International Journal of Engineering & Technology, 7 (2.14) (2018) 229-233

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research Paper

Food Safety Risk Analysis of Food Supply Chain in Small and Medium Enterprises (Case Study: Supply Chain of Fish)

Hana Catur Wahyuni[1]*, Wiwik Sumarmi[1], Ida Agustini Saidi[2]

[1]*Industrial Engineering Department, Universitas Muhammadiyah Sidoarjo, Sidoarjo, Indonesia*
[2]*Agricultural Department, Universitas Muhammadiyah Sidoarjo, Sidoarjo, Indonesia*
**Corresponding author E-mail: hanacw@umsida.ac.id*

Abstract

Food safety is an important element for human health. This study aims to identify risk and risk priority in the food supply chain. The case study used is a supply chain of fish crackers in SMEs. Data collection is done through observation and interview. Data processing is performed by calculating the likelyhood (L) and Impact (I) values. The results showed there were 6 actors in the supply chain of fish crackers, and 14 types of risk event. Based on the value of risk score known that the production environment and production equipment is the risk event that has the highest score. Therefore, production environment and production equipment is a priority risk that requires mitigation measures.

Keywords: *food safety,food supply chain, SMEs, risk score*

1. Introduction

Supply chain management (SCM) is one of the concepts that small and medium enterprises (SMEs) can use to improve product quality [1]–[7]. Therefore, SMEs must be able to integrate various activities in the supply chain such as manufacturer, supplier and costumer [8]. Moreover, implementation of supply chain management in SMEs has a positive effect on operational capability, especially in increasing the value of the SMEs [9]. In addition, SCM on SMEs is useful for shortening delivery times, ensuring timeliness, saving costs and minimizing risk [10]–[14]. This SCM can use to make decision for management. There are many of method of decision support e.g. Fuzzy, SAW, TOPSIS, and others [15]–[20].

One of the SMEs that is important for the growth of the country is food. Food SMEs are important because they have a significant impact on world economic growth and have complex supply chain structures [21]. The effect is shown through contribution to GDP that reached 4.4% in Europe, 25% of GNP in Greece [22]. In Indonesia, there was a growth in food SMEs, reaching 9.23% in 2017, 8.46% in 2016. While contribution to non-oil GDP reached 34.33%.

Nevertheless, food-borne disadvantages are common in many countries. There are 351,000 deaths caused by 22 diseases sourced from bacteria contaminated food since 2010 [23], 295 incidents of fruit and vegetables, meat and processed products, cereals and processed products in Beijing, China [24]. In Indonesia, BPOM in 2011, 2012 and 2013 stated that food poisoning is dominated by food produced by home industry (39%), catering industry (20%), food industry (21%) and processed food industry (13%). As for food poisoning is dominated by microbiological agents (46%) and chemical agents (18%). The phenomenon shows that food security has an important role for human health.

Therefore, risk analysis is needed to avoid contamination of food. Risk analysis in food supply chains is an important issue, as SMEs are often unaware of the risks until those risks arise and become a problem for the company, which requires a lot of resources to solve them, whereas risk identification from the start in supply chain management is able to increase the market share of SMEs [25]. However, there are limitations to current risk analysis methods, most of which are discussion of specific risk analysis on food safety from chemical hazards or toxic substances in the production process. There are not many studies discussing risk analysis in the supply chain context [26][27]. Most research on food risk analysis in the supply chain has not been discussed about food safety, for example in agro-industry, and fresh meat [28]–[30].

Given these limitations, further discussion of food safety risk analysis on food supply chain is needed. Because, safe and healthy food is a global and strategic issue that can improve the competitiveness of export products. Therefore, food needs to be properly addressed by recognizing the various risks contained in the food supply chain system of SMEs. This study aims to identify risk and risk priority in the food supply Chain.

2. Literature Review

A. Food supply chain

The food supply chain is the whole process, from raw materials to the food consumed, and the inclusion of many actors. Food supply chains have different characteristics than other supply chains. This is caused by food perishable product so the requirement for temperature and humidity environment in logistic process very rigorous [31]. Supply chains for fresh food types, involving many agents to deliver products from farmers to end-consumers, so policy is needed to obtain an economical supply chain, because the relationship between agents in the chain will affect the price.

Copyright © 2018 Authors. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

The structure of the supply chain differs based on the type of food [32] or its marketing area [33]. To simplify the structure, food supply chains can be classified based on the number of operators involved, distance, production and cultural background (socio-cultural) [34]. In its implementation, the success of the process in the food supply chain depends on environmentally friend operations, specificity of territorial brands, direct and ethical relationships between producers and consumers, organic production, food safety and traceability, cultural heritage, consumer's health, origin identification of products, local work , cooperation, and pride [34].

B. Food safety

Food safety is a necessary condition and effort to prevent food from possible biological, chemical and other contamination which may disturb, harm and endanger human health (Law No. 7 of 1996 on Food). Food safety is the basic right of all consumers, therefore the Government controls and regulates it specifically through the establishment of different laws, regulations and standards between countries, depending on the level of income and technological development [35].

Therefore, in an effort to improve local food safety, producers producing local food products need to pay attention or develop good practices in handling and processing local food products. Each food safety institution in each country has the legality and standard of food safety in accordance with the internal conditions of the country. Currently, the issue of food safety is a major concern because of the development of science that can increase consumer awareness to consume safe food [36]. Essentially, food safety in the supply chain has a focus on avoiding the product from the risk of chemical, physical and biological contamination. For example, on fresh products (fruits and vegetables) the food safety system is focused on the risk of chemical and microbiological contamination along the supply chain. The risk is avoided by implementing some food safety standards, at each stage of the supply chain [37].

C. Risk Analysis

Risk Analysis (RA) is one of the processes in supply chain risk management (SCRM) that aims to identify, assess and evaluate risks that may arise and affect the supply chain [38]. In addition, RA can be used to estimate human health and safety, take risk measurements, and communicate with steaksholders the risks and outcomes [39]. Risk analysis is a scientific process to address risks for risk assessment, especially to determine food safety policies, guidelines and other recommendations to improve consumer protection [40].

In food safety, risk analysis can provide a domino effect on the supply chain, increasing the cost of mitigation [41]. Some sources of risk that are not managed properly result in risks that are negative impacts on food products, such as contaminated Salmonella ssp, S.aureus, E Coli, Shigella spp, Fecal coliform [42]. Due to its unique characteristics, agricultural food products are highly vulnerable to risks, especially those from antibiotics resistance, weather related risks and natural disasters, policy and institutional risks, and unethical issues [43][44].

3. Methodology Research

The research object is a supply chain for fish products produced by SMEs. Specifically selected fish products are fish crackers. The research was conducted in East Java, Indonesia. Data collection is conducted through observation and interviews with SMEs entrepreneurs.

The study was conducted through three stages: risk identification, risk measurement and risk prioritization. The process business used in the supply chain refers to the SCOR (Supply chain operation Reference) concept with the following research framework [45].

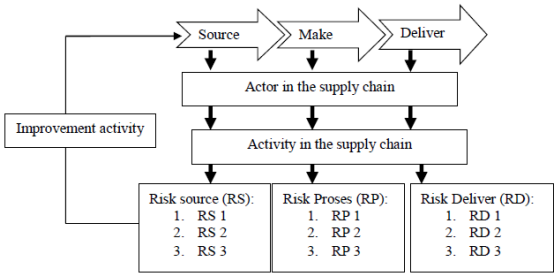


Fig.1: Research framework [45]

a. Identify risk event
   At this stage will be identification of various types of risk event in the supply chain of fish crackers. Identify the type of event ricks performed for each stage of the business process (source, make, deliver).
b. Risk measurement
   This stage is done to know the impact of risk event. Measurements begin with assessing likelihood (L) and, impact (I). Assessment is done by experts who know the food safety system on the supply chain of fish crackers, with a scale of 1-10.
c. Determination risk score (RS)
   The RPV shows the value of the impact of the risk event. RPV is obtained by the equation:

$$RS = IxL$$

Furthermore, RPV ranking will be conducted to determine the priority of risk. RPV can be used by decision makers to establish strategic steps of risk elimination

4. Results

Fish crackers are crackers with the main raw material of fish. The composition of fish crackers is fish and flour.



Fig.2: Fish (raw material)



Fig.3: Crackers manufacturer in SMEs



Fig.4: Fish crackers (product)

The result of observation and interview shows that the model of fish cracker supply chain is as follows:

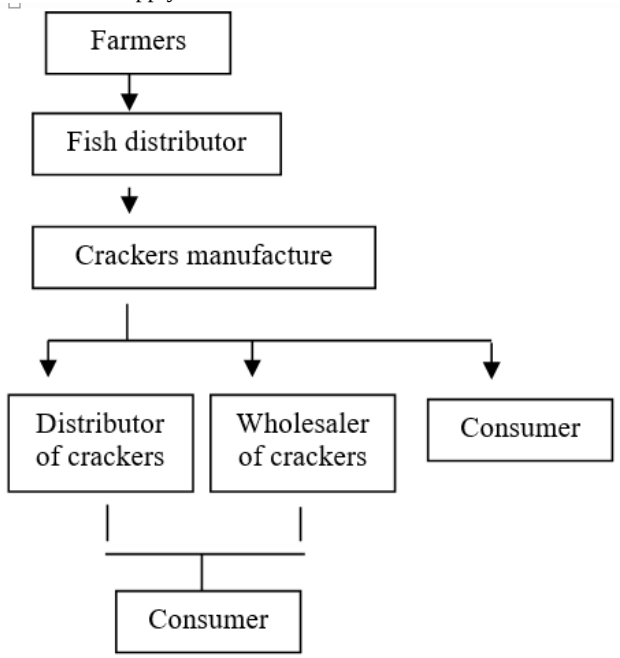


Fig.5: Supply chain of crackers

Figure 2 shows the raw materials used for the manufacture of fish crackers. The raw materials come from ponds originating in the area of SMEs. Figure 3 shows the process of making crackers in SMEs (production chamber and cracker drying). In this study, SMEs that were used as research objects were SMEs that had 1-5 workforce. Figure 4 is a cracker produced by SMEs. Packaging fish krupuk done with a certain size, for example ½ kg, 1 kg etc.

The supply chain of fish crackers in SMEs is shown in figure 5. Based on the figure, there are five actors in the supply chain of fish crackers: farmer, fish distributor, manufacture, distributor of crackers, wholesaler of crackers and consumer. In this case study, it appears that consumers have a special behavior that can buy goods from SMEs or through distributors / wholesalers.

Table.1: Risk Identification

Process Business	Actors	Activity	Risk event
Source	Farmers	Breeding fish as raw material of crackers	1. Fish food (R1) 2. Pond environment (R2) 3. The process of harvesting fish (R3)
	Fish distributor	Distributing fish from farmers to SMEs	4. The type of vehicle used (R4). 5. Fish packaging system (R5).
Make	Crackers manufacture	The production process of crackers	6. The production environment (R6). 7. Production equipment (R7). 8. Additional raw materials (R8) 9. Packaging system of crackers (R9)
Deliver	Distributor of cracker	Market the crackers	10. Type of vehicle for delivery of crackers (R10).
	Wholesaler of crackers		11. Product storage system (R11) 12. Product display environment (R12).
	Consumer	Buyers of crackers	13. Method of frying crackers (R13) 14. Method of serving crackers (R14)

Table 1 is the result of the identification of food safety risk on the supply chain of fish crackers. The results showed there were 14 types of identified food safety risks. Furthermore, risk assessments based on the value of likehood (L) and Impact (I).

Table.2: Risk Measurement

Risk Identification	Likelihood (L)	Impact (I)	Risk Score
R1	5	7	21
R2	7	7	49
R3	2	3	5
R4	7	6	42
R5	8	7	56
R6	8	8	64
R7	8	8	64
R8	4	5	20
R9	3	4	12
R10	3	3	9
R11	3	2	6
R12	2	2	4
R13	5	6	30
R14	3	2	6



Fig.6: Risk score

Table 2 is the result of assessment of likehood and implact given by experts. Likehood represents an opportunity for risk. Impact shows the magnitude of the impact of these risks. The value of likehood and implact are used as the basis for determining risk scores.

Figure 6 is the calculation result for each identified risk event type. Based on figure 5 can be known score for each type of risk event. The score value at each risk event shows the amount of risk. That is, the greater the value of risk scores, the greater the chances of risk and the impact caused.

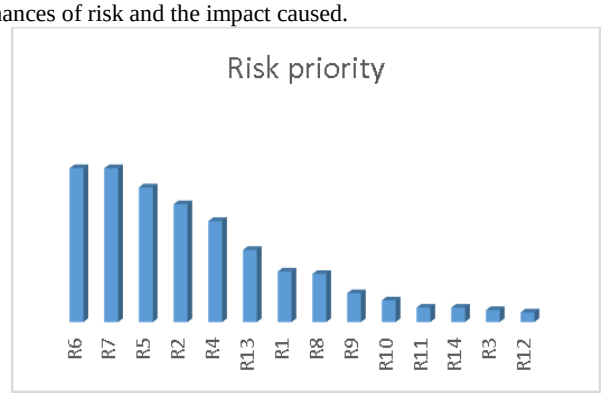


Fig.7: Priority risk

Based on the risk scores of each identified risk event, risk prioritization is prepared (Figure 6). Priority risk indicates the type of risk that requires immediate and appropriate mitigation measures. The calculation results show that the risk event that requires correct mitigation action is R6 and R7.

5. Discussion

In the context of food safety on the supply chain fish crackers there are 14 types of risk events that need attention. The highest risk event is the production environment (R6) and production equipment (R7). Therefore, SMEs actors need to pay attention to environmental factors and equipment. Therefore, to reduce the risks posed, it is necessary to immediately provide information to SMEs perpetrators about environmental management and maintenance of food production equipment.

If the risk event is not immediately anticipated, the meal will be feared when disease happen caused by food (crackers). Vitalis[46] States that food-borne diseases are an emergency condition that affects the quality of human life, and affects economically, because it encourages financing in terms of health and absenteeism at work or school.

6. Conclusion

Implementation of food safety system has an important role in keeping food safe for consumer consumption. This must be realized by SMEs actors, because now consumers increasingly concerned about food safety. Food safety systems in the food supply chain must be considered in all aspects of the business process, from sources (raw materials), processes, transportation and distribution systems. Every stage of the business process in the food supply chain has different types of risks and impacts on food safety.

This study shows that there are six actors in fish chips cracker system, namely: farmers, fish distributor, crackers manufacture, distributor of cracker, wholesaler of saler and consumen. Every stage in the business process of fish krupuk supply chain has a different risk event. Overall there are 14 risk events in the supply chain of fish crackers in SMEs. Each risk event has a different risk score according to the expectedness and impact value. In this research, the highest risk score is shown in risk event production environment and production equipment. Furthermore, SMEs actors need to pay attention to managing the environment and maintaining the production equipment so as not to have a negative impact on food safety.

This study is limited to risk assessment on food safety in fish supply chips. In this research has not been discussed about the preparation of mitigation strategies to avoid risk. Therefore, subsequent research is expected to be directed at the selection of mitigation strategies with various methods, eg with analytical hierarchy process (AHP), monte carlo, optimization etc.

Acknowledgement

In particular, we would like to thank Kemenristek Dikti who has provided research financing facility in 2018.

References

[1] J. Suyono, A. Sukoco, M. I. Setiawan, S. Suhermin, and R. Rahim, "Impact of GDP Information Technology in Developing of Regional Central Business (Case 50 Airports IT City Development in Indonesia)," in *Journal of Physics: Conference Series*, 2017, vol. 930, no. 1.

[2] M. Setiawan *et al.*, "E-Business, Airport Development and Its Impact on the Increasing of Information of Communication Development in Indonesia," *J. Phys. Conf. Ser.*, vol. 1007, no. 1, p. 012046, Apr. 2018.

[3] D. Napitupulu, M. Syafrullah, R. Rahim, D. Abdullah, and M. Setiawan, "Analysis of user readiness toward ICT usage at small medium enterprise in south tangerang," *J. Phys. Conf. Ser.*, vol. 1007, no. 1, p. 012042, Apr. 2018.

[4] M. Setiawan *et al.*, "E-Business, the impact of regional growth on the improvement of Information and Communication Development," *J. Phys. Conf. Ser.*, vol. 1007, no. 1, p. 012044, Apr. 2018.

[5] M. I. Setiawan *et al.*, "E-Business, The impact of the Regional Government Development (APBD) on Information and Communication Development in Indonesia," *J. Phys. Conf. Ser.*, vol. 1007, no. 1, p. 012045, Apr. 2018.

[6] S. Al Idrus, A. S. Ahmar, and Abdussakir, "Contribution of Organizational Learning and Market Orientation on Business Unit Performance Mediated by Job Satisfaction at Dairy Cattle Milk Cooperatives in East Java, Indonesia," *J. Rev. Glob. Econ.*, vol. 7, no. 1, 2018.

[7] S. Al Idrus, A. S. Ahmar, and A. Abdussakir, "The Effect of Organizational Learning on Market Orientation Moderated By Job Satisfaction," *Cogent Bus. Manag.*, vol. 5, no. 1, p. 1475048, 2018.

[8] M. M. Z.Lotfi, S. Sahran, "A product quality- supply chain integration framework." Journal of Applied Science, Vol 13, Iss 1, pp. 36–48, 2013.

[9] T. Ai, A. Bakar, A. Hamid, A. Raslic, and L. Hock, "The Impact of Supply Chain Integration on Operational Capability in Malaysian Manufacturers," *Procedia - Soc. Behav. Sci.*, vol. 130, pp. 257–265, 2014.

[10] J. Thakkar, A. Kanda, and S. G. Deshmukh, "Supply chain issues in SMEs : select insights from cases of Indian origin," *Prod. Plan. Control*, vol. 24, No. 1, pp. 47–71, 2013.

[11] U. Khair, H. Fahmi, S. Al Hakim, and R. Rahim, "Forecasting Error Calculation with Mean Absolute Deviation and Mean Absolute Percentage Error," *J. Phys. Conf. Ser.*, vol. 930, no. 1, p. 012002, Dec. 2017.

[12] A. S. Ahmar *et al.*, "Modeling Data Containing Outliers using ARIMA Additive Outlier (ARIMA-AO)," *J. Phys. Conf. Ser.*, vol. 954, no. 1, 2018.

[13] E. Sudarmaji and I. Nasip, "Service Innovation Capability That Spurs Internationalization in Indonesian SMEs," *ASIA Int. Multidiscip. Conf.*, 2017.

[14] S. Samad, "Organizational culture, strategic planning and performance: empirical evidence from organizations in Malaysia," *Int. J. Eng. Technol.*, vol. 7, no. 2.10, p. 62, Apr. 2018.

[15] I. Tahyudin, R. Rosyidi, A. S. Ahmar, and Haviluddin, "Comparison of the Simple Additive Weighting (SAW) with the Technique for Others Reference by Similarity to Ideal Solution (TOPSIS) methods," *Int. J. Eng. Technol.*, vol. 7, no. 2.2, pp. 87–89, 2018.

[16] N. Kurniasih, A. S. Ahmar, D. R. Hidayat, H. Agustin, and E. Rizal, "Forecasting Infant Mortality Rate for China: A Comparison Between α-Sutte Indicator, ARIMA, and Holt-Winters," *J. Phys. Conf. Ser.*, vol. 1028, no. 1, p. 012195, 2018.

[17] A. S. Ahmar, A. Rahman, A. N. M. Arifin, and A. A. Ahmar, "Predicting movement of stock of 'Y' using sutte indicator," *Cogent Econ. Financ.*, vol. 5, no. 1, 2017.

[18] D. U. Sutiksno, A. S. Ahmar, N. Kurniasih, E. Susanto, and A. Leiwakabessy, "Forecasting Historical Data of Bitcoin using ARIMA and α-Sutte Indicator," *J. Phys. Conf. Ser.*, vol. 1028, no. 1, p. 012194, 2018.

[19] A. S. Ahmar, A. Rahman, and U. Mulbar, "α- Sutte Indicator: a new method for time series forecasting," *J. Phys. Conf. Ser.*, vol. 1040, no. 1, p. 012018, 2018.

[20] A. S. Ahmar, "A Comparison of α-Sutte Indicator and ARIMA Methods in Renewable Energy Forecasting in Indonesia," *Int. J. Eng. Technol.*, vol. 7, no. 1.6, pp. 20–22, 2018.

[21] A. Turi, G. Goncalves, and M. Mocan, "Challenges and competitiveness indicators for the sustainable development of the supply chain in food industry," *Procedia - Soc. Behav. Sci.*, vol. 124, pp. 133–141, 2014.

[22] M. Bourlakis, G. Maglaras, E. Aktas, D. Gallear, and C. Fotopoulos, "Int . J . Production Economics Firm size and sustainable performance in food supply chains : Insights from Greek SMEs," *Intern. J. Prod. Econ.*, pp. 1–19, 2014.

[23] L. Jespersen, M. Griffiths, T. Maclaurin, B. Chapman, and C. A. Wallace, "Measurement of Food Safety Culture using Survey and Maturity Profiling Tools," *Food Control*, 2016.

[24] Y. Liu, F. Liu, J. Zhang, and J. Gao, "Insights into the nature of food safety issues in Beijing through content analysis of an Internet database of food safety incidents in China," *Food Control*, vol. 51, pp. 206–211, 2015.

[25] A. Badea, G. Prostean, G. Goncalves, and H. Allaoui, "Assessing risk factors in collaborative supply chain with the analytic hierarchy process (AHP)," *Procedia - Soc. Behav. Sci.*, vol. 124, pp. 114–123, 2014.

[26] X. Wang, D. Li, and X. Shi, "A fuzzy enabled model for aggregative food safety risk assessment in food supply chains,"

pp. 2898–2903, 2013.
[27] A. S. Wahyuningsih, M. T. Multazam, A. B. D. Nandiyanto, A. G. Abdullah, and I. Widiaty, "Green Chemistry Principles: An Alternative Approach to Practice Laboratory Safety and Health," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 288, p. 012001, Jan. 2018.
[28] W. Song, X. Ming, and H. Liu, "Identifying critical risk factors of sustainable supply chain management: A rough strength-relation analysis method," *J. Clean. Prod.*, 2017.
[29] C. Rao, X. Xiao, M. Goh, J. Zheng, and J. Wen, "Compound Mechanism Design of Supplier Selection Based on Multi-attribute Auction and Risk Management of Supply Chain," *Comput. Ind. Eng.*, 2016.
[30] B. Barafort and A. Mesquida, "Author ' s Accepted Manuscript Integrating Risk Management in IT settings from ISO Standards and Management Systems Reference :," *Comput. Stand. Interfaces*, 2016.
[31] F. Tian, "An Agri-food Supply Chain Traceability System for China Based on RFID & Blocl < chain Technology," *13th Int. Conf. Serv. Syst. Serv. Magement*, 2016.
[32] P. Akhtar, M. Tse, Z. Khan, and R. Rao-nicholson, "Author ' s Accepted Manuscript," *Intern. J. Prod. Econ.*, 2015.
[33] I. M. Saidon, R. M. Radzi, and N. A. Ghani, "FOOD SUPPLY CHAIN INTEGRATION : LEARNING FROM THE SUPPLY CHAIN," *Int. J. Manag. Value Supply Chain.*, vol. 6, no. 4, pp. 1–15, 2015.
[34] M. A. Sellitto, L. Antonio, M. Vial, L. Antonio, and M. Vial, "Critical success factors in Short Food Supply Chains: Case studies with milk and dairy producers from Italy and Brazil," *J. Clean. Prod.*, vol. 107, pp. 1361–1368, 2018.
[35] R. Wongprawmas and M. Canavari, "Consumers ' willingness-to-pay for food safety labels in an emerging market : The case of fresh produce in Thailand," *Food Policy*, vol. 69, pp. 25–34, 2017.
[36] N. Smigic, A. Rajkovic, I. Djekic, and N. Tomic, "Legislation , standards and diagnostics as a backbone of food safety assurance in Serbia," *Br. Food J.*, vol. 117, no. 1, pp. 94–108, 2015.
[37] M. Uyttendaele, L. Jacxsens, S. Van Boxstael, K. Kirezieva, and P. Luning, *Food safety standards in the fresh produce supply chain : advantages and disadvantages*. Woodhead Publishing Limited.
[38] S. N. Musa, *Supply Chain Risk Management : Identification , Evaluation and Mitigation Techniques*, no. 1459. 2012.
[39] J. M. Soon, W. P. Davies, S. A. Chadd, and R. N. Baines, "Expert Systems with Applications A Delphi-based approach to developing and validating a farm food safety risk assessment tool by experts," *Expert Syst. Appl.*, vol. 39, no. 9, pp. 8325–8336, 2012.
[40] S. Liu, Z. Xie, W. Zhang, X. Cao, and X. Pei, "Risk assessment in Chinese food safety," *Food Control*, vol. 30, no. 1, pp. 162–167, 2013.
[41] V. G. Venkatesh, S. Rathi, and S. Patwa, "Journal of Retailing and Consumer Services Analysis on supply chain risks in Indian apparel retail chains and proposal of risk prioritization model using Interpretive structural modeling," vol. 26, pp. 153–155, 2015.
[42] R. N. K. R. . A. Shabbithi, L.S.G.D.N. Reddi, "Identifying Critical Risk Practices Among Street Food Handler," *Br. Food J.*, vol. 119, pp. 390–400, 2017.
[43] G. Zhao, S. Liu, and C. Lopez, "A Literature Review on Risk Sources and Resilience Factors in Agri-Food Supply Chains," pp. 739–752, 2017.
[44] P. A. Kusumawardani, S. Cholifah, M. T. Multazam, A. B. D. Nandiyanto, A. G. Abdullah, and I. Widiaty, "Effect of Ginger Drinks on Nausea Vomiting in The First Trimester of Pregnancy," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 288, p. 012161, Jan. 2018.
[45] U. C. H.C. Wahyuni, I. Vanany, "Identifying risk event in Indonesian fresh meat supply chain Identifying risk event in Indonesian fresh meat supply chain," *Mater. Sci. Eng.*, vol. 337, 2018.
[46] 1 Vitalis, R. E., M. A. R. and 1 Nor-Khaizura, and R. Son, "Actor network theory in food safety 1,2*," *Int. Food Reseacrh J.*, vol. 23, no. December, pp. 2319–2325, 2016.