Nasi Lemak supply chain

2.3 Impact of Food Processing Techniques on Sensory

There are several conventional processes of traditional thermal treatments that involve heating one product at a specific time and temperature. Based on the heat intensity, they can be categorized into pasteurization at 65–90°C, sterilization at 110–121°C, and ultrahigh temperature at 140–160°C (P.E. Augusto, 2020). Old thermal treatments are used to eradicate pathogens, retard spoilage microorganisms, enhance safety, and increase the shelf life of food products (A. Rosenthal et al, 2021). However, these techniques can change the products' nutritional, physicochemical, and sensory properties. Barbhuya et al. (2021) stated that the non-thermal technique has better bioactive potential preservation and bioaccessibility compared to traditional thermal treatments. In another study, the thermal and high-pressure treatment can destroy the cell membrane, increase mass transfer, and alter the component's structure (Patist & Bates, 2008).

Therefore, food industries seek alternatives in novel food-processing technologies to minimize the possible adverse effects of classical thermal treatments on food properties (N.G. Ribeiro et al., 2022). Some example of recently introduced novel food-processing techniques include high pressure processing (HPP), pulsed electric field (PEF), ultrasonic, irradiation, cold plasma, hydrodynamic cavitation etc (Knorr et al., 2011).

2.4 Foodborne Illness Cases Involved in Inflight Meal and Sources of Contamination

Customer complaints related to spoiled meals, food safety and food poisoning issues have been the subject of concern for many retailers including airline catering. To avoid this scenario, caterers or food producers are practicing high food safety protocols as well as promoting the sustainability approach that covers the health and safety aspects. A report was lodged in 2022 that six cases of food poisoning related to inflight food and four of them are suspected from Pak Nasser's Nasi Lemak (Santan Airasia, unpublished). With regards to this matter, the company is implementing stringent food safety requirements which include food handlers' hygiene and sanitation, a facility that practiced HACCP or GMP as well as complying with other regulations stipulated in the Food Hygiene Regulation 2009 in the Malaysia Food Act 1983. Regardless of the implementation, foodborne illness cases are increasing worldwide (Mead et al., 1999; Soon et al., 2011). WHO reported as updated in the year 2023, approximately 600 million nearly 1 in 10 people in the world fall sick before consuming contaminated food and 420 000 death cases are reported every year, resulting in the loss of 33 million healthy life years (DALYs, 2023). In Malaysia, unhygienic food handling practices are identified as the main aspect that causes foodborne diseases which accounted for more than 50% of the poisoning episodes. Food handlers are highly responsible for ensuring the prevention of food poisoning during food preparation (Soon et al., 2011).

The most common pathogen related to food outbreaks traced to inflight meals is *Salmonella* (M. Hatakka and K. Asplund, 1993). *Salmonella* contamination is oftenly associated with produce such as poultry, cattle, and their feeds. However, other products such as dried foods, infant formula, fruit and vegetable products, and pets have also become important sources of the contamination (Ehuwa et al., 2021). It has been reported to cause 15 outbreaks and has infected approximately 4000 people. Eight different serotypes have been determined, with *S. Enteritidis* being the most typical, causing 6 outbreaks. In addition, *Salmonella enterica serovar typhi* (hereafter *S. typhi*) was the cause of two outbreaks. In 1947, 41 outbreaks have been reported accumulatively. *Salmonella spp.*, *S. aureus* and *Vibrio* spp. have been the most commonly reported agents which involve thousands of flights. Nearly 9,000 air passengers and cabin crews have been reported to have suffered from food poisoning including 11 deaths. In 1976, it resulted in a *Salmonella enterica serovar typhimurium* (hereafter *S. typhimurium*) outbreak due to infected cold salads from Las Palmas served on charter flights causing six deaths.

Later, in March 1984, it was reported that 186 cases of gastroenteritis due to *Salmonella enteritidis* after 29 flights to the United States on an international airline. Approximately 2,747 passengers on flights to the United States were affected. Of all 23 reported outbreaks of foodborne illness on aircraft, *Salmonella* has been the most notable pathogen (seven outbreaks), followed by *Staphylococcus* (five outbreaks), and *Vibrio* species (five outbreaks). Outbreaks are frequently the consequence of improper temperature control during preparation or holding food in the central kitchens (Tauxe et al., 1987).

In 1975, on a Boeing 747 aircraft Tokyo outbound and Paris inbound, the enormous poisoning outbreak occurred between Anchorage and Copenhagen in which one hundred ninety-six passengers and one crew member of a total of 343 onboard suffered symptoms of nausea, vomiting and abdominal cramps after about 1 to 1.5 hours consumed a ham omelet breakfast prepared at Anchorage where 143 were admitted to the ward with 30 in a critical condition (Munce, 1989). Munce reported that most gastrointestinal diseases that have a short incubation period originate from bacteria. Nonetheless, there are several numbers of food- and water-borne infections with longer incubation periods, neither of which have gastrointestinal as a major symptom.

The popular food poisoning bacteria are *Salmonella, Staphylococcus aureus, Bacillus cereus, Clostridium perfringens* and *Vibrio parahaemolyticus*. The most common bacteria that is transmitted by humans as the host is *Staphylococcus aureus* which readily gains access to food through human touch. **Table 2.4** presents a list of common pathogens that may present in food classified by food category and most likely and hardest to kill target organism and rationale for recommended cooking treatment, tabulated by the International Flight Services Aviation (IFSA) for the World Food Safety Guideline for Airline Catering.

Table 2.4: List of pathogens may be present in food and the cooking temperature references adapted from World Food Safety Guideline for Airline Catering, International Flight Services Aviation (IFSA), Version 4, 2016

Food group	**Types of Pathogens**	**Dominant and hardest-to-kill organism and rationale for recommended cooking treatment**	**Cooking treatment**	**References**
Dairy Products	*Salmonella* *Campylobacter* *Listeria monocytogenes* *Escherichia coli* *Staphylococcus aureus*	***Salmonella*** – Readily destroyed at pasteurization time/temperatures. Minimum pasteurization treatments allow sufficient safety margins to ensure the destruction of pathogens likely to be present initially in raw milk.	71.7 °C / 161 °F, 15 seconds	ICMSF (1998) Jay (2000
Poultry & Eggs	*Salmonella Campylobacter* *Listeria monocytogenes* *Staphylococcus aureus* *Clostridium perfringens*	***Salmonella*** – Minimum pasteurization treatments allow sufficient safety margins to ensure destruction of pathogens	74 °C / 165 °F 15 seconds for <u>poultry</u> 70 °C / 158 °F for <u>eggs & omelets</u> 75 °C / 167 °F core temperature	FSIS (2001) FDA (2013) FDA (2013) Boulton & Maunsell (2004); Food Standards Agency Scotland (2005)
Fin Fish	*Clostridium botulinum* *Vibrio spp* *Parasites* *Salmonella* *Campylobacter* *Listeria monocytogenes*	***Parasites*** – Pasteurization temperature to allow sufficient time to ensure destruction	65 °C / 149 °F core for <u>raw fish</u> 63 °C / 145 °F, 15 seconds 70 °C / 158 °F for <u>comminuted fish</u>	ICMSF(1996) AIFST (1997) ICMSF (1996) AIFST (1997) FDA (2013)

Shell Fish / Crustaceans	*Listeria monocytogenes* *Clostridium botulinum* *Salmonella* *Vibrio spp. especially V.parahaemolyticus* *Campylobacter*	***V. parahaemolyticus*** – predominant pathogen in seafood.	> 65 °C / 149 °C core 63 °C / 145 °F, 15 seconds > 60 °C / 140 °F	ICMSF(1996) AIFST (1997) FDA (2013) FDA/CFSAN (2000)
Meats	*Escherichia coli O157:H7* *Salmonella* *Staphylococcus aureus* *Parasites* *Campylobacter* *Clostridium perfringens* *Yersinia*	***Salmonella*** – FSIS suggests a 6.5D reduction. ***VTEC*** – For a 6 log reduction: 70 °C / 158 °F for 2 minutes or 80 °C / 176 °F for 6 seconds	***Salmonella***: > 70 °C / 158°F for comminuted and mechanically tenderized meats ***VTEC***: 80 °C / 176 °F ***EHEC***: > 68 °C / 154 °F ***Searing***: Cooked on both the top and bottom to a surface temperature of 63 °C / 145 °F or above **and** a cooked color change is achieved on all external surfaces (for whole muscle, intact beef)	FSIS, (2001) FDA, (2013) Jay, (2000) ACMSF (1995) Codex CX/FH 03/5 (2003) FDA (2013)
Rice / Pasta / Cereals	*Bacillus cereus* *Clostridium perfringens*	FDA does not specify cooking process for starches as cooking will not destroy spores of Bacillus cereus or C. perfringens. Adequate cooling is imperative to prevent germination and growth of spores.	N/A	FDA/CFSAN (2000) ICMSF (1996)
Vegetables	*Listeria*	Blanching at 95-99 °C/ 203-210 °F for 1-5	N/A	FDA/CFSAN

& Fruit	*monocytogenes* *Escherichia coli* *Salmonella* *Clostridium botulinum* *Bacillus cereus*	minutes should destroy non-spore forming pathogens. Pasteurization temperatures (71,7 ° C / 161 °F, 15 sec) will destroy Listeria spp. Adequate cooling is imperative to prevent germination and growth of spore forming pathogens.		(2001) Jay (2000) ICMSF (1996)

2.5 Effect of Storage Condition on the Quality of Ready-to-Eat Nasi Lemak

2.5.1 Microbial Growth

Food spoilage can be defined as a metabolic process that causes foods to be unpalatable or undesirable for human consumption due to the adverse effects of sensory characteristics. Negative changes in texture, smell, taste, color or look cause the meals to be rejected even though they may be safe to eat, for example, they may not cause foodborne illness as there are no pathogens or toxins (Bukerpile, 2006). Therefore, the safety of ready-to-eat (RTE) foods relies on the use of correct and suitability of raw materials, the processing operation, and several other parameters tabulated in Table 2.5.1 (Kotzekidou, 2016).

Table 2.5: Factors Affecting Safety of RTE Foods Adapted from Factors influencing microbial safety of ready-to-eat foods

Main Factors	Subfactors
Product category	• Fresh produce (raw fruit and vegetables ready for consumption) • Multi-ingredient preparations consisting of cooked and uncooked foods • Cooked foods
Product formulation	• Water activity (aw) (NaCl, sucrose) • pH (lactic acid, acetic acid) • Antimicrobials and preservatives • Indigenous microbiota • Epiphytic microbiota (fruit, vegetables) • Microstructure (liquid vs structured foods) • Scattered availability of nutrients • Edible coating
Storage temperature	• Cold storage (≤4℃) • Hot-held products (>60C)
Packaging	• Vacuum-packed • Modified-atmosphere packed • “Smart packaging”
Shelf-life	•25 days •>5 days

Food preparation surfaces (food contact surfaces, cutting boards)	• Biofilm formation • Disinfection
Hands of food handlers	• Use of disposable gloves • Bare hand contact with RTE foods • Frequency of hand washing • Dishcloths
Cross-contamination	Mishandling of RTE foods • Irrigation water (fresh produce) • Slicing of foodstuffs • Utensils (knives, serving spoons)

Source: Kotzekidou (2016)

Luning et al., (2011) in his study mentioned that, for RTE foods, the growth and/or survival of pathogens (including their spores) are affected by the intrinsic criteria i.e. water activity, pH, presence of preservatives) as well as the application of inactivation technology for instance, sterilization pasteurization, probability on post-contamination. RTE products can be classified as mild or high risk when the final product has a water activity (aw) $>$ 0.6 or a pH $>$ 4.2, without intrinsic antimicrobials. In high-risk situations, the product to keep a very high-water activity (aw of 0.98) or a pH of 6.5 or must be sensitive to post-contamination.

Besides that, food preparation surfaces are one of the potential accumulations of bacterial contamination for RTE foods and it is very important to ensure the surface area is thoroughly and properly cleaned and disinfected regularly ("Clean as you Go") to prevent bacterial proliferation and dissemination. A contaminated preparation area, due to the transmission of fecal-oral route and minimal hand washing, may expose consumers to foodborne pathogens. Shelf Life Study of an inflight Nasi Lemak reported that the identification of the microbiology spoilage, samples were left at chill temperature (0-4℃) and tested with four parameters of pathogens which include total plate count, *Escherichia coli, Staphylococcus aureus* and *Salmonella*. Samples stored at chill temperature to replicate similar retail conditions were tested on Day 1, Day 8, Day 16, and Day 24. According to the laboratory analysis, it is reported that the total plate count consistently showed more than $1.0x10^5$ cfu/g starting from Day 7 and onwards, respectively.

2.5.2 Sensory Attributes Acceptance

The unpublished results of the sensory attributes study on inflight Nasi Lemak reported that at six days of chilled Nasi Lemak has a dry texture. On the seventh day, rice has become hardened, not aromatic, not sticky and not palatable anymore. The characteristics shown are opposite to the first several hours after preparation as Nasi Lemak was tested aromatic, and fragrant, and rice is soft, fluffy and sticky.

2.6 Types of Additives Used in Cooked Food

Food additives are natural or synthetic substances added intentionally to food products to increase food safety and durability, improving or preserving food organoleptic characteristics as well as to lengthen the shelf life of a food product. Nonetheless, additives should be used sparingly and should give benefit consumers their use (Bacak, 2017)

In the European Union (EU), food additives are classified into 26 functional classes, relying on their role in food: sweeteners, colorants, preservatives, antioxidants, carriers, acids, acidity regulators, anticaking agents, antifoaming agents, bulking agents, emulsifiers, emulsifying salts, firming agents, flavor enhancers, foaming agents, gelling agents, glazing agents, humectants, modified starches, packaging gasses, propellants, raising agents, sequestrants, stabilizers, thickeners, and flour treatment agents (Council Regulation (EC) 1333/2008).

Meanwhile, in Malaysia, as stipulated under Malaysia Food Regulation 1985, there are 11 classes of food additives that include food additive, processing aids, preservative, antimicrobial agent, coloring substance, flavouring substance, flavour enhancer, antioxidant, food conditioner, added nutrient and probiotic culture.

Initially, antimicrobials are added to food for two objectives, which include controlling natural spoilage of food (food control) and/ or preventing or controlling contamination by microorganisms, including pathogenic ones due to food safety concerns (Tajkarimi et al., 2010). The major chemical antimicrobials used in food with quantum satis status are acetic acid (E260), potassium acetate (E261), calcium acetate (E263), lactic acid (E270), carbon dioxide (E209), and malic acid (E296) (Carocho et al., 2014). Figure 2.6 shows groups and subgroups of food additives.

Figure 2.6: Groups and subgroups of food additives.

Source: Branen and others (2001), Watson (2002), and Sarikaya and others (2012)

2.6.2 Acidity Regulators, Preservatives, and Antioxidants

The usage of acidity regulators, preservatives, and antioxidants to protect the food, respectively, by pH reduction or adjustment, microbial growth retardation, and free radicals or metals inactivation (Bacak, 2017). Additionally, acidity regulators aid in preserving the authentic taste and color of the food and contribute to its healthiness through pH control as a guarantee for preventing the growth of spoilage microorganisms. Some acidifiers play a role as stabilizers, while others act as aids for antioxidants or for holding the color. In addition to preventing the development of bacteria, acidity regulators contribute to preserving the desired quality of the food. Most of the acidity regulators are present naturally in foods. The common widely used compounds are acetic acid, citric acid, lactic acid, and their salts. Table 2.6.2 presented a list of acidity regulators with the E-number, origin substance and type of common food in which they are used.

Table 2.6.2: Food acid regulator and their applications in food products

E-Number	Origin Substance	Applications
E260	Acetic acid	Fish fingers, Butter, Margarine, Processed cheese, Curry powder, Cooking oil
E263	Calcium acetate	Packet desserts, Pie fillings
E270	Lactic acid	Cheese, Milk, Meat and Poultry, Salads, Sauces and Beverages
E296	Malic acid	Canned fruit, Vegetables and Pulses, Jams, Jelly, Frozen vegetables
E297	Fumaric acid	Bread, Fruit drinks, Pie fillings, Poultry, Wine, Jams, Jelly
E330	Citric acid	Fruits and Vegetables (lemons and limes), Doft drinks
E334	Tartaric acid	Bakery, Candies, Jams, Juices and Wine

Source: Food Additive Module – 16, Paper No 13

The mechanism of acidity regulator can relate to when foods that contain organic acid may require pH alteration and buffering system. The sourness is reduced and smoother product flavors are to be obtained without inducing neutralization flavors. Generally, it can be accomplished by establishing a buffer system in which the salt of a weak organic acid is dominant. The usual ion effect is fundamental to achieving pH control in these systems, and as such, the system develops when the added salt contains an ion that is already present in an existing weak acid. The added salt promptly ionizes causing the acid to repress ionization with reduced acidity and a more controlled pH. The buffer efficiency is determined by the concentration of the buffering substances. The pool of undissociated acid and dissociated salt resulting in buffers resist changes in pH (Damodaran et al., 2008).

Preservatives reduce and suppress the growth of bacteria, molds, and yeasts in food, preventing it from degradation or toxin development (Bacak, 2017). Due to the rapid growth of the economy, and hectic lifestyle, many consumers expect foods to be available all year long, free from pathogens, and have a reasonably long shelf life. Even though improvements have been made using sophisticated packaging or novel technology processing systems to preserve foods without additional chemicals, antimicrobial food preservatives play a significant role in protecting the global food supply. Food preservatives commonly belong to groups of sorbates, benzoates, and sulfites.

Antioxidants are substances added to food to prolong the shelf life of foods as it can protect food against deterioration caused by oxidation, for example, fat rancidity and color changes (Regulation UE 1333/2008). Lipid oxidation impacts significant changes in foods for instance, texture, appearance, and nutritional profile, as well as worsening and reducing the shelf life. In many foods, lipid oxidation is unfavorable due to it causes off-flavors (rancidity) for example, from the milk fat could be released butyric acid, which has a typical nauseating smell and acrid taste followed by a sweetish aftertaste. However, there are various rancidity processes of fatty substances that can be distinguished by the origin and type of produced compounds. They are the result of the reaction of oxygen present in air, by enzymatic activities (oxidase, decarboxylase, lipoxidase), or by enzymatic and oxygen activities (Bacak, 2017).

2.7 The Effect of Type of Rice to the Stickiness and Hardness of Cooked Rice

The texture of cooked rice is influenced by various elements, including amylose content, postharvest processing, and cooking techniques (Hongyan, Melissa, Sangeeta, Timothy & Robert, 2017). According to Hongyan et al, 2017, the structure of starch plays a crucial role in the rice texture. Starch, the primary component of rice grains, is a branched glucose polymer made up of two types of molecules: amylopectin (Ap) and amylose (Am). Amylopectin molecules are highly branched with numerous short branches and relatively large molecular weights, approximately 10^7-10^8. In contrast, amylose has a smaller molecular weight (about 10^5-10^6) and contains fewer long branches. In their study also stated that, stickiness increases as amylose content in the whole grain decreases, meanwhile in the leachate, it increases with a higher total amount of amylopectin, a greater proportion of short amylopectin chains, and larger amylopectin molecular size.

2.8 Consumer Demands and Trends in Food Consumption

Consumers have become more adamant that foods available in retail must be of good quality, safe, and not potential risks to them. Hence, to further ensure this, the role of all related parties involved is very crucial. Knowledge of the factors that are important in producing good-quality and safe foods is a prerequisite (Kotzekidou, P., 2016). The latest and radical improvements in the food marketing and distribution system through globalization have caused profound effects on food consumption patterns. Consumer health awareness continues increasing with the rising availability of health information going hand in hand with the aging of populations and increased risk for lifestyle diseases. Selection of foods that are acceptable to an individual increasingly takes place in a context where availability is substantially influenced by the food industry and food retailers (Kearney, 2010). In the United States, the trend emerged that consumer demand for new foods and changes in eating habits and food safety risks are impacting the food processing industry. Society is becoming older on average; plus, consumers tend to consume fresh and minimally processed food. Hence, manufacturers are seeking new food processing and preservation methods to address the need for safer food and compete for consumer acceptance (Zink, 1997).