Method and Approach Mapping for Agri-food Supply Chain Risk Management: A literature review

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***Abstract*— One of the agri-food characteristics is perishable product which made it has a higher chance damage risk from the farmer to the consumer. Therefore issues around food security and associated risks are extremely important. Identification of some methods or approaches in risk management are needed to help the process of decision making for handling supply chain risk in agri-food. The purpose of this research was to identify the development of methods or approaches used to identify and assess the risks that occurred in the agri-food supply chain. The articles search was undertaken through articles search on selected relevant journals of supply chain risk management for agri-food published from 2004 until 2015. A total of 79 randomly selected journal articles had been analyzed. These mapping were arranged in systematic stages, started from searches related supply chain risk management for agri-food. Furthermore, the articles identified and classified the methods or approaches for each stage of supply chain risk management, and were divided into three main stages: risk identification, risk assessment and risk mitigation. The last, the articles of risk identification were categorized into three groups: qualitative, semi-quantitative and qualytatively.The mapping results showed that risk assessment supply chain for agri-food was much related to microbiology risk assessment. It related to the characteristics of agri-food products. Standard models used for risk assessment in supply chain for agri-food were based on integration of statistical analysis and simulation. The other techniques used included intelligent technique, optimization models and multi-criteria decision analysis. The literature on supply chain risk management for agri-food is so vast, complex and difficult to understand, therefore this mapping of method and approach usefull for fastering and better understanding of the subject discussed to the research community.**

***Keywords*—** *supply chain risk, risk identification, risk assessment, risk mitigation, agri-food*

1. Introduction

Logistic and supply chain management play a crucial role in food supply chain [1]. Food supply chain defined by [2] as "Responsibility for the supply of safe, healthy and nutritious food is shared by all involved, from primary production to final preparation and consumption". Supply chain for agri-food has different characteristics with other supply chain [2]. One of the characteristics of the agri-food is perishable product [3], which has a higher chance for damage risk from the farmer to the consumer. Food quality and food safety are important issues in food supply chain. A "holistic food chain approach" will recognize that responsibility for the safe supply and nutritious food lies with all those involved in food .

The diseases caused by food occur most frequently because of consumption food that has been contaminated with microbiological or chemical hazards [4]. Therefore, FAO considers that risk in the food supply chain is extremely important. FAO was arranged guidelines for risk categorization of food and food establishments for enhanching food safety by strengthening food inspection systems in ASEAN countries in 2011/2022. Risk could not be eliminated completely but can be mitigated through a proactive approach. Risks need to be identified before the incident occurred. Several studies have been conducted, showing the diversity of methods or approaches in identifying and assessing risks in the food supply chain.

Some reviews of articles associated with the food supply chain include [5], [6], [7], [8] and [9]. The development of RFID technology in the agri-food sector has been analyzed [5]. An assessment of the state of the art food

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supply chain planning models from the different components [6]. Development of hierarchical decision making framework and critical taxonomy from agri-food supply chain [7]. The risk assessment of Campylobacter result in broiler meat has been analyzed [8]. Food transportation system model with notices the temperature parameter, bacterial growth and others in the food transport [9]. Those articles were not discussed deeply in the use of methods or approaches that can be used to identify and assess risks. While issues around food security and associated risks are extremely important. The selection of appropriate methods and approaches will lead to the correct risk management decisions.

The purpose of this paper is to identify the development of methods or approaches used in identifying and assessing the risks that occur in the agri-food supply chain. Mapping method and approach in this paper is specific on agri-food supply chain due to a deep discussion on the use of methods or approaches of risk management at every stage of agri-food supply chain. There are several methods or approaches which measure the use of specific risks that occur in the agri-food supply chain, according to their characteristics products that is perishable, such as the risk of microbiological growth in the food delivery chain from farmers to consumers.

In this paper, we mapped some methods or approaches to manage supply chain risk agri-food. These mapping were arranged in systematic stages, started from identified and classified the methods or approaches for each stage of supply chain risk management, and were divided into three main stages: risk identification, risk assessment and risk mitigation. The literature on supply chain risk management for agri-food is so vast, complex and difficult to understand that a mapping of method and approach is needed and much value for the research community. We hope this mapping can provide an initial information to use methods or approaches risk management supply chain for agri-food.

2. Definition of supply chain risk management for agri-food

Food industries are transforming towards interconnected global network. Food supply chain has unique characteristics compared to other types of supply chain. First, food supply chain tends to be relatively longer and influenced by complex factors. Second, the time of production, storage and transportation need strict supervision. Third, the food supply chain has relatively strong commonality and sociality [3].

Classification of food product in the following seven categories: (1) Horticultural product (fruit general, pineapple, tomato, fresh cut salads, flowers general, grape wine, rose); (2) Meat product (meat general, beef, pig); (3) Dairy product (general, cheese, milk); (4) Fishery product (seafood in general, fish, lobster, smoked seafood); (5) Bakery product (bakery in general, bread); (6) Beverages (beverage in general, beer, wine); and (7) Other food (egg, sushi, pasta, coffee, milk, olive oil) [5]. While [6], explained that agri-food supply chain grouped into two categories, i.e: the supply chain of fresh agri-foods and the supply chain for non-perishable agri-food.
Food safety and food quality receive high attention from the public, as the risks in the food supply chain [10]. Assessment should be integrated with food supply chain among risk assessment, food quality and safety management, traceability and sustainability. The main interest of the food supply chain is to provide high quality food, safety guarantees and transparency.

The principles of supply chain collaboration were applied. There are two pillars that was built in this framework that (1) designing and governing supply chain activities, and (2) establishing and maintaining SC relationships [3]. A model framework for risk assessment and risk management capabilities in the agricultural supply chain in developing countries was conducted. The main risks assessed are included weather-related risks, natural disasters, biological and environmental risks, market-related risks, logistical and infrastructural risk, management and operational risks, public policy and institutional risks and order of risk magnitudes [11].

Logistics and supply chain play crucial roles in the food industry, which involves multi-disciplinary and multiple viewpoints [12]. Framework for assessment food supply chain (FSC) and logistics developed by integrating four main elements: quality, safety, sustainability and logistic efficiency. The other thing that must be considered in the agri-food supply chain is a problem in transportation [1]. Development of a model of food transport system, with the aim to ensure the safety and quality of food by maintaining the temperature of food during the trip. The main purpose of controlling the temperature in the food supply chain is to reduce the rate of microbial growth in food [9]. Food supply chain and risk is defined as the possibility of breakdown, operational difficulties, credit lossand economic loss due to various uncertain factors during the operation process of each and every nodal enterprise along food supply chain [3]

3. Methodology

3.1 The inclusion criteria

There are four inclusion criterias used in selecting the articles that will be reviewed:

1. The articles search was undertaken through the keywords such as "supply chain risk management for agri-food", "risk identification for agri-food", "risk assessment for agri-food", "risk mitigation for agri-food", "food product" and "food industry".
2. Focus on three distribution stages of risk management i.e. the risk identification, risk assessment and risk mitigation.
3. Focus on methods or approaches have been used in agri-food supply chain risk management.
4. Mapping methods and approaches in risk identification stage are categorized into three groups : qualitative, semi-quantitatives and quantitatives.

The mapping to cover or discuss supply chain risk management for agrifood is very wide and complex. These constraints are needed to make it easier in the selection and limitation the scope of method and approach mapping.

3.2 Search process and studies selection

The paper materials was traced by using a few keywords such as “supply chain“, “risk management”, “risk assessment”, “agri-food”, “risk identification”, “food industry”, and “food supply chain”. They were traced using the publisher websites: Springerlink, Willey Interscience, Elsevier Science Direct, and Emerald Insight**.**

1. Groupings are conducted to see the mapping of supply chain risk management research in agri-food in several articles.
2. Classifying journals based on the main stages in management, which were divided into three main stages: risk identification, risk assessment and risk mitigation.
3. Mapping the use of methods and approaches based on the stage of supply chain risk management
4. Methods and approaches used in the identification phase of risk applied in three groups: qualitative, semi-quantitative and quantitative.
5. Mapping of methods and approaches to risk assessment stage adapted to the selected articles.

The group of qualitative methods and approaches are defined as methods or approaches that are not through statistical procedures or other forms of matter. Some common methods include focus groups (group discussions), individual interviews, and participation/ observations. Quantitative methods are being classified as a method of measured variables relationships, with research data in the form of figures and analysis using statistical analysis, mathematical and numerical analysis. Between these two extremes is semi-quantitative analysis, which assigns approximate measurements to data, rather than an exact measurement. Often used in cases where a direct measurement is not possible, but inference is unacceptable, semi-quantitative analysis has many applications in both the natural and social sciences.

3.3 Analysis of selected studies

This section presents an overview of the literature survey. The total publications for each year is shown in Figure 1

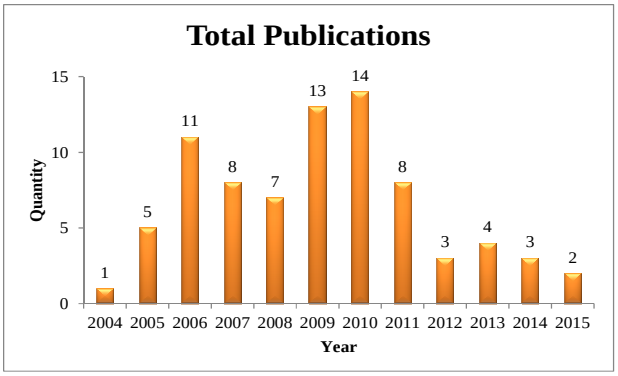

Figure 1. Total publications for each year (2005-2015)

Distribution of articles by journal title and journals impact factors can be seen in Table 1.

The articles were selected from Economic Journals, Management and Production Research Journals, Computer Science Journals, Supply Chain Management Journals, Environmental Management Journals, Agricultural Journals, Microbiology Disease Journals, Risk Management Journals, Dairy Science Journals, and others.

4. Result and Discussion

4.1 Journal grouping based on method used

The identification of methods or approaches in supply chain risk management for agri-food started with classifying the papers based on the stage of risk management. They were divided into three parts: risk identification, risk assessment and risk mitigation (Figure 2).

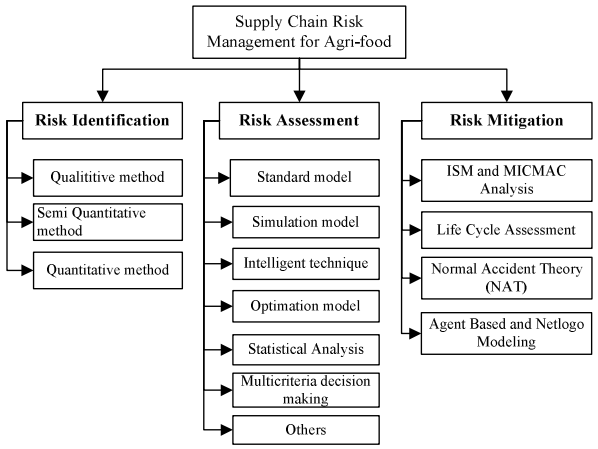

Figure 2. Journal grouping based on method used

Table 1. Distribution of articles by journal title and journals impact factors

Group	Journal Title	Articles
Management and Production Research	Journal of Management Research	[13]
	Journal of Production Research	[14], [15], [16], [17]
	Journal Operation Research	[6]
	Business Process Management	[18]
	Engineering and Technology	[19]
	IIB Management Review	[20],
Model and Computer Science	Computer in industry	[21]
	Fuzzy Sets and Systems	[22]
	Reliability Engineering and System Safety	[23]
	Journal of Theoretical and Applied Information Technology	[24],
	International Journal of Hybrid Information Technology	[25]
Supply Chain Management	Journal of Purchasing & Supply Management	[26]
	International Journal of Supply Chain Management	[27]
Environmental	Corporate Social Responsibility and Environmental Management	[28]
	Journal of Environmental Management	[29], [30]
	Springer Science+Business Media	[31]
Agricultural	Journal of Agricultural	[32]
	Agricultural System	[33], [34]
	Agricultural and Rural Development	[11]
	Journal of Agricultural and Resource Economics	[35]
Food	British food journal	[36]
	Food policy	[37]
	Journal of Food Engineering	[1]
	Food Bioprocess Technology	[5]
	Food Control	[38], [39], [40], [39], [41], [42]
	Food composition and Analysis	[2]
	Food Chemistry	[43]
	International Journal of Food Microbiology	[44], [8], [45], [46], [47], [48]
	Food Research International	[49]
	Food and Chemical Toxicology	[50], [51], [52], [53]
	Trends in Food Science & Technology	[54], [55]
	British Food Journal	[56]
	Meat Science	[57]
Microbiology, disease	Applied and Environmental Microbiology	[58], [59]
	Regulatory Toxicology and Pharmacology	[60]
	Emerging Infectious Diseases	[61], [62]
	American Journal of Industrial Medicine	[63]
Risk management	Risk Analysis	[64], [65], [66], [67]
Dairy	J Dairy Science	[68]
	Anim Health prod	[7]
Other aspects	AiChE journal -Chemical Engineering	[69]
	Appetite	[70]
	International of Refrigeration	[9]
	Biosystems engineering	[7]
IEE	Presented in International conference	[71], [3], [72], [10]
	Presented in International conference	[73]
	Presented in International conference	[74]

4.2 Risk Identification of supply chain for agri-food

Risk identification defined as "identifying the sources and nature of risk and the uncertainty associated with the activities or phenomena under consideration is often considered to be the first and major step in the risk assessment process" [75]. Table 2 below shows the results of grouping methods/approaches on risk identification stage in agri-food supply chain. They are categorized into three groups: qualitative, semi-quantitative and quantitative.

Table 2. Grouping method or approach in risk identification of supply chain risk for agri-food

Grouping method	Methods or approaches	Articles
Qualitative	Expert judgment, Expert Focus Group	[70], [38], [76]
Semi Quantitative	Comparative analysis	[37]
	Comprehensive checklist	[55]
	Analytical Hierarchy Process (AHP)	[36]
	Observation and questionare	[68], [13]
	Knowledge base modelling system	[49]
	Failure Mode Effect and Critically Analysis (FMECA)	[21]
	Failure Mode and Effect Analysis (FMEA)	[73]
	Hierarchy Risk Breakdown Structure (HRBS)	[73]
Quantitative	Statistical analysis : Hypothesis test, multiple logistic regression	[61], [63]
	Sampling error	[35]

Qualitative

A focus group discussion approach for identifying risks [70], [38] and [76]. The different types of consumers and experts have been paired in identifying the differences and similarities of perception of food risk management of key strategic stakeholders [70]. Group discussion followed by individual ranking in an expert study for identifying critical factors of emerging food safety risks in dynamic food production chain [38].

Semi Quantitative

Comparative analysis of production trend in Maldovan dairy sector to identify how asymmetric information between farmers and processors led to market failure [37]. The comprehensive checklist to diagnose microbial safety control activities in a food safety management system. The diagnostic instrument enabled a company to check its own FSMS system on presence of crucial safety control activities and to position themselves by assessing which levels activities are executed [55].

Criteria in a multi criteria decision making for determining the location of food industry manufacturing. The methodology chosen was AHP method, with three factors considered: regional potential factor, region risk factor, and industrial potential factor [36]. Risk factors campylobacteriosis in fresh chicken with multivariate analysis. Risk factors obtained from 3 analytical approaches for sporadic campylobacteriosis in Denmark [71].

Potential risks by means of observation and deployment questionnaire [68] and [13]. Risk factors for bacteriological quality of bulk tank milk in Price Edward Island dairy herd [68]. Questionnaires based on the various risk areas that meant for the dairy food supply chain. The data collected are analyzed with SPP 17 in order to draw inference out of it [13].

Knowledge base modelling system to identify problems and to offer solutions to monitor and prevent microbiology food safety risks during all phases of food production and supply [49]. Analytical Hierarchy Process (AHP) to identify risk factors for food supply chain [3].

Investigate risk factors on the supply chain network use Failure Mode Effect Critically Analysis (FMECA) technique [21]. Failure Mode and Effect Analysis (FMEA) to identify the risks that occur in the dairy supply chain industry. Risks identification started from farmers, cooperatives until the dairy processing industry [73].

Semi-quantitative method noticed qualitative and quantitative aspects when identifying risk possibility in supply chain Agri-food. Quantitative aspect obtained from the measurement result, while the qualitative aspect obtained from expert subjective assessment, such as identify about the causes and impacts of the risk.

Quantitative

The risks identified through inspection and quantitative measurements. Sampling and testing system of inspection to collect information about the safety and quality [61]. Multiple logistic regressions for identifying the risk factors for injury. Risks factors were examined at two outcome severity level: (1) any injury vs no injuries and (2) serious injury vs no injuries [63].

4.3 Risk assessment of supply chain for agri-food

Risk assessment proses as "a set of logical, systemic and well defined activities that provide the decision make with a sound identification, measurement, quantification and evaluation of the risk associated with certain natural phenomena or man activities" [75].

The result of searches using a method or approach in assessing supply chain risk agri-food from several journals grouped into seven categories: standard models used to assess the risk in the agri-food, simulation model, intelligent technique, optimization model, statistical analysis, multi criteria decision making and others. Mapping method or approach in each group is shown in Table 3.

Table 3. Grouping methods or approaches in assessment supply chain risk for agri-food

Group Method	Methods or Approaches	Articles
Standard models used to assess the risk in the agri-food	EMRISK Model	[77]
	FSO (Food Safety Objective)	[57]
	QRA (Quantitative Risk Assessment)	[40]
	QMRA (Quantitative Microbiological Risk Assessment)	[46], [66], [8], [58], [54]
	SAFE FOOD Model	[42], [41]
	FRAMp (A fram food safety-risk assment)	[43]
	NUSAP (Numeral Unit Spread Assessment Pedigree)	[64]
Simulation Model	Monte Carlo simulation	[48], [44], [60]
	Simulation model	[49], [40]
	PetriNet model based simulation	[21]
	Agent Based and Netlogo Modelling	[27]
Intelligent Technique	Fuzzy risk assessment tool	[22]
	Integrated Fuzzy Stochastic Risk Assessment (IFSRA)	[29]
	Fuzzy Analytical Hierarchy Process (AHP)	[3], [71]
	Genetic Algorithm, Particle swarm optimization, Artificial bee colony	[15]
	Fuzzy regression approach, Fuzzy utility optimization	[24]
	Fuzzy ANP and Fvikor method	[19]
	Fuzzy Inference System (FIS), Fuzzy Associative Memories (FAMs)	[73]
	Expert System, Neural Network	[74]
Optimization Model	Dynamic modelling, Epidemic model	[67]
	Data Envelopment Analysis (DEA)	[72]
	Stochastic programming	[69]
	Multi cut L shape method	[69]
	Optimization model	[35], [10]
Statistical Analysis	Analysis statistic	[62], [59]
	SEM (Structural Equation Modelling)	[78]
	Bayesian network	[48], [16]
	Probabilistic modelling, IPRA (Integrated Probabilistic Risk Assessment)	[50], [60], [53], [52], [51]
	Classic beta poison model, Beta binomial, Probability of illness, Sigmoidal model	[8]
	Multiple regression technique	[13], [68]
Multi criteria decision making	ANP, Fuzzy ANP (Analytical Network Process) and Vikor method	[72], [19]
	Fuzzy-AHP	[3], [25]
Others	Semi quantitative : Risk profile, Risk rating, what if scenario	[45]
	BSD, ET, SA8000	[28]
	Risk dependency chain	[73]
	Sustainability risk counting system	[31]
	Rasch rating scale method	[56]
	Multiple case study method	[26]

Standard Models

The use of the standard models for supply chain risk agri-food assessment closely related to microbial risk assessment, such as L.Monocytogenes in broiler meats, Compylobacter in broiler meat, salmonella in pork and others. Microbial models were used to see a growth bacterial opportunity in the food handling process from farm to consumer. Risk assessment models built were based on a statistical approach and simulation models.

EMRISK model developed to identify the hazards during production from farm to fork. EMRISK model is a holistic approach in collecting and using multiple indicators in assessing risks in supply chain of agri-food [77]. Food Safety Objective (FSO) as risk management tool, case studies on L.monocytogenes in ready to eat (RTE) meats. FSO is used to control the hazard, specifically measure the frequency and number of pathogens in food, ranging from the initial point of the food chain [57]. A model Quantitative Risk Assessment (QRA) proposed in integrating all the agents involved in decision making of food quality and safety and all stages of the food chain, starting from the farm to the consumer [40].

Food chain modelling built in the transmission dynamics of a pathogen over food pathway by using QRMA model (Quantitative Microbiological Risk Assessment) [46], [66] and [8]. This model was also developed by [58] and [54]. These models assumed independence of units, random homogeneous distribution of cells (for pastitioning) and equal contribution of units (for mixing), which is often not realistic in food and food handling processes. A QMRA model developed to compare risk assessment *Campylobacter* in broiler meat [66] and [8]. QMRA models applied for estimating the annual risk of enteric virus infection associated with consuming raw vegetables that have been overhead irrigated with non-disinfected secondary treated reclaimed water were constructed. The model is run with multiple scenarios of crop type, viral concentration in effluent, and time since last irrigation event [58]. QRMA model used to see the fate of the phatogens microorganisms along the food chain and the associated health risks [54].

Microbial risk assesment includes: (i) hazard identification/risk profile, (ii) hazard characterization; (iii) exposure assessment; and (iv) risk characterization [22]. Microbial risk assessments (MRA) in food systems are designed to support the understanding and management of consumer health risks related to the ingestion of pathogenic organisms.

The Numeral Pedigree Assessment Unit Spread (NUSAP) model implemented to evaluate the quality of data input parameters for QMRA for *Salmonella* in the Pork Production Chain. Pedigree analysis score was done in two ways: (1) by assessing criteria and overall pedigree strength, (2) by producing kite diagrams [64].

Implementation of the SAFE FOODS risk analysis framework for risk analysis of GMOs and derived food/feed product [42]. SAFE FOOD risk analysis framework was used as a sustainable approach to governance of food production and food safety [41].

Farm-food safety risk assessment (FRAMp) applied as a self assessment and educational tool for fresh produce farms. Risk was measured by two dimensions: the severity and likelihood. Two main groups of food safety hazard were considered during the development of FRAMp, chemical and microbiological hazard [43].

Statistical Analysis

Statistical analysis was used to analyze the risk of pathogenic bacteria in the food chain that impact on human health. The method or approach used probabilistic modelling, multi regression technique and Bayesian network. Statistical approaches applied to estimate the impact of disease and risk associated with eating different foods in England and Wales. Assimilation judgment of expert panels used Delphi technique [62]. Statistical analysis used on risk assessment for the pathogen comodity combination of *Campylobacter* and chicken meat [59].

Bayesian network is used by [48] and [16], for analysing risks in supply networks to facilitate outsourcing decision. This methodology is used to design the risk profile of individual supplier. Multiple regression technique is used by [48], in developing a quantitative risk assessment (QRA) model for *Salmonella* in the production chain from breeder farm to the chilled carsass. The model was built with three approaches: Bayesian Network (BN), Markov Chain Monte Carlo (MCMC) and simulation model.

Probabilistic modelling used by [50], [60], [53] and [39]. A new semi-quantitative Health Impact Appreciation tool for risk managers described to determine and evaluate the health impact of human exposure to one or more chemicals. This model was built on three parameters: (1) the type of effect(s) expected to occur; (2) the size (i.e degree of severity or seriousness) of these efected(s); (3) the fraction of the population at the risk in the given exposure situation [50]. Probabilistic modelling used in calculating the exposure doses (acute and chronic) to assess possible adverse effects on human health [53]. A framework for integrated probabilistic risk assessment of chemicals in diet which accounts for the possibility of cumulative exposure to chemicals with a common mechanism of action [60].

Probabilistic modelling used to study of thermophilic *Campylobacter spp*. in raw Swedish broiler chickens in order to evaluate some risk management strategies and the frequency of consumer mishandling. Uncertainty was evaluated by performing repeated simulations and subtituting model parameters, distributions and software (Analytica) [47].

Probabilistic exposure assessment and probabilistic hazard characteristic have integrated become Integrated Probabilistic Risk Assesment (IPRA) [51]. Whereas [52] integrated probabilistic risk assessment (IPRA) with Relative Potency Factor (RPF) to represent the cumulative risk assessment of three anti-adrogenic pesticides (vinclozolin, procymidone and prochloraz).

Consumer evaluations of food risk management quality conducted using structural equation modelling technique (SEM). Model assessment was based on the Comparative Fit Index (CFI) and the Root Mean Square Error of Approximation (RMSEA) as well as using it to estimate the regression coefficient differences country [78].

Multivariable logistic regression method approach used by [68] and [13]. The model used to determine the risk factors on farm for bacteriological quality of bulk tank milk [68]. The multi regression technique has been used to represent the individual risk corresponding to the overall risk impact [13].

Simulation Model

Some studies used a simulation approach to risk assessment on agri-food supply chain. Monte Carlo simulation in risk assessment for food [48], [44], [47] and [60]. Simulation used in modelling the contamination of poultry meat with Salmonella sp. The Monte Carlo simulation approach is a more complex model that can be considered more practical than a Bayesian method [48]. The level of food contamination modelled with a Monte Carlo simulation approach using R software Simulations with a combination factor of time and temperature at each stage of the food chain [44]. Chemical mechanism risk assessment conducted in food by using Relative Potency Factor (RPF) approach and Monte Carlo simulations. The framework was demonstrated by the organophosphorus pesticides risk assessment [60]. Proposed methods for the risk assessment related to food quality. The proposed method was predictive modelling, event tree analysis and fault tree analysis. Food quality refers to all attributes that influence the product value for the consumer. Monte Carlo simulation was used to simulate previous chain performance models that have been built [23].

Application of simulation modelling was for climate changing scenarios and the logistic chain of fresh produce supply chain. Simulation modelling was used as a tool to provide insights in the complex dynamic ecosystem. Mathematical models to optimize packaging technology was to maintain quality and safety of fresh produce [49]. Risk management procedure of the supply chain network integrated through the Petri Net (PN) based simulation [21].

Many simulation methods were used in food supply chain risk. The commonly used method was monte carlo simulation to determine bacterial contamination level in the supply chain. In addition, this model also was able to assess food chain from farm into consumer.

Intelligent Technique

The intelligent approach technique identified in this review was fuzzy logic and genetic algorithm. The vagueness and subjectivity are handled with linguistic terms. A SC risk assessment developed approach based on the Analytic Network Process (ANP) and the VIKOR methods under the fuzzy environment [19]. Structured aggregative food safety risk analysis proposed to perform in the food supply chain by using the concepts of fuzzy set theory and analytical hierarchy process (AHP). It was tested on British meat cooked by medium-sized producer with three hazard categories: biological, chemical and physical [71]. A hierarchical structure of food supply chain risk factor built by using Fuzzy AHP with the risk factors were demand, supply, technical, production and environmental. Fuzzy AHP is combination of AHP and fuzzy decision making process [3], [25]. Expert systems and neural network used to predict and assess the pasteurized milk quality from examination of fresh milk as a raw material with finished product quality checks in the form of pasteurized milk [74].

The use of fuzzy for microbial risk assessment was carried out by [22], who developed Fuzzy Risk Assesment Tool (FRAT) for early stage risk assesment of microbial hazards in food systems. The fuzzy risk assessment tool was illustrated using four examples of hazards and food combinations: *E.coli* O157:H7 in ground beef, *Camplybacter* in chicken, *Salmonella* in hard cheese and *Listeria* in milk. A framework that integrates fuzzy logic, expert judgment and stochastic simulation proposed for risk assessment of ground water contamination with Fuzzy-Stochastic Risk Assessment (IFSRA) approach. This model was developed to systematically quantify both probabilistic and fuzzy uncertainties that associated with the site condition, environmental guidelines and health impact criteria [29].

Risk model balanced to determine the corn price at the farmer level by considering the risk in each supply chain network. The approach used was fuzzy risks regression utility [24]. Dairy supply chain risk assessed by using

Fuzzy Inference System (FIS) and Fuzzy Associative Memories (FAMs) [73].

An operational strategy model developed to minimize the risk factors in cost, by using the Genetic Encryption, Particle Swarm Optimization, and Artificial bee colony. The models designed contain five suppliers, two manufacturing plants, three warehouses and six markets [15].

Optimation Model

The optimization models used to determine how the inspection function and trace ability system were influenced by awareness of suppliers to deliver food safe for consumption. The parameters used were diagnostic error, sampling error, the cost of failing inspection and the cost of an illness caused by contaminated food [35]. A model proposed to determine inventory and sourcing decision with risk assessment in the perishable food supply chain. This model aimed to minimize costs and reduced waste that did not meet quality standards. The variables included in the model were the time kept in the storage, the temperature level of storing facilities, the time in transit, and the transportation temperature level [10].

Quantitative models formulated on the transmission dynamics for comprehensive risk assessment on the Campylobacter prevalence in the chicken production chain (from young born chicken till chicken fillet) in the Netherlands [67]. The effectiveness of the proposed stochastic models and decomposition algorithms demonstrated for global supply chain planning under uncertainty. Multi objective optimization schemes implemented to balance the tradeoffs between cost and risk [69].

DEA's objective approach and the ANP's subjective approach integrated to evaluate and choose a supplier in the food supply chain. Supplier evaluation was conducted to ensure food material safety to consume through risk control in the supply chain [72].

The commonly model used was the stochastic models. The choice of the model is related to the characteristics of complex food products, with unstable degrees of certainty. The Stochastic events cannot be determined its function with certain, but range of functions in which their values has not been set yet.

Others

The preparations of product hazard level proposed by using qualitative and semi quantitative approach. Risk profile structure is to identify food safety risks in the industry and for the priority actions of risk management [45]. International standards such as SA8000, FLO and IFAOM applied to formulate systematic models of sustainable supply chain management of Soybeans [28]. Risk rating scale models applied to analyze the perceived environmental uncertainty in the agri-food supply chain. The model was built by using a statistical approach, methodology and management theory [56].

Multiple approaches case study method to identify, assess and treat supplier sustainability risks and elaborated on the integration of sustainability risk management used in supplier management procesesses [26]. Risk assessment information tool used to identify and analyse sustainability risk in dairy supply chain. Process risk analysis tools can be seen as examples of a sustainability risk accounting system. The analysis aimed at the economic, environmental and social sustainability of dairy supply process [31]. The linkages of milk supply chain risk were modelled by using dependency chain risk [73].

4.4 Risk Mitigation

Papers traced which have relation with food mitigating supply chain risk is only slight. Some papers taken, only have application on supply chain risk in general, not specifically on food supply chain. The use of Interpretative Structural Modelling (ISM) and Matrice d'Impacts Croises Multipication Appliquee a un Classement (MICMAC) Analysis [18] and [14]. Some possibilities that can assist in mitigation of supply chain risk represented in a hierarchy and classifying them in drivers and dependent categories. ISM was used to identify and conclude relation between enablers of risk mitigation[18]. Risk model that can be identified built in the food supply chain by using ISM.

There were five criteria of supply chain risks that were modeled with ISM: macro level risk, demand management risks, supply management risks, product/service management risks and information management risks. Analysis of the relationship between driving power and dependence power used MICMAC analysis approach [14]. A theory proposed that contributed an understanding of how postponement could be used as a mitigation supply chain disruption strategy from the complex perspective. Postponement dimensional complexity and its impact on the supply chain were described through the principle of Normal Accident Theory (NAT).

There were two basic elements in application of NAT in SCRM: interactive complexity and coupling [17]. Whereas [79] applied Life Cycle Analysis (LCA) to create a scenario of analysis in improving life cycle balance sustainable environment aspect. Although in his analysis he did not devote to food supply chains risk analysis, but [79] in his analysis focused on sustainability, transparency and trace ability that were relevant to food supply chains

risk. Otherwise, risk mitigation by [27] was built a model to calculate the fair distribution of added value among the actors in palm oil supply chain using agent based and netlogo modelling. The model provided to facilitate the negotiation behavior of supply chain actors. Other risk mitigation was formulate a fair pricing mechanism using risk balancing model with fuzzy risk utility preference [25].

5. Conclusion and Recomendation

Based on systematic literature review of 79 articles, this paper classified the use of method or approach in the food supply chain into three parts: identification, assessment and risk mitigation. The journal titles selected in this review were very diverse, such as production economic, distribution and logistics, computer science, environmental, agricultural, food and microbiology, risk management and others. Many food journals were relevant to food control and food microbiology. It indicated that the study about supply chain risk was quite extensive and had an impact on various aspects.

In this paper, we have reviewed literatures which were relevant to supply chain agri-food. Some paper reviews were analyzed, such as SCRM in general, agri-food supply chain, supply chain in general, SC integrated with knowledge management and sustainable supply chain.
Based on literatures review results that have been done, the study found much researches focus on risk assessment. Publications which specifically discuss risk mitigation is only slight. The approach to identify risks is mostly used semi quantitative approach like comparative analysis, comprehensive checklist, Analytical Hierarchy Process (AHP) and the other approaches with combined objective and subjective assessment. While for many risk assessments, they used statistical analysis approach. Another approaches also could be used such as intelligent technique, Optimization models, multi-criteria and others.
The standard model used in the food supply chain risk assessment such as QRMA (Quantitative Microbiological Risk Assessment), FRAMp (A farm food safety-risk assessment), SAFE FOOD and any other models built with static simulation like Monte Carlo and statistical analysis approach. Risk assessment in the food supply chain is closely related to risk assessment microbiology. This is in accordance with the perishable food product's characteristics because of the bacterial activity in the food.

Consciousness development of food supply chain risk models, both in the industry and academia is expected to be able to improve guarantee of security and health food to be consumed. This risk emerged since food is produced in farmers, sent to food processing industries until the food products is sent to consumers for consumption.

The opportunity for futher research is to conduct research on food supply chain risk by using approach, method, model and new procedure with implementing information measurement, the model quantification and analysis and decission making. Considering the complexity problem of food supply chain risk, risk assessment models should be also available, usable and credible. There is also opportunity to do the research which is comprehensive and multidiscipline integrated among modeler, analysts, decisionmakers, policymakers and other professionals.

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