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# A framework for effective food supply chain safety controls

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ABSTRACT

Food safety assurance is becoming a prevalent concern due to several food scandals that have eroded customer trust and confidence. Despite the importance of food safety, little is known about the current state of food supply chain safety controls (FSCSC). Therefore, this study aims to identify and establish a conceptual model for FSCSC. To gain a preliminary grasp of the impetus behind the FSCSC, this study applied a comprehensive literature review to fully integrate the various elements that drive FSCSC. Relevant literature on food safety, food quality, and food safety control measures is being scrutinized. Regulation and legislation, traceability and trackability, technology, and human capital are recognized as important aspects to enhance FSCSC. All four main aspects provide a communication network that is capable of aiding food controllers to verify, identify, and isolate potential sources of contamination. Insights from this study could offer a better understanding of FSCSC and serve as a platform for future empirical research. This study proposed an alternative strategy to transform the current FSCSC. Hence, future studies could incorporate inquiry, in-depth evaluation, and panel interviews to gain a more comprehensive understanding of the general awareness of FSCSC processes.

## 1. Introduction

Malaysians are popular as a foodie. Food will very certainly be sold anywhere. The shift in Malaysians lifestyles from “eating in” (home cooking) to “eating out” (dining out), particularly among city dwellers, has spurred the local food industry's rapid expansion. Undoubtedly, Malaysians are passionate about food and taste, however, they are less concerned about food safety. According to Philip (2015), the public pays little attention to food safety and cleanliness. When it comes to purchasing foods, these factors have been placed at the bottom of the priority list. Several decades ago, several unethical cases shook the food

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industry. Bovine spongiform encephalopathy (BSE) or commonly denoted as mad cow disease, dioxin in chicken feed, foot and mouth disease (FMD), and the use of genetically modified (GM) crops in foods were among the cases that arose in the food industry. In addition, the outbreak of foodborne diseases such as campylobacter, salmonella, and *eschericia coli* likewise contributes to public fears concerning food safety and quality (Aung & Chang, 2014). Some other incidents include the Chinese milk scandal in 2008 (NBC News, 2008) and the European horsemeat crisis in 2013 (BBC, 2013).

In Malaysia, foodborne diseases are usually hepatitis A, cholera, food poisoning, typhoid fever, and dysentery. Earlier, Sharifa-Ezat, Netty and Sangaran (2013) reported that there were 62,47 cases of food poisoning per 100,000 population in 2008 and 36,17 cases in 2009. Most cases of food poisoning occurred in schools, and the number of cases has been steadily rising since 2010 (New et al. 2017). Food and water-borne diseases (including cholera, typhoid, viral hepatitis A, food poisoning, and dysentery) were reported at a rate of 49 cases per 100,000 people, with food poisoning accounting for 45 of those cases (MOH, 2013). Furthermore, according to Abdullah and Ismail (2021), a total of 21 cases of child food poisoning were reported in Terengganu in 2016, with 63.6% of them becoming unwell. Among them, 95.3% of events were held at MOE schools, while 81% were held at private institutions, with 57.1% taking place in a city. Around 62% of food poisoning cases were caused by poultry. According to studies conducted by Basurra et al. (2021), most food poisoning outbreaks in Malaysia were linked to the consumption of ready-to-eat (RTE) items such as meat, poultry, fried rice, and noodles.

The intricacy and variety of Malaysia's food safety system determine its success. The lack of a traceability system in the food supply chain is a major contributor to the problem of food safety in Malaysia. Food is freely transported without hindrance. This is because the food supply chain network has multiple supply resources, processes, outputs, and players impacting food integrity (Osman et al., 2020; Wang, Van Fleet & Mishra, 2017). Past researchers such as Manning (2016) and Rajendran and Kamarulzaman (2018) emphasized that lengthy and complex food supply chains are becoming increasingly vulnerable to incidents and problems that could threaten food quality. Meanwhile, restrictions on the importation of several foods from other countries and lack of knowledge on food safety-related matters are also the contributing factors that have affected the food industries. Diseases are major reasons that have led European countries to set high standards of food safety, specifically for the export of fresh produce (Lamuka, 2014). Rahmat, Cheong and Abd Hamid (2016) highlighted some food manufacturers, especially exporting countries, are not alert to the production of healthy and safe food. Some manufacturers attempt to reduce the cost of production by mixing low-quality ingredients, which may affect people's health. It is very challenging for customers to differentiate between nutritious food and unhealthy food because of a lack of knowledge and awareness. Additionally, Rahmat, Cheong and Abd Hamid (2016) argued that food quality assurance is one of the critical elements to be imposed for food production to comply with the standard of production.

Conversely, New et al. (2017) in their study pointed out that when an outbreak occurred, the source of the disease was not reported to the authorities. This is most likely due to a variety of factors. Firstly, the procedures for identifying the microorganism are time-consuming and labour-intensive. As a result, the source of the outbreak or contamination can no longer be determined, or it has been lost throughout that time. In the worst-case scenario, a majority of foodborne illness sufferers do not seek proper medical treatment or report their sickness to the appropriate authorities. Therefore, surveillance data would be limited, and preventive measures would be unavailable. Besides, when a foodborne illness outbreak occurs, the media will paint a poor picture of the item that is associated with the outbreak, causing consumers to avoid it entirely. This is owing to the rapid spread of social media, in which most customers are now fully engaged. Hence, food safety concerns must be addressed. Otherwise, Malaysia will face serious threats in the future. Accordingly, this study proposes a conceptual model for food supply chain safety controls (FSCSC). The model distinguishes various pieces of evidence by collecting and categorizing criteria from various investigations. Grounded theory was utilized to categorize and collect food safety-related studies which were then grouped into a conceptual model (Hassauer & Roosen, 2020). As a result, it classifies and

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aggregates holistic approaches that aim to rationally represent and characterise numerous facets of food safety standards.

Globally, consumers' new trend in food intakes where there is too much concern about hygiene, nutrition, and purity. In general, high-quality food is an important requirement for consumers. Hence, maintaining food quality along the supply chain is important. Kher et al. (2010) emphasised the importance of quality assurance as a pillar of food safety policy. Food quality assurance is an efficient system that enhances food safety within food chains and increases consumers' confidence. Food supply chain management (FSCM) was created in response to the growing concern about food quality and safety. It demonstrates the operations of production, distribution, and consumption to maintain the safety and quality of various food products effectively and efficiently (Marsden, Banks & Bristow, 2000; Blandon, Henson & Cranfield, 2009). FSCM differs from other supply chain management because it prioritizes factors such as food safety, quality, and freshness over a given time frame, rendering the underlying supply chain more complicated and challenging to manage (La Scalia et al., 2016). As the global food industry has exacerbated the challenges, the emphasis from a single echelon such as food manufacturing has moved to integrate supply chain quality and effectiveness. The supply chain network's effectiveness and efficiency are critical to food safety and quality. This means that all actors in the food supply chain must execute and control logistics operations such as warehousing, handling and storage, and transportation to maintain food safety and quality through effective exercises such as optimization decisions (Wu et al., 2016). Considering that the growing globalization demands safer and more nutritious food, the current food supply chain system faces some challenges.

The growing number of food contamination incidents have drawn the attention of both practitioners and academics. As food production has evolved into a global industry, many of these incidences are tied to the supply chain (Auler, Teixeira & Nardi, 2017). Therefore, in food contamination occurrences, supply chain issues are becoming increasingly relevant. As a result of this issue, a number of researchers are looking at food safety throughout the supply chain. Hence, the following research questions were proposed: What are the most important impetuses behind food safety controls throughout the supply chain system? Accordingly, the goal of this study is to examine food safety controls across the supply chain system, starting with raw material procurement and continuing through production and handling until it reaches the point of consumption. Scholars have identified this approach either as *farm-to-fork* (Ali & Suleiman, 2018; Soon, Chandia & Regenstein, 2017), *seed-to-shelf* (Morris & Young, 2000), or *farm-to-plate* (Mousavi et al., 2002; Opara & Mazaud, 2001). Moreover, a study by Ali et al. (2017) reveals that food safety controls would be examined from the entire supply chain context rather than the specific firm.

## 2. Literature review

### *2.1 Food supply chain*

In brief, a supply chain can be described as a whole process that begins from the point of origin to point of consumption to transform raw materials into finished end items to satisfy the needs of the customers. Along with the processes, integrated activities such as purchasing, manufacturing, warehousing, transportation, customer service, and supply planning will connect among the people, organization or system that works together, either locally or globally to ensure that the flow of goods, information and cash are smooth between the players (buyers and suppliers) at the right cost, quality, and time to achieve competitive advantage. Therefore, a supply chain can be referred to as a connected network system among multiple groups of people who work together to plan, implement, control and monitor the movement of various types of goods from suppliers to customers without disruption along the chain.

It is argued that the food supply chain is different from other products of the supply chain. In the food sector, according to Elliott (2014), each stage in the food supply chain such as how food is sourced,

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procured, processed, and distributed, is important and needs to be addressed specifically. Today the food industry consists of vast and complicated networks in which the main manufacturing and processing plants are located at a long distance. The networks are extended throughout the world and are transformed into a food supply chain. In food production, the food supply chain starts from the supplier to the retailer and ends with the consumer. FSCM has been developed to demonstrate the activities or processes of production, manufacturing, delivery, and use in order to ensure the safety and consistency of different food items efficiently and effectively. Dubey et al. (2017) claimed that the FSCM system which covers whole activities from the processing of raw materials to semi-finished goods and finished goods are derived from core activities such as agriculture, forestry, finishing, zootechnics, and so on. The FSCM goes through several processing steps that impact its quality and safety significantly. The responsibility of ensuring the safety and quality of food integrity along the supply chain is a huge task to be managed and monitored (La Scalia et al., 2016). The reality of this situation has raised questions on the credibility of the supply chain players concerning the integrity to protect the safety and quality of the food products.

The globalisation of the food industry has resulted in an integrated FSCM conceptual model. The integrated FSCM system plays a key role in maintaining high and reliable safety and quality of food products (Choi, Chiu & Chan, 2016). Xun Xu and Wang (2016) in their study have supported the fact that synchronization in the food supply chain, from production to consumption, is essential to safeguard the safety and consistency of different food items. The following sub-sections will discuss each of the food safety system mechanisms in detail.

### *2.2 Regulation and legislation*

Food safety and quality are the essential basic requirements that can be achieved through the implementation of a few food safety management tools like hazard analysis and a critical control point (HACCP), good agricultural practices (GAP), and good manufacturing practices (GMP) (Rajendran & Kamarulzaman, 2018). A study by Soon, Chandia and Regenstein (2017) highlighted these practical approaches provide food manufacturers with a series of food safety and hygiene principles. All these systems are associated significantly with food safety and quality. The following subsections will discuss food safety and quality in each of the systems in detail.

#### *2.2.1 Hazard analysis and critical control point (HACCP)*

Davidson et al. (2017) explain that the hazard analysis and critical control point (HACCP) is a mechanism of a food safety system that forbids and alleviate unintended hazards that can deprive the level of food supply chain safety. Back in 2009, the Codex Alimentarius Commission entrenched the seven principles of HACCP. According to HACCP's seven principles, hazard analysis (HA) should be conducted at a very beginning proposition which required firms to access the entire food supply chain processes and determine what type of potential hazard and where the potential hazard might occur. A tendency of occurrence of the hazard severity has to be scrutinized at this proposition. According to Wallace, Sperber and Mortimore (2014), a "significant hazard" is a type of hazard that emanates from the unacceptable risk and feasibility. Moving forward, the second proposition of HACCP is to detail the critical control point (CCP). This is where the firm is able to control the possible significant hazard which enables the firm to possibly prevent, reduce, or eliminate the potential of a food supply chain safety hazard. The proposition of HACCP will then be followed by establishing the critical limits, a system to control the CCP, a CCP corrective action, and finally CCP procedures for verification.

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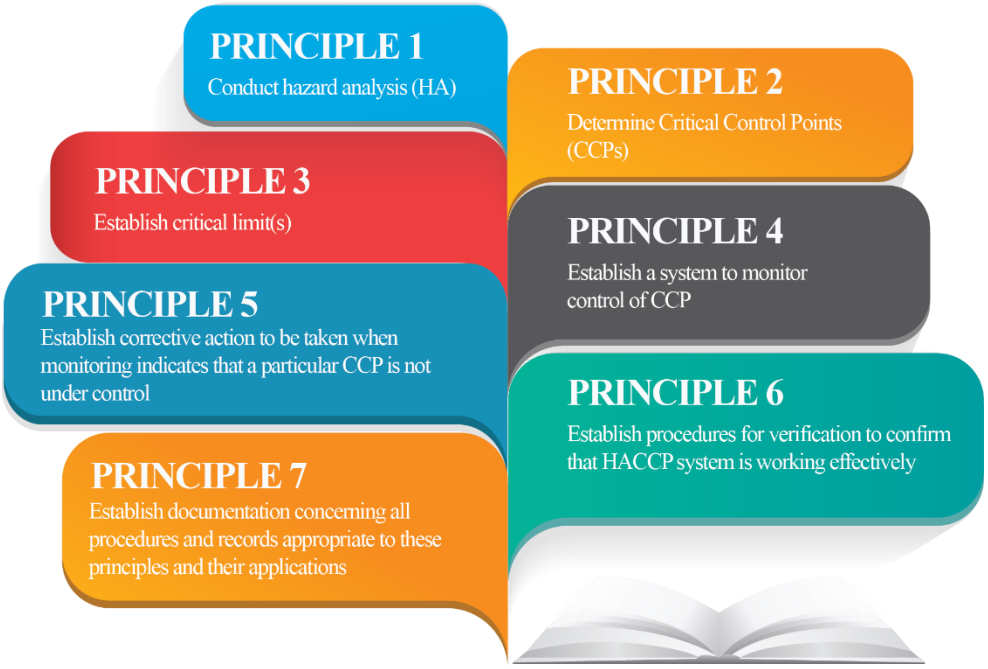


Figure 1. HACCP seven principles.
Source: Codex Alimentarius Commission (2009)

### *2.2.2 Good agricultural practices (GAPs)*

Good agricultural practices (GAPs) play a role in establishing a standard in on-farm processing and crop harvesting to ensure that the process works to eliminate fresh fruit and vegetable contamination. Some pathogenic substances, such as E. Coli and salmonella enter the food processing system through raw materials (Luna-Guevara et al., 2019). Agricultural products that use raw material supplies derived from animals are at risk of cross-contamination by animal faeces. Such risks can be minimized by ensuring that suppliers of raw materials practice GAPs (Dudeja & Singh, 2018). Practically, GAPs help the growers to avoid contamination of fruit and vegetable on the farm. GAPs are a constructive way of food safety. The GAPs are about knowing where food safety risks can occur and taking preventive measures before a product enters the market. GAPs focus on four primary areas of production and processing. They are soil, water, hands, and surfaces. Diseases or illnesses caused by microorganisms in soil can be reduced during the stages of growth and harvesting. Water quality becomes more significant for farming. Thus, water used to irrigate, cool, process, or clean equipment and buildings should be free from microbial pollutants (Luna-Guevara et al., 2019).

Meanwhile, the farmers or producers of fresh vegetables and fruits play important roles to ensure the safety and quality of food during food production and processing. Likewise, poor health and hygiene, unclean clothes or shoes, or unsafe practices on the part of workers may threaten food safety. Further, fresh produces may have several surfaces in physical contact during pre-harvest, harvest, and post-harvesting (Luna-Guevara et al., 2019). The fresh produces may require additional processing, special equipment and containers, conveyor bins, knives, and other utensils such as sorting and packaging tables, food packaging, and storage areas before moving to the next players. Through the implementation of GAPs on a farm, the

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bacteria and pathogens can be avoided. That way, product quality as well as product safety can be improved (Som et al., 2015).

### *2.2.3 Good manufacturing practices (GMPs)*

With an increase in the incidence of food safety reports, the efficacy of the existing regulatory mechanism on food safety assurance is questionable. A study by Noor Hasnan et al. (2014) found that rodents, cockroaches, and maggots were seen at the local factories. Floors were found slippery and filthy, and that waste was not properly segregated. Factories' drainage system were poor and ventilation was inadequate (Noor Hasnan et al., 2014). Good manufacturing practices (GMPs) should thus be incorporated into food law and regulations and food safety assurance should be made compulsory. Jarvis (2014) referred to the term GMPs as food manufacturers' practices and procedures which cover all aspects including food production, storage, handling, and distribution to ensure food safety, hygiene, and quality (Ling & Wahab, 2020). GMPs apply to manufacturing process personnel, machinery, processes, as well as the environment. GMP's key emphasis is on reducing the potential risks of any food production. GMPs seek to provide a better production strategy and to reduce contamination in the processing of foods. These allow manufacturers to plan, implement, monitor, and control necessary actions. According to Ng, Chin and Ahmad (2017) and Dudeja and Singh (2018) studies, the role of top management or business operators of the food business must ensure the requirements are adhere to the nature of food operations and the statutory and regulatory requirements. In brief, GMPs are a concept globally known for production, testing, and overall quality assurance and management in the food industry (Dudeja & Singh, 2018).

## *2.3 Traceability and trackability*

Traceability can be defined as a medium to assure food safety and quality as summarized in Table 1 and Table 2. Traceability is vital in enhancing supply chain food safety. According to ISO (2015), traceability is defined as the ability to track the entire supply chain movement and process towards managing the history, location, and application before it reaches the end-user. Nowadays, transparency is becoming a vital need not just for the stakeholders, but also for the consumers. Thus, it is essential for each member in the supply chain to establish traceability in the entire products across the supply chain (Pant, Prakash & Farooquie, 2015). In a study on the application of the technology, traceability is able to assist food handlers to recognise, identify, and record pertinent information about food safety and quality for the entire supply chain system. It helps the food handler to detail out the entire food product progress including sourcing, processing, and delivering which is expected to render the minimum standard (Badia-Melis, Mishra & Ruiz-Garcia, 2015).

Table 1. Selected food traceability definitions

| Sources | Traceability definition |
|---|---|
| ISO (2015) | Capability to trace the past record, location, and utilization of an object (anything perceivable or conceivable) |
| ISO (2007) | Capability to trace the progress of food processing in a specified phase of production |
| European Commission (2002) | Capability to trace and track food, food-producing animal or substance expected to be, or intended to be integrated into food at all stages of the entire production |
| Olsen & Borit (2013) | Capability to connect any information that is under review through recorded identification throughout the entire food processing life cycle |
| Bosona & Gebresenbet (2013) | Capture, keep and convey sufficient information on food, food-producing animal or substance at all stages of the entire production, traced and tracked both upstream and downstream for food safety and quality at any time |

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Full cooperation from every member in the food supply chain system is imperative to ensure that food safety is managed in the utmost effective and efficient way (Opara & Mazaud, 2001). In current practices, traceability and technologies work side by side to ensure that the food information can be transferred accurately, and it must be accessible to validate the food safety as well as food quality at every phase in the supply chain.

Table 2. Selected literature concerning traceability

| Dimension | General role | Sources |
|---|---|---|
| Food Supply Chain | To assure safety and quality | Tan, Gligor and Ngah (2020); Ling and Wahab (2020); Haleem, Khan and Khan (2019); Sun and Wang (2019); Pant, Prakash and Farooquie (2015); Dabbene, Gay and Tortia (2014); Aung and Chang (2014); Olsen and Borit (2013); Bosona and Gebresenbet (2013) |

### *2.4 Technology*

The extensive use of technology in food safety is undoubted. Firms across the food supply chain apply technology to monitor, track, trace and identify information (Wahab et al., 2018). The growth and utilization of technology particularly in the use of blockchain technology (BT), big data analytics (BDA), internet of things (IoT), near-field communication (NFC), radio-frequency identification (RFID), intelligent packaging, DNA barcoding, isotope analysis, chemometrics, and physiochemical and biological techniques (Tan, Gligor & Ngah, 2020; Wahab, Loo & Say, 2020; Ben-Daya et al., 2020; Han et al., 2017; Kumari et al., 2017; Sohail, Sun & Zhu, 2018; Meng et al., 2019; Ahmed et al., 2018; Melucci et al., 2016), presents a superlative opportunity for the food supply chain.

Galvez, Mejuto & Gandara, (2018) argued that BT could provide higher efficiencies, better customer relations, consolidation, and asset management. Likewise, with the advance of BDA, firms could integrate different sources of information, and support for better decision-making towards improving food safety and quality (Marvin et al., 2017). Additionally, with the IoT applications, firms could further safeguard food supply chain safety (Liu et al., 2016) including enhancing quality, transparency, safety, track and trace the entire food supply process. Moreover, in a study on the technology application in the food supply chain safety, Ling and Wahab (2020) find that technology has been identified as an enabler to facilitate the transparency of the information transfer between parties across the supply chain. It includes both the hardware and software. RFID is used in the food supply chain to identify product details without any physical contact that allow the development of better reliability and efficiency of food traceability (Barge et al., 2014; Badia- Melis et al., 2015). On the other hand, the extension of RFID is known as NFC. NFC with a small size technology that allows two-way communications among devices, and it can be custom-fit inside the food products. It allows stakeholders to access a complete history of the products that are purchased (Wan et al., 2019). Additionally, there are also innovations in food packaging known as intelligent packaging to intensify the traceability of food products. It allows stakeholders to closely monitor the potential issues of food products including contamination and damage (Fang et al., 2017).

Given that food safety is vital, Baroni et al. (2015), Luo et al. (2015), and Dutra et al. (2011) in their study identified that the utilization of isotope analysis is capable of tracking and tracing the origin of food products and identifying and distinguishing the various food products origin. Besides, DNA barcoding is an alternative technology that could enhance the traceability of food products (Hellberg et al. (2017); Carvalho et al. (2015); Khaksar et al. (2015). The food supply chain also experiences the use of technological advancements such as physicochemical and biological techniques. It is useful to heighten the

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food supply chain traceability (Badia-Melis et al., 2015). Furthermore, the food supply chain also experiences statistical and mathematical application which is the use of chemometrics approach to enhance the food product traceability (Versari et al., 2014 & González-Martín et al., 2014). Hence, the food supply chain is essential to leverage the thriving utilisation of technology through a proper technology adoption investment analysis. Table 3 summarizes the selected technology used to enhance food supply chain safety.

Table 3. Selected technology implementation to enhance food supply chain safety

| Technology | Implementations | Sources |
|---|---|---|
| Blockchain Technology (BT) | Decentralized supply chain traceability system for data access and transfer | Tan, Gligor and Ngah (2020); Wahab, Loo and Say, 2020; Galvez, Mejuto and Gandara (2018); Tian (2017) |
| Big Data Analytics (BDA) | Data integration from different sources and support for decision-making in food safety | Han et al. (2017); Marvin et al. (2017) |
| Internet of Things (IoT) | Enhance quality, transparent, safety, track and trace the entire food supply processes | Ben-Daya et al. (2020); Liu et al (2016); Verdouw et al (2016) |
| RFID | Traceability of the entire supply chain which includes dairy products, wheat flour, etc. | Kumari et al. (2017); Barge et al., (2014); Feng et al. (2013); Qian et al. (2012) |
| Near-field communication (NFC) | Checking a complete history of products and providing clear communications among stakeholders | Wan et al. (2019); Nychas, Panagou and Mohareb (2016); Mainetti et al. (2013) |
| Intelligent packaging | Monitoring external environment impact on food processing | Sohail, Sun and Zhu (2018); Fang et al. (2017); Matindoust et al. (2016) |
| Isotope analysis | Determination of the geographical origin | Meng et al. (2019); Luo et al. (2015); Baroni et al. (2015); Dutra et al. (2011); Horacek & Min (2010) |
| DNA barcoding | Traceability of poultry species and seafood in food products | Ahmed et al. (2018); Hellberg et al. (2017); Carvalho et al. (2015); Khaksar et al. (2015) |
| Physiochemical and biological techniques | Identifying the presence of food genes for plant or animal | Aung & Chang (2014) |
| Chemometrics | Traceability of wheat grain, wine, olive oil, etc | Melucci et al. (2016); Versari et al (2014); González-Martín et al. (2014) |

### *2.5 Skilled human capital*

According to Rajendran and Kamarulzaman (2018), the firm owner sets an example for smaller businesses and has a substantial impact on food safety standards in the food production industry. However, several earlier studies by Zain et al. (2012); Talib, Ali and Idris (2013); Saleh and Ndubisi (2006) have identified a shortage of qualified human resources as one of the primary restrictions faced by small, medium and enterprises (SMEs) in the food industry. New et al. (2017) also claimed that the availability of human resource expertise in food safety in Malaysia is still on average. Past works of literature typically found that there is a shortage of professional and qualified workers as well as a lack of knowledge. Manpower such as food inspectors, researchers, and laboratory assistants are very important to monitor, inspect and investigate the food safety system. These experts should have a strong scientific and technical expertise-based qualification to maintain and ensure the food safety system in the food manufacturing industry. Due to the limited experience manpower and cost of providing technical training, the food manufacturing industry particularly the SMEs are facing human resource issues. Generally, the inexperience is particularly noticeable among the workers in technology utilization and ICT, involvement in research and development activities, management expertise, technical knowledge, and entrepreneurial skills (Zain et al., 2012).

In the meantime, the Global Food Safety Initiative (2018) reported findings from the World Health Organization that eating processed food or food cooked by others sickens around one in ten people. The

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activities from farm to food served on our table rely solely on every player in the food supply chain to make the right choices in order to safeguard the hygiene and quality of the food. Such decisions are heavily impacted by the practices of each firm along the chain, either allowing or disrupting food safety decisions and practices. However, food safety is not the "one size fits all" strategy. Food safety aims to educate, inform, and raise awareness among all new and existing employees of safe practices so that they take ownership of their role in ensuring the production, processing, and distribution are complied with the safety and quality regulations (Ling & Wahab, 2020). For that, every member and department across the organization should have a clear understanding of the company's food safety regulations and procedures. For example, the responsibility of a purchasing department may be different from a maintenance team. The purchasing department is responsible for selecting suppliers that are economically viable and meet the company's food safety requirements, not one or the other. In the meantime, the maintenance leader should look at the condition of the equipment to maximize uptime and food safety performance (Zain et al., 2012). Thus, a skilful and knowledgeable human capital is necessary to understand the essential role of everyone in maintaining the food safety of the entire organization as well as to foster a culture of food safety.


Fig 2. Food supply chain safety controls conceptual model.
Source: Authors original

The proposed conceptual model in this study mainly emphasises the mechanisms for food safety controls that correlate with the organization, structure, and practices of the entire supply chain as suggested from the literature. In the era of globalization of FSCM, strategic decision-making is critical as the visibility of the whole chain could be improved by a holistic effort from an efficient system. In this proposed conceptual model, end consumers are able to obtain the optimal safety and quality as well as hygienic and healthy food products. Regulation and legislation, traceability and trackability, technology, and skilled human capital

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are recognized as the important medium to enhance food safety controls across the supply chain. The food safety controls conceptual model is shown in Figure 2.

## 3. Methodology

This study adopted a systematic literature review by utilizing a qualitative content analysis and thematic analysis in establishing the preliminary understanding of the motivation behind the FSCSC. Accordingly, this study scrutinizes the appropriate literature on food safety, food quality, and food safety control measures to systematically assimilate the possible mechanisms driving FSCSC. Sources involved in identifying the related literature were (1) Google Scholar, (2) Scopus, (3) Science Direct, (4) Springer Nature, (5) IEEE Xplore, (6) MDPI, and (7) Emerald Insight due to their acceptable publication standard for varies disciplines. and highlighted important items that should be reported in this kind of systematic reviews paper. Besides information sources selection, the search strategy is also considered crucial in the identification process. The literature considered in the review was based on several criteria, such as types of publication, language used, and publication timeline. The search was limited to peer-reviewed journal articles published in English. This study methodology aligns with the approach highlighted by Fabbe-Costes and Jahre (2008), whereby the literature review offered a thorough understanding, particularly on the logistics-related topic. Due to the lack of previous studies, this study predetermined the feasible mechanisms towards food safety controls. The promising mechanisms for food safety control derived from various related food safety and control articles to articulately depicts mechanisms affecting food safety controls. The authors also compared the findings from past food safety, food quality and FSCM literature to evaluate whether the predetermined mechanisms are valid and logical.

## 4. Conclusion and implications

This study deliberates and determines various food safety controls across the food supply chain industry. The discoveries from the study have vital implications for research and practice as the proposed food safety controls conceptual model provides a distinctive contribution to a variety of decision-making situations in safeguarding food safety among the businesses' operations and enhanced consumers' confidence. This study highlighted those substantial regulations and legislations, traceability and trackability, rampant use of technology, and skilled human capital are the dominant aspects that influence the effectiveness of food safety controls. It is hoped that this study is able to provide an understanding of food safety across the supply chain management in the food industry. This study emphasized that investigating food safety controls might discover unique insights into the potentials and concerns of the food industry. The findings from this study might be beneficial for practitioners in formulating future strategic undertakings.

### *4.5 Research implications*

Food industries will play a significant role in driving the food supply chain towards safety and quality. Coordination with various stakeholders is capable of leading to a win-win situation in which sizable companies would benefit economically and, in exchange, food supply chain members including SMEs could also benefit. The upstream and downstream players may integrate the advancement of IT along with the food chain members. Lastly, the engagement of government agencies may lead and promote integrity in the food supply chain. Thus, blockchain and IoT is extremely important for these food industries practitioners, government bodies and consumers to figure out up-to-date statistics report, the existing standing of a food supply chain, and practitioners' suggestions and complaints. To conclude, each individual end-user could be beneficial from future implementation.

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### *4.6 Limitation and future recommendations*

Due to this study being one of a few research focusing on food supply chain safety controls in Malaysia, one of the limitations in this study is the extremely subjective mechanisms findings. The author's emphasised mechanisms are based on a thorough literature review and industry observation. A field study should be conducted in the future to obtain empirical evidence to support the suggested model. The precise mechanisms described in this study may benefit future research, notably in food safety and security. Furthermore, because the food market is always evolving, the findings of this study should be seen as a guideline, as the highlighted mechanisms may alter in the future.

Moreover, the literature indicates that more research in the field of food studies in Malaysia should be performed (Ling and Wahab, 2020; Rajendran & Kamarulzaman, 2018; Ng, Chin & Ahmad, 2017). Future research should therefore concentrate on more systematic and comprehensive empirical studies. More research is needed to fully comprehend and identify other relevant or hidden food safety control mechanisms in Malaysia. Future research should also include further investigation and an in-depth evaluation. Hence, future empirical research should involve panel interviews in order to gain more comprehensive insights into the overall awareness of food safety procedures.

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**Conflicts of interest statement**

The authors declare no conflict of interest.

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**Author's contributions**

Siti Norida Wahab and Salini Devi Rajendran carried out the research, wrote and revised the original article. Eric Kaiyue Ling performed a literature review search and developed the theoretical framework. Aroop Mukherjee carried out the final review and editing prior to submission.