Improving halalness and food safety management systems in the Indonesian broiler supply chain: an interpretive structural modeling and Bayesian network approach

by Ivan Gunawan

Submission date: 29-Mar-2025 09:48AM (UTC+0700)
Submission ID: 2628500328
File name: 6-Improving_halalness_and_food.pdf (1.64M)
Word count: 12719
Character count: 69732

The current issue and full text archive of this journal is available on Emerald Insight at:
https://www.emerald.com/insight/1759-0833.htm

Journal of Islamic Marketing

Improving halalness and food safety management systems in the Indonesian broiler supply chain: an interpretive structural modeling and Bayesian network approach

Received 22 February 2023
Revised 29 May 2023
19 January 2024
1 June 2024
19 October 2024
Accepted 22 October 2024

Hana Catur Wahyuni
Department of Industrial Engineering, Universitas Muhammadiyah Sidoarjo, Sidoarjo, Indonesia

Iwan Vanany
Department of Industrial and Systems Engineering, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia, and

Ivan Gunawan and Julius Mulyono
Department of Industrial Engineering, Universitas Katolik Widya Mandala Surabaya, Surabaya, Indonesia

Abstract

Purpose – By exploring the halalness and food safety risks from the perspective of technology and the relationship among them, this study aims to make quantitative predictions of such risks in the broiler supply chain to determine the critical control points (CCPs) in Hazard Analysis Critical Control Point (HACCP).

Design/methodology/approach – This study integrates Interpretive Structural Modeling (ISM) and Bayesian Network (BN) to achieve the objectives. Data were collected from focus group discussions (FGDs) with experts and direct observations at the broiler supply chain.

Findings – This paper identified 19 risks in the Indonesian broiler supply chain. The risk for halalness and food safety reached 30.92%, indicating that assuring halalness and food safety remains improbable or unlikely. The two CCPs of halalness and food safety are the knife's sharpness and the vehicle's storage temperature.

Research limitations/implications – This study quantifies the halalness and food safety risks in the Indonesian broiler supply chain, but it only involves one step forward and one step backward in the slaughterhouse's chain.

Practical implications – The findings can provide insights for stakeholders, such as business owners, employees, management system auditors and consumers, regarding the critical control points of halalness and food safety in the broiler supply chain to improve the halalness and food safety management systems.

Originality/value – This study's novelty lies in the examination of halalness and food safety risks using a risk prediction model to determine CCPs for the HACCP plan in the broiler supply chain in Indonesia.

Keywords Broiler, Food safety management system, Halal, Risk, Supply chain

Paper type Research paper

1. Introduction

World religions set certain dietary laws for their followers. In Islam, the law is called halalness, built upon the Qur'an (the Holy Scripture of the Muslims) and the Hadith (the

Journal of Islamic Marketing
© Emerald Publishing Limited
1759-0833
DOI 10.1108/JIMA-02-2023-0057

traditions of the Prophet). This dietary law categorizes food as allowed (*halal*) or forbidden (*haram*) for consumption. The demand for lawful food provision such as this increases as the number of followers increases. Islam is one of the largest religions, with more than 18% of the population worldwide and an average annual growth of 1.5%. It is predicted that the religion will have followers of 26.4% of the global population by 2030 and that more than 50 countries will have Muslim-majority populations. The largest share of the Muslim population lives in South Asia, Southeast Asia, the Middle East and Northern Africa, with Indonesia having the largest Muslim population, not only in Asia but in the world. This creates a large potential market for halal food products. In this case, food businesses can focus on fulfilling the demand for halal foods.

Halalness is mandatory for Muslims because it is a divine order, as stated in the Qur'an, Surah Al-Maidah 88, "And eat food that is lawful and good of what Allah has blessed you, and fear Allah whom you believe in." Muslims believe that following this order can bring rewards and that disobeying it is sinful. Many scientific studies have also proven that halal food benefits health (Nurdeng, 2009; Shafaghat, 2010) because halal food requires food safety, called *halalan tayyiban* (lawful and good), which means that the halal food supply chain must meet both halal requirements and food safety. With this premise, non-Muslims are also interested in halal food because it is safe and healthy (Ismail *et al.*, 2017), which expands the potential customers from Muslims to everyone who prioritizes safety and health. This opportunity accelerates the development of the halal food market globally.

However, since the market share for halal food products continues to increase, the risk of food fraud also increases (Ruslan *et al.*, 2018). To avoid food fraud, consumers demand a guarantee of a food product's halal status. In response, the halal supply-chain management system has been established to protect halal integrity in the supply chain (Tieman, 2011). Likewise, the halal assurance system has been set to ensure that the halal-labeled food actually meets the halal requirements. Halal labels show that a product meets the requirements of halal food in all aspects, from farm to fork. Globally, the Codex Alimentarius Commission has established CAC/GL 24-1997, the general guidelines for using the halal term. In Indonesia, a halal assurance system is managed by *Badan Penyelenggara Jaminan Produk Halal*, which issues halal certificates for industries that have met the halal assurance system's requirements. In Korea, this process is led by the Korean Muslim Federation. In Malaysia, *Jabatan Kemajuan Islam Malaysia* issues halal certificates for industries that comply with the Malaysian Halal Standard (MS1500:2004). More than 400 food companies in Europe have been certified by the European Halal Food Council (Aniqoh and Hanastiana, 2020).

Although most countries have set standards for halal products, there are always risks along the food supply chain where food products are contaminated before reaching consumers. Improper handling or contamination can change the status of food products from halal to non-halal. In 2001, an Indonesian Monosodium Glutamate (MSG) company recalled its products due to the use of non-halal materials in the production process (Kobayashi, 2002). Gelatin is commonly used in food and medicinal products, which can come from non-halal animal body parts such as pork skin, making final products non-halal (Demirhan *et al.*, 2012). Although MSG is a halal product, the incompatibility in the production process can make this product non-halal. In other words, the production process, which is only a section of the food supply chain, can lead to various risks. Therefore, a halal risk assessment, which examines the entire food supply chain, will declare a failure in a halal-food supply chain system when the food products delivered are not halal (Khan *et al.*, 2021a, 2021b). The limited understanding of halal requirements may pose risks to halalness in the food supply chain. For example, most actors assume that avoiding prohibited (*haram*) raw materials is sufficient to produce halal products, overlooking other halal aspects, such as storage, transportation and distribution.

Previous studies have attempted to address the halal food supply chain risk. Ali *et al.* (2014) proposed supply chain integration to mitigate halal-food integrity risks, which include production, raw material, food security, outsourcing practice, service and logistics risks. Tieman (2017) formulated risk propositions in the halal supply chain from the perspective of food products, animal-based products, suppliers, logistics services and inbound-outbound processes. Using interview data, Yaacob *et al.* (2018) found that halal risks in logistical activities include delay, operational, natural hazards, technology adoption and halal integrity. Meanwhile, Olya and Al-Ansi (2018) identified halal risks based on the products and services. Fujiwara and Ismail (2018) observed halal risks from supplier management's perspective. Khan *et al.* (2021a, 2021b) identified seven risks along the halal supply chain: planning, sourcing, production, logistics and outsourcing, market, information technology and sustainability risks. They concluded that production and planning risks are the most significant. In any case, these studies provide a pathway for developing research on halal food supply chain risks.

Technologies in the contemporary supply chain have been developing rapidly (Andiyappillai and Prakash, 2020). The adoption of new technologies allows the halal food industry to gain a competitive advantage (Zaidi, 2020). However, certain new technologies may affect consumer confidence in justifying halal products, such as nanotechnology (Bujang *et al.*, 2020) or cultured meat (Ho *et al.*, 2023). This is because halal compliance includes the sources of new raw materials, synthetic materials and innovation in production (Regenstein *et al.*, 2003). On the other hand, the development in information technologies, such as halal blockchain, actually supports the assurance of halal products from farm to fork (Vanany *et al.*, 2024). This is because information technology helps the halal supply chain comply with strict policies, which are different from those of the general supply chain, to ensure halal integrity from farm to fork. Additionally, technology development can encourage adjustments in policy compliance procedures as it allows risk identification through a focused and comprehensive approach. Nonetheless, halal risks from the perspective of technological development in the supply chain have not been well-explored. Therefore, we consider the technology perspective in identifying halal and food safety risks as one of the gaps in the research area of halal supply chain management.

The current research focuses on the broiler supply chain in Indonesia, which is a complex network due to the large number of entities involved in each stage (Harwati *et al.*, 2022) and issues regarding halalness and food safety management system (Wahyuni *et al.*, 2018). Halal assurance and food safety management systems use the same risk management tools, namely Hazard Analysis Critical Control Point (HACCP) (Demirci *et al.*, 2016). Halalness and food safety risks in the broiler supply chain can be identified using four components of technology: technoware, humanware, infoware and orgaware (Smith and Sharif, 2007). The identified risks can be modeled using Interpretive Structural Modeling (ISM), which enables a holistic construction of causal relationships to avoid logical fallacies (Gunawan *et al.*, 2021). ISM has been widely used in risk modeling in the food supply chain, such as by Diabat *et al.* (2012), Prakash *et al.* (2017), Babu *et al.* (2021) and Ramos *et al.* (2021). However, studies that utilize risk models through prediction simulation remain limited. No such model has been developed, especially in halal risk, so a gap for further research is open. Therefore, this study aims to develop a risk prediction model using ISM-based BN to determine CCPs in the HACCP plan. Determining CCPs using a risk prediction model is a novelty in the research of halalness and food safety management systems.

Technically, the directed graph (diagraph) resulting from the ISM becomes the Bayesian Network (BN) Directed Acrylic Graph (DAG). Then, the BN performs a risk evaluation to predict the halalness and food safety risks from the perspective of technology adoption in the broiler supply chain. The ISM-based BN is a new approach developed to predict halal risks. It is an improved method of risk modeling experimented in the context of halalness and food safety through a technological development factor. The technical hypothesis, i.e. the prediction of risk values, is tested using an empirical approach examined using mathematical logic in ISM, which increases the validity of risk calculation compared to conceptual network construction. ISM enables a holistic construction of causal relationships to avoid logical fallacies in developing DAG (Gunawan *et al.*, 2021). The risk prediction simulation seeks to find CCPs in the broiler supply chain, which will help practitioners prepare an HACCP plan to integrate halalness and food safety management systems. The findings can guide the assurance of halalness and food safety amid the rapid technological developments in the food supply chain. As such, this study can make significant theoretical and practical contributions.

2. Theoretical background

The food supply chain is complex due to the nodes' interdependence and the high volatility, making it vulnerable to various risks (Azizsafaei *et al.*, 2021). Supply chain risk management includes risk identification, measurement, handling, analysis, and monitoring stages across the management framework. Risks in the food supply chain have been widely researched due to the interconnectedness of events that cause disruptions and reduce organizational performance, including the assurance of halalness and food safety (Septiani *et al.*, 2016).

According to Malaysian Standard (Department of Standards Malaysia, 2010), the halal supply chain must manage halal networks to maintain halal integrity from farm to fork. An indicator of a successful halal supply chain is the management of procurement, transportation, storage and handling of food products from farm to fork, following the general principles of Sharia law (Tieman *et al.*, 2012). Accordingly, the threat of failure to deliver products that comply with halal standards becomes a halal risk (Khan *et al.*, 2022a, 2022b).

However, it is noteworthy that halal cannot stand alone but must be accompanied by a concept called *tayyib*, which refers to health and safety aspects (Khan *et al.*, 2022a, 2022b). The concept of *tayyib* is comparable to the globally recognized standards of food safety, which have been set in various countries to protect consumers from food safety threats. Food safety management systems aim to estimate and mitigate risks to human health arising from food consumption by identifying, selecting and implementing the most effective mitigation strategies (Koutsoumanis and Aspridou, 2016). Thus, food safety risk management decisions can influence other hygiene initiatives (Schlundt, 1999).

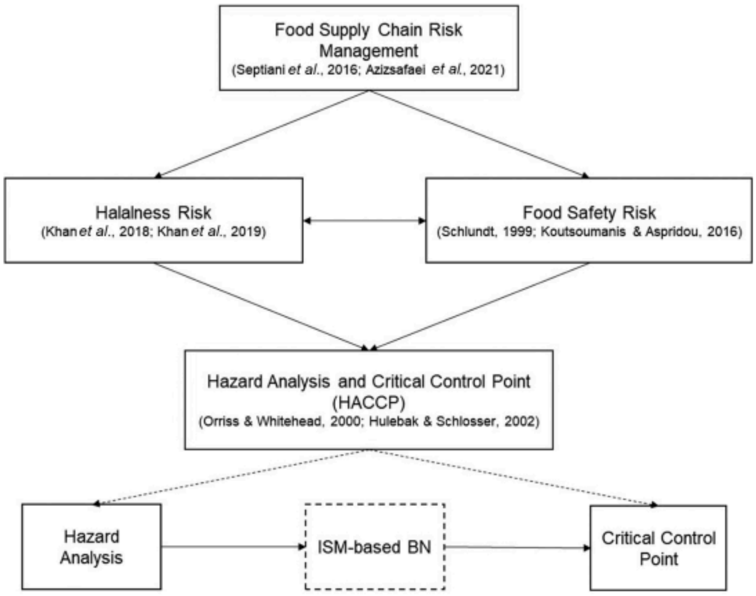
One of the widely accepted food safety control systems is HACCP (Orriss and Whitehead, 2000). In the early 1960s, HACCP was initiated as a food safety control instrument for US astronauts. The risk management framework uses two main components: hazard analysis (HA) and critical control points (CCPs). The former identifies hazards at each stage and evaluates the severity and their effect on human health, while the latter enables the prevention or complete elimination of risk or the reduction of risk to an acceptable level and their control (Bendeković *et al.*, 2015). The initial objective of HACCP was to ensure food safety control in food production.

Hulebak and Schlosser (2002) believe that HACCP is suitable for use in both meat and poultry products. In this study, HACCP is assumed to improve not only the food safety management system but also the halalness in the broiler supply chain in Indonesia (see Figure 1). The integrated ISM-BN approach is used to determine CCPs following HA. Such integration between ISM and BN is new in risk assessment (Wu *et al.*, 2015), enabling empirical modeling of the risk of occurrence of interrelated events. Thus, ISM-BN results from the HA of halalness and food safety in the broiler supply chain are robust, providing a solid foundation for determining CCPs.

3. Literature review

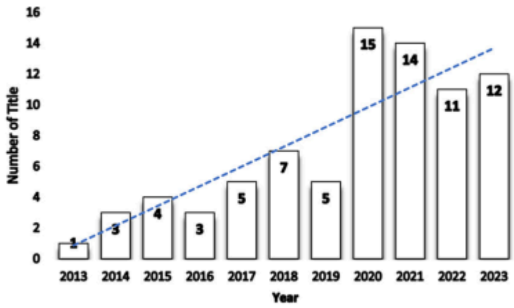
The literature search for halal risk studies was conducted in the Scopus database on May 17, 2023, focusing on studies in the past decade (2013–2023). Eighty articles were collected from various reputable journals in the following subject areas: business, management, and accounting; economics, econometrics, and finance; agricultural and biological sciences; decision sciences; computer sciences; engineering; and mathematics. Only journal articles were included in this study. Figure 2 shows the distribution of halal risk articles per year.

In general, halalness risks have received more attention, as shown in the increasing trend since 2020. Research related to halalness risks increased in 2020 because of the extraordinary event, namely the COVID-19 pandemic, encouraging people to be more aware of the food they consume to maintain health. It should be noted that the articles from 2023 were obtained on May 17, 2023, so the number of publications in 2023 may be higher than recorded in this study. Table 1 shows the distribution of articles by the journals. The journal that publishes the most articles related to halalness risk (18 articles) is Journal of Islamic Marketing (see Table 1) (see Tieman, 2017; El-Bassiouny *et al.*, 2017; Maman *et al.*, 2018;



Source: Author's own work

Figure 1. Theoretical framework



Source: Author's own work

Figure 2. Halal risk research trend

Table 1. Article distribution by the journals

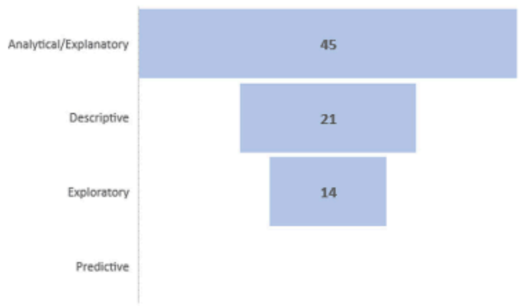
Journal's title	No. of articles
Journal of Islamic Marketing	18
International Journal of Supply Chain Management	4
Food Research	3
Journal of Business Ethics	2
Malaysian Journal of Consumer and Family Economics	2
Supply Chain Forum	2
Sustainability	2
Uncertain Supply Chain Management	2
Other journals	45

Source: Authors' own work

Hendijani Fard and Seyyed Amiri, 2018; Anwer, 2019; Kabir *et al.*, 2021; Aji *et al.*, 2021; Akın and Okumuş, 2021; Ab Rashid and Bojei, 2020; Azmi *et al.*, 2020; Khan *et al.*, 2022a, 2020b; Aziz *et al.*, 2022; Abror *et al.*, 2022; Kristanto and Kurniawati, 2023; Rusydiana *et al.*, 2023; Sudarsono *et al.*, 2023; Deku *et al.*, 2023; Masood and Zaidi, 2023).

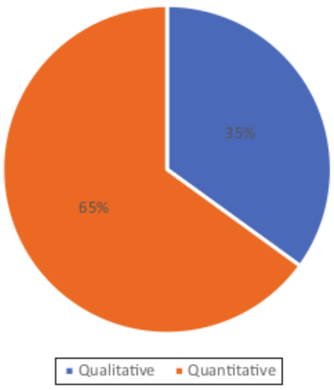
Based on the purposes, the articles are grouped into four: exploratory, descriptive, analytical/explanatory and predictive research (Collis and Hussey, 2003). Exploratory research aims to understand a phenomenon that has never been studied before or to gain new insights (patterns, ideas, or hypotheses) from a phenomenon. Descriptive research aims to describe a phenomenon as it is accurately. The analytical/explanatory research aims to understand a phenomenon by finding and measuring the cause-effect relationship between variables. Predictive research aims to predict a certain phenomenon based on the relationship between variables. Figure 3 shows that most articles on halalness risk are analytical/ explanatory, followed by descriptive and exploratory research. Of the 80 articles, none was identified as predictive research.

The research designs are both qualitative and quantitative, grouped based on the data collection and data processing techniques. Methodological choices are closely related to research purposes, with a qualitative approach often used in exploratory research. Figure 4 shows that most research on halalness risk (65%) is quantitative. The reason for selecting a quantitative approach in risk analysis is that the results can be expressed in scientific



Source: Author's own creation

Figure 3. The classification of articles based on the research purposes



Source: Author's own work

Figure 4. The classification of articles based on methodology

management terminology, the evaluation and results are objective, and the data accuracy increases as the organization gains more experience (Ramona, 2011).

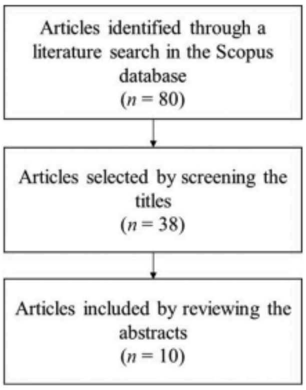
3.1 Related work and research positions

The screening involved 80 articles that were searched with the keyword "halal AND risk" in the Scopus database (scopus.com). The world has three major databases: Scopus, Web of Science and Dimensions. The Scopus database was chosen because it is one of the most widely used databases for bibliometric analysis. Scopus has a broader coverage of journals and substantially more exclusive journals than Web of Science. Dimension has a higher proportion of output in the social sciences and arts and humanities fields unrelated to this research (Singh *et al.*, 2021). We used the Boolean operator "AND" to limit the search results to those involving both terms. The Boolean operator "AND" commands the database to find articles about halal and risk, helping to focus search results and include relevant combinations.

The first stage was screening article titles, eliminating 42 irrelevant articles. The second stage was reviewing the abstracts, eliminating 28 irrelevant articles. This systematic process aims to avoid circular literature searches, thereby increasing the effectiveness of the literature search. Figure 5 summarizes the stages.

After that, content analysis was carried out on the ten most relevant articles to identify the research purposes, methodological choices, data processing techniques, and research subjects. This classification seeks to compare the antecedents. The results can be seen in Table 2.

Table 2 shows that the analytic/explanatory purpose is predominant in the halalness risk research. Supply chain risk models have been developed to identify halalness risks in the food supply chain, one of which is the House of Risk (HOR), developed by Pujawan and



Source: Author’s own work

Figure 5. The article selection process

Table 2. Review of the related works

Authors	Year	Purpose	Methodological choice	Data processing technique	Research subject
Maman *et al.*	2018	Analytical/Explanatory	Quantitative	HOR	Meat
Wahyuni *et al.*	2020	Analytical/Explanatory	Quantitative	BN	Chicken
Azmi *et al.*	2021a	Exploratory	Quantitative	Factor analysis	Food
Azmi *et al.*	2021b	Analytical/Explanatory	Quantitative	SEM	Food
Khan *et al.*	2021a	Analytical/Explanatory	Quantitative	Fuzzy BWM	Not specific
Khan *et al.*	2021b	Analytical/Explanatory	Quantitative	Fuzzy DEMATEL	Food
Khan *et al.*	2022a	Analytical/Explanatory	Quantitative	IFN-D number	Food
Khan *et al.*	2022b	Analytical/Explanatory	Quantitative	Fuzzy AHP	Food
Khan *et al.*	2023	Analytical/Explanatory	Quantitative	BWM	Food
Kristanto and Kurniawati	2023	Analytical/Explanatory	Quantitative	SCOR and HOR	Milkfish
This research	2024	Predictive	Quantitative	ISM-based BN	Chicken

Notes: HOR (House of Risk), BWM (Best-Worst Method), SEM (Sequential Equation Modeling), DEMATEL (Decision-Making Trial Evaluation and Laboratory), IFN (Intuitionistic Fuzzy Number), AHP (Analytical Hierarchy Process), and SCOR (Supply Chain Operations Reference)

Source: Authors’ own work

Geraldin (2009) and adopted by Maman *et al.* (2018) and Kristanto and Kurniawati (2023). Using this model, Maman *et al.* (2018) found that disseminating halal policies and guidelines to stakeholders is crucial to guarantee halalness in the beef supply chain. Besides HOR, other quantitative approaches to the identification of food supply chain risks include BN (Wahyuni *et al.*, 2020), Structural Equation Modeling (SEM) (Azmi *et al.*, 2021b) and Best Worst Method (BWM) (Khan *et al.*, 2023). For example, using BN as an approach, Wahyuni *et al.* (2020) found that the halalness risk in the Indonesian chicken slaughterhouse is small. Another popular approach in halal risk studies is an integrated fuzzy approach, such as Fuzzy BWM (Khan *et al.*, 2021a, 2021b), Fuzzy DEMATEL (Khan *et al.*, 2021a, 2021b), IFN-D number (Khan *et al.*, 2022a, 2022b) and Fuzzy AHP (Khan *et al.*, 2022a, 2022b). For example, using a fuzzy approach differing from Wahyuni *et al.* (2020), Khan *et al.* (2022a, 2022b) stated that the status and the integrity of raw materials, the processing methods and the public facilities for halal and non-halal products are at more severe risks.

Meanwhile, exploratory research on halalness risks often uses a qualitative approach, except for Azmi *et al.* (2021a), who used a quantitative factor analysis approach. While the exploratory research is quite extensive in this area, the use of a predictive approach remains scarce. Therefore, this research seeks to fill the gap by proposing ISM-based BN to predict the halalness risk in the broiler supply chain. A predictive approach quantitatively determines CCPs in the HACCP plan to implement the best monitoring system and corrective actions.

4. Methodology

4.1 Research design

This study employs a multi-method design (Mingers and Brocklesby, 1997) involving an ISM approach to identify the relationship between halalness and food safety risks and a BN to quantitatively predict halalness and food safety risks in the broiler supply chain (Wahyuni *et al.*, 2020). Hereinafter, this method is introduced as the ISM-based BN.

4.2 Population and sampling

The population refers to the Sidoarjo area, with contributing experts from the halal center at a private university in Sidoarjo, East Java, Indonesia. The site selection decision was motivated by the authors' collaboration and the broiler supply chain experts supporting this study. Therefore, Sidoarjo was chosen because of the researcher's accessibility.

This study requires the field of practitioners and academics, so non-probability, purposive sampling was used. The sample size was seven seasoned actors with more than ten years of experience representing all expertise relevant to this study (see Table 3). All were supported with evidence of status, work experience and job titles in the halal food supply chain field.

Table 3. Group of experts

No.	Status	Work experience	Job title
1	Academic	> 15 years	Halal assurance system auditor
2	Academic	> 15 years	Halal assurance system auditor
3	Professional	10–15 years	Quality assurance manager
4	Academic	> 15 years	Halal researcher
5	Professional	10–15 years	Veterinarian
6	Professional	> 15 years	Food supply chain manager
7	Professional	> 15 years	Food business owner

Source: Authors' own work

4.3 Research instrument

On-site observations and semistructured interviews with four supply chain actors were conducted to identify broiler supply chain risk events from halal and food safety aspects. The interview guide can be seen in Appendix 1. Meanwhile, a focus group discussion (FGD) with seven experts explored the relationship between risk events in the broiler supply chain (Rowe and Wright, 1999). An FGD is a qualitative process to gather information on possible relationships between risk events. However, it is crucial to prevent bias arising from the inherent power relations in a social group, including a group of experts (van Eeuwijk and Angehrn, 2017). In this study, each expert contributes to the discussion by giving a perspective on an issue from their respective field so that they are not easily influenced by the answers of other experts. Two experienced facilitators guided the FGD in managing the dynamic process during the discussion and ensuring each expert listened attentively and anticipated actively. The agenda of the FGD was to identify relationships between risk events (see Appendix 2). The facilitator directed the experts to determine the relationship between risk events using a pairwise comparison table called the Structural Self Interaction Matrix.

An expert is characterized by having comprehensive and authoritative knowledge in a particular field that most people do not have (Caley *et al.*, 2014). The inclusion criteria used to select experts as FGD participants were:

- having more than ten years of professional experience in the food sector related to the broiler supply chain;
- having a work record in halal assurance systems and/or food safety management system development; and
- having a solid understanding of the broiler supply chain in Indonesia.

The inclusion criteria were determined by assuming that the FGD participants could communicate judgments clearly and accurately and adapt or extrapolate to new situations. This scenario was expected to achieve the FGD's objective of establishing an integrated halal and food safety risk relationship in the broiler supply chain.

In the ISM approach, the FGD results were quantitatively translated into instruments. The qualitative-to-quantitative transformation process in the ISM procedure occurs at the initial reachability matrix (IRM) stage, translating relationship identification results into binary values. The output of the ISM procedure is a diagraph model of risk event relationship.

Next, structured direct observations of 2,000 replications in the broiler supply chain were conducted to obtain risk probability values. This stage used a form filled with binary values to obtain risk occurrence. The diagraph and risk probabilities were then used to develop a BN model to predict halalness and food safety risks along the broiler supply chain.

4.4 Research procedures

This study uses the ISM-based BN to analyze the relationship and probability of halalness and food safety risks in the broiler supply chain. Halalness and food safety risk events were identified through observation and semistructured interviews. Risk events are interdependent; therefore, they need to be methodically structured. ISM overcomes the weakness of building Directed Acrylic Graph (DAG) in risk studies using BN, which are usually carried out conceptually (Chen and Pollino, 2012). Risk calculations using BN depend on the accuracy of the DAG structure. ISM facilitates the systematic development of BN structures based on expert judgment, thereby increasing the accuracy of risk predictions. Wu *et al.* (2015) successfully used ISM-based BN in performance prediction, analyzing past events in two cases of offshore pipeline projects. The ISM process involves an FGD with experts to identify relationships between risk events, subsequently informing the construction of the risks' hierarchical structure. Using conditional probability, BN then uses this structure to calculate the probability of each risk occurring based on the presence of other risks. In this study, the risk probabilities were obtained from observations of 2,000 replications to quantify the occurrence of each risk. The results provide valuable insights into critical risks and their interrelationships, thereby assisting in developing strategies to improve halalness and food safety in the broiler supply chain. The simulations tested the critical risk predictions and whether they become critical control points in halalness and food safety to support the HACCP plan. The systematic process can be seen in Figure 6.

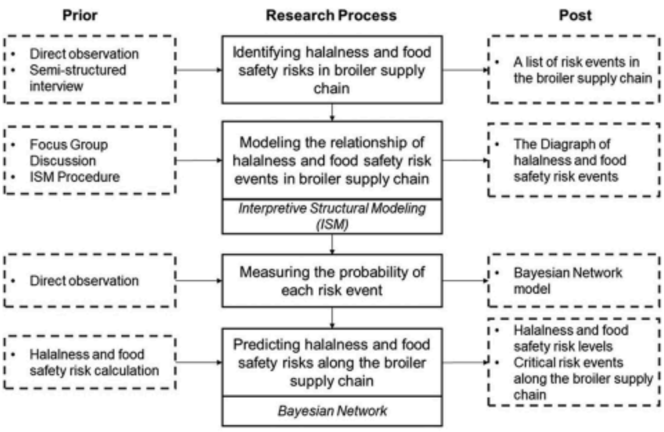
5. Results

The halalness risks in the broiler supply chain are identified one step backward and one step forward from the slaughterhouse. This study uses observations and semi-structured interviews with stakeholders to reveal the broiler supply chain's halalness and food safety risks.

Table 4 shows the 19 identified halalness and food safety risks. The first criterion is technoware, which comes from the use of tools. Based on the halalness requirements, there are two risk events: the chicken dies during the stunning process, and the knife is dull. Regarding food safety, there are six risk events: difficulty in plucking feathers, microbial contamination, temperature instability in cold storage, foreign object contamination in the vehicle during transportation and incomplete boiling process.

The second criterion is humanware, which refers to the risks caused by humans. The two halal risk events are inadequate slaughter processes, so the chickens are still alive after being slaughtered and when being boiled. This condition is a form of torture of living things, which must be avoided because it is not compliant with the halalness law. In terms of food safety, the risks are incorrect packaging, inadequate plucking so the feathers remain, imperfect draining, and blood remaining on the chicken carcass.

The third criterion, infoware, is the risk caused by the information obtained. There is only one halal risk: the possibility of contamination of haram products. The shipping uses third-



Source: Author's own work

Figure 6. Research process

Table 4. The identified risk events

Criterion	Risk source	Risk event	Code
Technoware	Halalness	Death during the stunning process	TH1
		Dull cutting equipment (knife)	TH2
	Food safety	Difficulty in plucking chicken's feathers	TF1
		Microbial contamination	TF2
		Temperature instability in the cold carrier	TF3
		Foreign object contamination in the vehicle during transportation	TF4
		Temperature instability in the cold storage	TF5
		Incomplete boiling process	TF6
Humanware	Halalness	Incorrect slaughter process	HH1
		The chicken is still alive when boiled	HH2
	Food safety	Incorrect packaging process	HF1
		Unclean plucking of chicken's feathers	HF2
		Incomplete draining process	HF3
		Residual blood in the chicken	HF4
Infoware	Halalness	Contamination of haram products	IH1
	Food safety	Inaccurate chicken health information	IF1
		Information about the chicken's bruise	IF2
		No information about the chicken's bruise	IF3
		No information about chicken's physical handicaps	IF4
		No information about the chicken's limpness	IF5
Orgaware	Halalness and food safety	The butcher's insufficient knowledge of the slaughter process	OH1

Source: Authors' own work

party services, so it is difficult to know the previous load of the vehicles and what load is carried together. Regarding food safety, the risks are no information about bruised, deformed and limped chickens.

The fourth criterion is orgaware, which is the risk caused by the organization. The prevalent issue is the lack of training for butchers. They must know that three channels must be cut at once during the slaughter process: the airway, the right channel of eating and the left blood vessels and the neck parts.

The risks in Table 5 were identified for their causal relationships through FGDs. The SSM obtained from the FGD is translated into IRM. The IRM is then checked for transitivity. Transitivity is stated if risk X is related to risk Y and risk Y is related to risk Z, then risk X is always related to risk Z. IRM that has been checked for transitivity is called Final Reachability Matrix (FRM).

After the FRM is formed, the reachability set (R), antecedent set (S) and the intersection between reachability and antecedent (R ∩ S) can be established. The reachability set (R) is a set of risks corresponding to a column where all risks in row i of the FRM are 1. The antecedent set (S) is a set of variables corresponding to a row where all risks in column i of the FRM are 1. The iterations to determine the hierarchical structure are performed by evaluating the reachability set (R), antecedent set (S), and the intersection between reachability and antecedent (R ∩ S).

The arrangement of elements starts from the first level placed at the top of the hierarchy. Elements with the same reachability and intersection sets (R = R ∩ S) are selected. In the next iteration, elements that have entered the first level are removed from the FRM, and the process is repeated until the levels for all risks are found. The iteration process can be seen in Table 5.

Table 5. Level partitioning

Iteration	Element	Reachability set	Antecedent set	Intersection set
1	TF2	4, 7, 12, 13, 14, 15	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 19	4, 7, 12, 13, 14, 15
	IH1	2, 4, 8, 10, 11, 12, 14, 15,19	1, 2, 3, 5, 6, 8, 9, 10, 11, 12, 13, 14, 15, 19	2, 4, 8, 10, 11, 12, 14, 15,19
	IF1	16, 17	1, 2, 7, 8, 9, 12, 13, 14, 16, 17, 18	16, 17
	IF2	16, 17	7, 12, 14, 16, 17, 18	16, 17
2	TF3	2, 5, 8, 9, 12, 13, 14	1, 2, 5, 8, 9, 12, 13, 14	2, 5, 8, 9, 12, 13, 14
	TF4	6, 8, 11	2, 6, 8, 10, 11, 19	6, 8, 11
	TF5	7, 12	2, 7, 9, 10, 12, 19	7, 12
	HF1	6, 8, 11	2, 3, 6, 8, 9, 10, 11, 13, 19	6, 8, 11
	HF2	5, 7, 8, 9, 12, 13, 14	2, 5, 7, 8, 9, 10, 12, 13, 14, 19	5, 7, 8, 9, 12, 13, 14
	HF4	5, 8, 9, 12, 14	1, 2, 3, 5, 8, 9, 10, 12, 13, 14, 18, 19	5, 8, 9, 12, 14
3	TH1	1	1, 18	1
	TF1	2, 3, 8, 10, 19	2, 3, 8, 10, 19	2, 3, 8, 10, 19
	HH2	2, 3, 8, 9, 10, 13, 19	2, 3, 8, 9, 10, 13, 19	2, 3, 8, 9, 10, 13, 19
4	TH2	2, 8, 9, 13, 19	2, 8, 9, 13, 19	2, 8, 9, 13, 19
	TF6	2, 8, 9, 13, 19	2, 8, 9, 13, 19	2, 8, 9, 13, 19
	HH1	2, 8, 9, 13, 19	2, 8, 9, 13, 19	2, 8, 9, 13, 19
	HF3	2, 8, 9, 13, 19	2, 8, 9, 13, 19	2, 8, 9, 13, 19
	IF3	18	18	18
	OH1	2, 8, 9, 13, 19	2, 8, 9, 13, 19	2, 8, 9, 13, 19

Source: Authors' own work

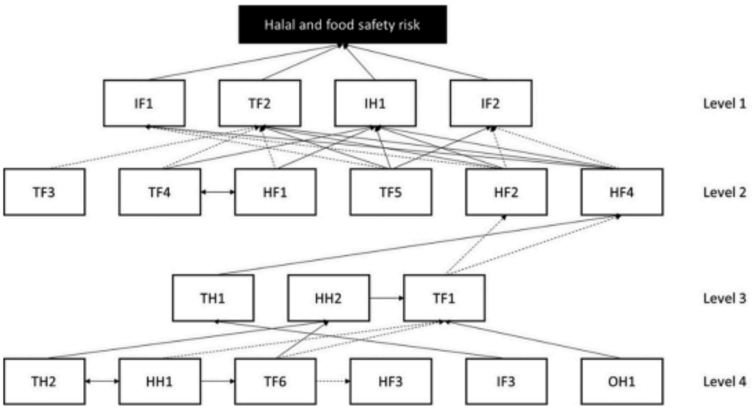
Four risks, TF2, IH1, IF1 and IF2, entered the level in the first iteration. At level 2 in the second iteration, there were six risks: TF3, TF4, TF5, HF1, HF2 and HF4. At level 3, in the third iteration, there are three risks: TH1, TF1 and HH2. Finally, at level 4 in the fourth iteration, there are six risks: TH2, TF6, HH1, HF3, IF3 and OH1. The diagraph can be seen in Figure 6.

Based on Figure 7, the risk at level 4 causes the risk at level 3, the risk at level 3 causes the risk at level 2, and the risk at level 2 causes the risk at level 1. A solid arrow indicates that the preceding risk directly causes the target risk. Likewise, the dotted arrow indicates that the preceding risk indirectly causes the target risk.

The constructed diagrams are then translated into DAG BN by asking experts for their opinions about the relationships in the digraph. After the BN structure is created (see Figure 8), the probability data at each node are entered. The data were obtained from observations on 2,000 replications of the chicken processing. The BN is calculated with Microsoft Belief Network 1.4.2.

Figure 9 shows that the probability of halalness and food safety risks in the broiler supply chain is 30.923% or 0.30923. The risk event with the highest probability is IH1, with a probability value of 0.23909 or 23.909%. The risk event with the lowest probability is IF3, with a probability value of 0.0003 or 0.03%.

Figure 10 shows a simulation of the effect of each risk event on the halalness and food safety risks. If the knife is dull (TH2), the halalness and food safety risk will increase to 0.9998 or 99.98%. In addition, TH2 risk also triggers several other risks at level four: the risk of incorrect slaughter process (HH1), incomplete boiling process (TF6) and incomplete draining process (HF3). At level three, the chicken is alive when being boiled (HH2), caused by the risk of an incomplete slaughter process. The second risk is difficulty plucking the



Source: Author's own work

Figure 7. The ISM diagraph

feathers (TF1), caused by the risk of the chicken being alive during the boiling. At level 2, the risks are unclean feather plucking (HF2) and residual blood in the chicken (HF4). These two risks occur due to difficulty plucking feathers (TF1). The risks at level one are contaminations by haram products (IH1) and microbes (TF2), both of which occur due to unclean feather plucking (HF2) and residual blood (HF4).

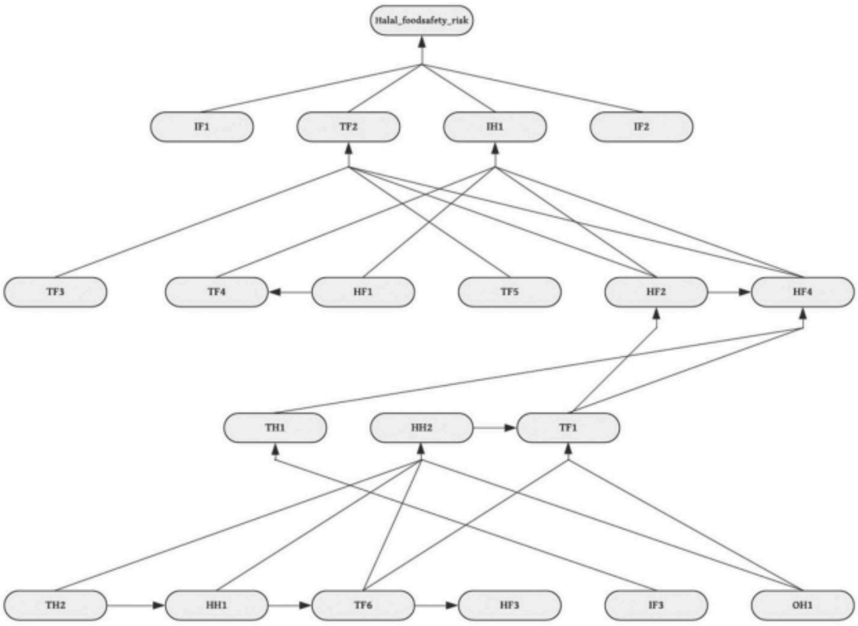
Another risk event simulation can be seen in Figure 11. If the chicken meat is damaged due to the unstable temperature of the cold storage in the vehicle (TF3), the halalness and food safety risk will increase to 0.9848 or 98.48%. Another risk triggered by TF3 is damaged chicken meat due to microbial contamination (TF2), with a percentage of 99.59%.

This study aims to develop a risk prediction model using ISM-based BN to determine CCPs in the HACCP plan. The first finding is the risk prediction model of halal and food safety. The second finding is the CCPs identified from the risk prediction model. The simulation results of the risk prediction model showed that the ISM-based BN successfully found two CCPs: knife sharpness and vehicle storage temperature.

6. Discussions

The knowledge base regarding halal and food safety in the broiler chicken supply chain has been firmly established. There is no debate regarding halalness and food safety standards in broilers. This condition is beneficial in research regarding halalness and food safety risk modeling for the broiler supply chain. This research highlights the need to improve risk assessment approaches to increase accuracy. The ISM-based BN model makes it possible to carry out risk prediction simulations that identify CCPs in the HACCP plan.

This study has identified 19 halalness and food safety risks in the broiler supply chain. The most prevalent halalness and food safety risk events originated from the technoware domain. The stunning process aims to make chickens unconscious so they do not feel pain when slaughtered (Berg and Raj, 2015). This stunning practice should maintain animal welfare and uphold ethical grounds. However, this study observed that chickens may die during the stunning process. In that case, the chicken becomes non-halal. The unhealthy physical conditions of the chicken will also pose a risk of death before the slaughter. One of



Source: Author’s own creation

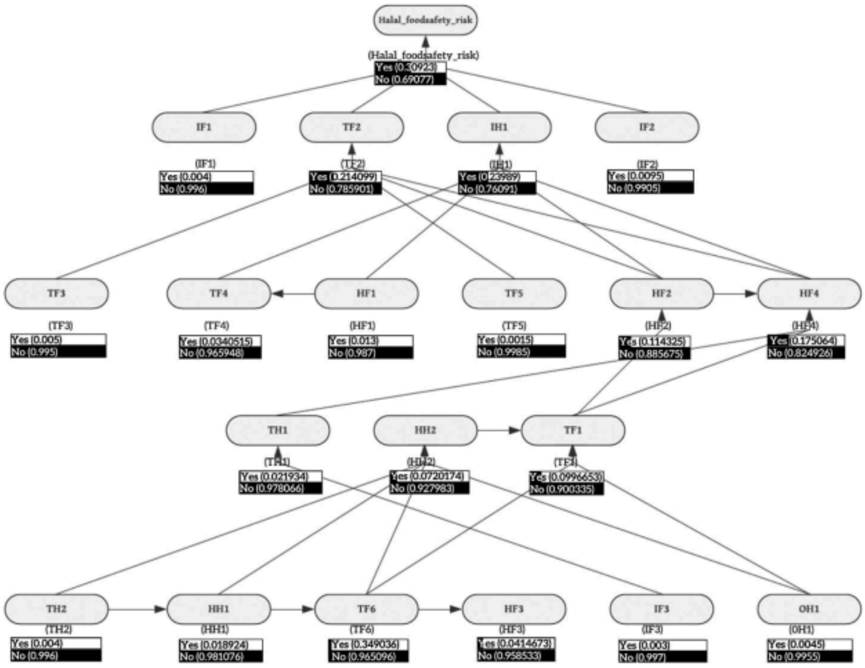
Figure 8. The directed acrylic graph

the halal requirements is that the chicken dies when being slaughtered by observing Islamic law. Inadequate technology in the stunning process increases the risk of death during the stunning process.

In addition, the slaughter method must also be acceptable to Muslims (Abdullah *et al.*, 2019). A dull knife or an unskilled butcher often results in chickens not dying immediately in one cut as the throat is not cut perfectly (three channels on the front of the neck must be severed at once). Chickens that do not die after being slaughtered will feel tortured in the following stages. Likewise, plucking chicken feathers requires the right tools and methods (Omidiji *et al.*, 2014). Otherwise, the chicken will not be perfectly clean from feathers, and fine feathers will remain. Limited tools in slaughterhouses make plucking chicken feathers difficult. Chickens should also be dead before plucking so they are not tormented.

Meanwhile, contaminated tools allow microbes to grow, damaging chicken meat. The shape and quality of the material may cause contamination. Non-food-grade materials and tools with difficult-to-clean shapes are prone to contamination. Inadequate packaging also reduces the shelf life of the chicken. Damaged packaging or an inadequate vacuum process allows for contamination and the development of aerobic bacteria.

Temperature instability in a vehicle’s cold storage occurs when monitoring and control of the cooling room are not possible. During transportation, the air temperature on the outside is dynamic. Accurate temperature measurement and control capability are necessary. Other objects in the transportation equipment, such as pieces of wood, small stones/gravel and others, may also lead to cross-contamination. Therefore, the vehicle must be inspected before



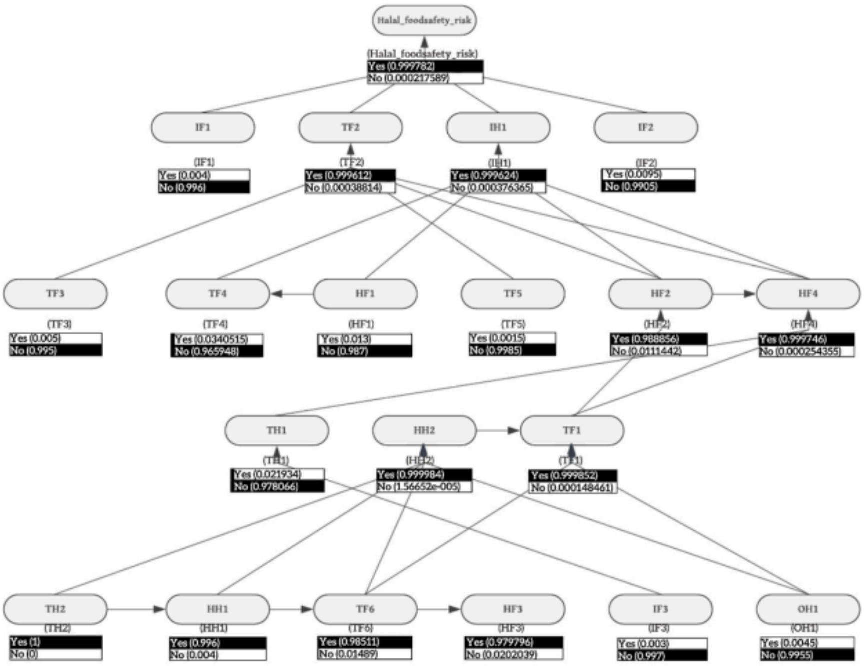
Source: Author's own work

Figure 9. Risk calculation based on the observation results

loading chickens to ensure cleanliness. The transport vehicle must be specialized for transporting halal food. The temperature of the cold storage room must be monitored and controlled. Changes in storage temperature can deteriorate chicken. During boiling, a too-high temperature will disintegrate the chicken when the feathers are plucked by a machine (Omidiji *et al.*, 2014). Therefore, the boiling process needs to involve a device that can control the temperature.

This study shows that the broiler supply chain's halalness and food safety risks reach 30.92%. This risk level is categorized as unlikely or improbable (0–40%) (Cox, 2008). This study predicts the risk from a simulation. The finding shows that the first critical point is the slaughter knife. The sharpness is vital in the halal and food safety assurance system. If the knife is dull, the total risk will immediately become 99.98%. In addition to violating Islamic law that results in non-halal products, using a dull knife will also torture chickens. Therefore, slaughterhouses must use a sharp knife to ensure animal welfare. The second critical point is the vehicle's storage temperature, which contributes significantly to halalness and food safety assurance. The temperature instability of the transport vehicle will increase the risk of halalness and food safety to 99.59%.

These two critical points relate to equipment maintenance. A robust standard operating procedure, knife quality and maintenance information must be established. Knives must be sharpened regularly, and coolers in transportation equipment must also be checked and maintained regularly to prevent damage.



Source: Author's own work

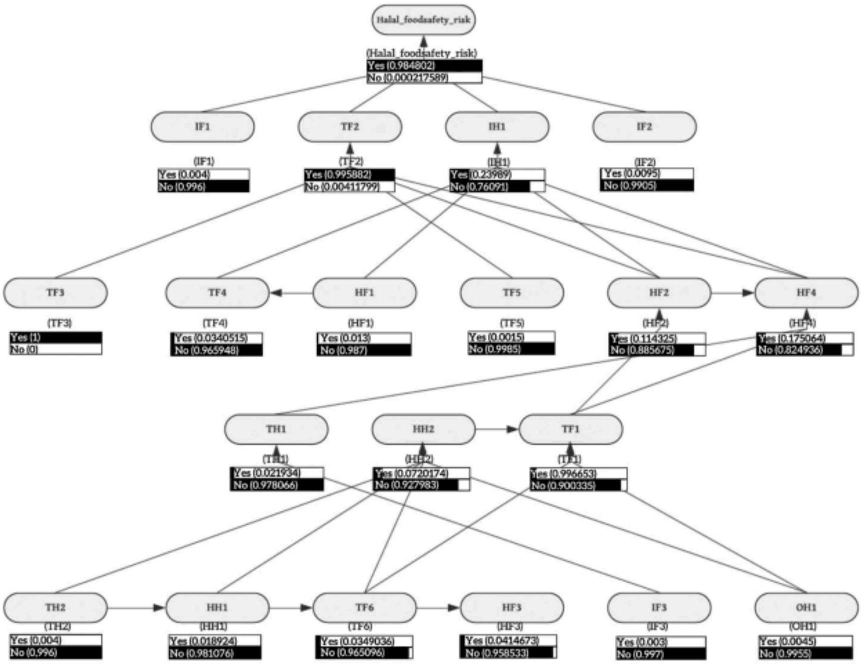
Figure 10. The effect of dull knife on the halalness and food safety risks

7. Conclusion

This study has successfully identified 19 risks in the broiler supply chain. Quantitatively, the broiler supply chain's halalness and food safety risk reached 30.92%, which can be categorized as unlikely/improbable. These findings support Wahyuni *et al.* (2020), stating that halalness and food safety risks in the Indonesian chicken supply chain are low. However, unlike Wahyuni *et al.* (2020), this study uses a logical basis to justify the risk value and build the risk-event relationship.

The risk prediction simulation with Microsoft Belief Network 1.4.2 in this study reveals two CCPs of technoware in halalness and food safety management systems. The first CCP is the knife quality used in the slaughter, and the second is the temperature stability of the vehicle's storage. Experts have validated these two CCPs, confirming that they significantly influence the total risks in the halalness and food safety management system. Therefore, we propose standard operating procedures for maintaining vehicles and knives.

This finding is different from previous research. The risk model developed by Wahyuni *et al.* (2020) found that the highest risk in the processing was chicken death during stunning, and the highest departmental risk was in cleaning and cooling. However, those findings have not been validated. This study makes improvements by building risk-event relationships logically to generate more accurate results than the hierarchical relationships based on activity levels.



Source: Author's own work

Figure 11. The effect of temperature instability in the vehicle with cold storage on the halalness and food safety risk

8. Theoretical, managerial and policy implications

This research contributes to the theory by demonstrating the accuracy of the ISM-BN method in predicting risks and identifying CCPs in a system. ISM overcomes the weakness in a contextual BN structure. With automatic, real-time data collection using sensors, CCPs in the HACCP plan can also be updated automatically; hence, the halal assurance and food safety management systems can be improved continuously. Accordingly, this research's managerial implication is that the industry players can find CCPs through risk prediction simulation in the food supply chain using the robust ISM-based BN approach. With such robust prediction, stakeholders can develop a more reliable HACCP plan. The measures taken will be more effective, backed by an accurate quantitative approach with BN as an artificial intelligence tool.

More specifically, the halalness and food safety risks found in this study can inform stakeholders about CCPs in the broiler supply chain. As such, more targeted policies can be developed to reduce halalness and food safety risks. The first CCP regarding knife sharpness can be addressed by standardizing the knife material and establishing procedures (method and time) for knife sharpening. Meanwhile, the second CCP, i.e. the vehicle's storage temperature, can be handled using reliable vehicle coolers with strict maintenance procedures.

9. Limitations and future research directions

This study's limitation is that it only involves one step forward and one step backward in the slaughterhouse's chain. Future research needs to be conducted to overcome this study's limitations: to calculate the risk for the entire broiler supply network to discover the aggregate risk value from farm to fork. Additionally, participatory action research instead of FGD is advisable to improve the data collection process.

References

Ab Rashid, N. and Bojei, J. (2020), "The relationship between halal traceability system adoption and environmental factors on halal food supply chain integrity in Malaysia", *Journal of Islamic Marketing*, Vol. 11 No. 1, pp. 117-142.

Abdullah, F.A.A., Borilova, G. and Steinhauserova, I. (2019), "Halal criteria versus conventional slaughter technology", *Animals*, Vol. 9 No. 8, p. 530.

Abror, A., Patrisia, D., Engriani, Y., Omar, M.W., Wardi, Y., Noor, N.M.B.M., … Najib, M. (2022), "Perceived risk and tourist's trust: the roles of perceived value and religiosity", *Journal of Islamic Marketing*, Vol. 13 No. 12, pp. 2742-2758.

Aji, H.M., Muslichah, I. and Seftyono, C. (2021), "The determinants of Muslim travellers' intention to visit non-Islamic countries: a halal tourism implication", *Journal of Islamic Marketing*, Vol. 12 No. 8, pp. 1553-1576.

Akın, M.S. and Okumuş, A. (2021), "Shaping the consumers' attitudes towards halal food products in Turkey", *Journal of Islamic Marketing*, Vol. 12 No. 6, pp. 1081-1096.

Ali, M.H., Tan, K.H., Pawar, K. and Makhbul, Z.M. (2014), "Extenuating food integrity risk through supply chain integration: the case of halal food", *Industrial Engineering and Management Systems*, Vol. 13 No. 2, pp. 154-162.

Andiyappillai, N. and Prakash, T. (2020), "Latest developments in logistics and supply chain systems implementations", *International Research Journal on Advanced Science Hub*, Vol. 2 No. 3, pp. 12-17.

Aniqoh, N.A.F.A. and Hanastiana, M.R. (2020), "Halal food industry: challenges and opportunities in Europe", *Journal of Digital Marketing and Halal Industry*, Vol. 2 No. 1, pp. 43-54.

Anwer, Z. (2019), "Islamic venture capital investment style–opportunities and challenges", *Journal of Islamic Marketing*, Vol. 10 No. 3, pp. 848-859.

Azizsafaei, M., Sarwar, D., Fassam, L., Khandan, R. and Hosseinian-Far, A. (2021), "A critical overview of food supply chain risk management", Cybersecurity, Privacy and Freedom Protection in the Connected World: Proceedings of the 13th International Conference on Global Security, Safety and Sustainability, London, January 2021, pp. 413-429, *Cham*: *Springer International Publishing.*

Azmi, F.R., Abdullah, A., Musa, H. and Wan Mahmood, W.H. (2020), "Perception of food manufacturers towards adoption of halal food supply chain in Malaysia: exploratory factor analysis", *Journal of Islamic Marketing*, Vol. 11 No. 3, pp. 571-589.

Azmi, F., Musa, H., Chew, B. and Jagiripu, I. (2021a), "Supply risk management: a case study of halal food industry in Malaysia", *Uncertain Supply Chain Management*, Vol. 9 No. 2, pp. 501-512.

Azmi, F., Musa, H., Zailani, S. and Fam, S. (2021b), "Analysis of mitigation strategy for operational supply risk: an empirical study of halal food manufacturers in Malaysia", *Uncertain Supply Chain Management*, Vol. 9 No. 4, pp. 797-810.

Babu, H., Bhardwaj, P. and Agrawal, A.K. (2021), "Modelling the supply chain risk variables using ISM: a case study on Indian manufacturing SMEs", *Journal of Modelling in Management*, Vol. 16 No. 1, pp. 215-239.

Bendeković, J., Naletina, D. and Nola, I. (2015), "Food safety and food quality in the supply chain", *Trade Perspectives*, Vol. 151, pp. 1-13.

Berg, C. and Raj, M. (2015), "A review of different stunning methods for poultry—animal welfare aspects (stunning methods for poultry)", *Animals*, Vol. 5 No. 4, pp. 1207-1219.

Bujang, A., Rahman, F.A. and Omar, S.R.S. (2020), "Nanotechnology in the food processing and packaging: an overview of its halalan tayyiban aspect", *Malaysian J Consum Fam Econ*, Vol. 24, pp. 1-14.

Caley, M.J., O'Leary, R.A., Fisher, R., Low-Choy, S., Johnson, S. and Mengersen, K. (2014), "What is an expert? A systems perspective on expertise", *Ecology and Evolution*, Vol. 4 No. 3, pp. 231-242.

Collis, J. and Hussey, R. (2003), *Business Research: A Practical Guide for Undergraduate and Postgraduate Students*, Palgrave MacMillan, Basingstoke, United Kingdom.

Cox, L.A. Jr. (2008), "What's wrong with risk matrices?", *Risk Analysis: An Official Publication of the Society for Risk Analysis*, Vol. 28 No. 2, pp. 497-512.

Deku, W.A., Wang, J. and Das, N. (2023), "Innovations in entrepreneurial marketing dimensions: Evidence of halal food SMES in Ghana", *Journal of Islamic Marketing*, Vol. 14 No. 3, pp. 680-713.

Demirci, M.N., Soon, J.M. and Wallace, C.A. (2016), "Positioning food safety in halal assurance", *Food Control*, Vol. 70, pp. 257-270.

Demirhan, Y., Ulca, P. and Senyuva, H.Z. (2012), "Detection of porcine DNA in gelatine and gelatine-containing processed food products—halal/kosher authentication", *Meat Science*, Vol. 90 No. 3, pp. 686-689.

Department of Standards Malaysia (2010), "MS 2400-1:2010 (P): Halalan-Toyyiban assurance pipeline– part 1: management system requirements for transportation of goods and cargo chain services. Malaysia".

Diabat, A., Govindan, K. and Panicker, V.V. (2012), "Supply chain risk management and its mitigation in a food industry", *International Journal of Production Research*, Vol. 50 No. 11, pp. 3039-3050.

El-Bassiouny, N.M., Wilson, J.A. and Esmat, S. (2017), "An Islamic macromarketing perspective on sustainability", *Journal of Islamic Marketing*, Vol. 8 No. 2, pp. 187-203.

Fujiwara, T. and Ismail, R.M. (2018), "Supplier management system in halal food supply chain: a case study approach", *International Journal of Supply Chain Management*, Vol. 7 No. 3, pp. 216-220.

Gunawan, I., Vanany, I. and Widodo, E. (2021), "Typical traceability barriers in the Indonesian vegetable oil industry", *British Food Journal*, Vol. 123 No. 3, pp. 1223-1248.

Harwati, Asih, A.S. and Sopha, B.M. (2022), "Fuzzy logic prioritization in halal risk assessment (a case study of halal chicken supply chain in Indonesia)", 2022 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM), *IEEE*, pp. 1261-1265.

Hendijani Fard, M. and Seyyed Amiri, N. (2018), "The effect of entrepreneurial marketing on halal food SMEs performance", *Journal of Islamic Marketing*, Vol. 9 No. 3, pp. 598-620.

Ho, S.S., Ou, M. and Vijayan, A.V. (2023), "Halal or not? Exploring muslim perceptions of cultured meat in Singapore", *Frontiers in Sustainable Food Systems*, Vol. 7, p. 188.

Hulebak, K.L. and Schlosser, W. (2002), "Hazard analysis and critical control point (HACCP) history and conceptual overview", *Risk Analysis*, Vol. 22 No. 3, pp. 547-552.

Ismail, F.H., Nasiruddin, K. and Samad, N.S. (2017), "Halal and non muslim: what matters", *International Journal of Accounting and Business Management*, Vol. 5 No. 2, pp. 1-13.

Kabir, S., Shams, S. and Lawrey, R. (2021), "Trade diversion risk for halal food exports", *Journal of Islamic Marketing*, Vol. 12 No. 4, pp. 705-729.

Khan, S., Haleem, A. and Khan, M.I. (2021a), "Assessment of risk in the management of halal supply chain using fuzzy BWM method", *Supply Chain Forum: An International Journal*, Vol. 22 No. 1, pp. 57-73.

Khan, S., Haleem, A. and Khan, M.I. (2021b), "Risk management in halal supply chain: an integrated fuzzy Delphi and DEMATEL approach", *Journal of Modelling in Management*, Vol. 16 No. 1, pp. 172-214.

Khan, S., Haleem, A. and Khan, M.I. (2022a), "Risk assessment model for halal supply chain using an integrated approach of IFN and D number", *Arab Gulf Journal of Scientific Research*, Vol. 41 No. 3.

Khan, S., Khan, M.I., Haleem, A. and Jami, A.R. (2022b), "Prioritising the risks in halal food supply chain: an MCDM approach", *Journal of Islamic Marketing*, Vol. 13 No. 1, pp. 45-65.

Khan, S., Haleem, A., Ngah, A.H. and Khan, M.I. (2023), "Exploration of risks with halal logistics: a case of emerging economy", *Journal of Global Operations and Strategic Sourcing*, Vol. 16 No. 3.

Kobayashi, Y. (2002), "Ajinomoto Indonesia haram or halal?" *ISIM Newsletter*, Vol. 9 No. 1, pp. 32-32.

Koutsoumanis, K.P. and Aspridou, Z. (2016), "Moving towards a risk-based food safety management", *Current Opinion in Food Science*, Vol. 12, pp. 36-41.

Kristanto, D. and Kurniawati, D.A. (2023), "Development of halal supply chain risk management framework for frozen food industries", *Journal of Islamic Marketing*, Vol. 14 No. 12.

Maman, U., Mahbubi, A. and Jie, F. (2018), "Halal risk mitigation in the Australian–Indonesian red meat supply chain", *Journal of Islamic Marketing*, Vol. 9 No. 1, pp. 60-79.

Masood, A. and Zaidi, A. (2023), "Empowerment of SME's sustainability in halal cosmetics' ecosystem by diagnosing growth constraints", *Journal of Islamic Marketing*, Vol. 14 No. 2, pp. 622-644.

Mingers, J. and Brocklesby, J. (1997), "Multimethodology: towards a framework for mixing methodologies", *Omega*, Vol. 25 No. 5, pp. 489-509.

Nurdeng, D. (2009), "Lawful and unlawful foods in Islamic law focus on Islamic medical and ethical aspects", *International Food Research Journal*, Vol. 16 No. 4, pp. 469-478.

Olya, H.G. and Al-Ansi, A. (2018), "Risk assessment of halal products and services: Implication for tourism industry", *Tourism Management*, Vol. 65, pp. 279-291.

Omidiji, B.V., Owolabi, H.A., Oyenuga, A.A. and Adeleke, A.A. (2014), "Development of chicken de-feathering machine", *Journal of Engineering and Engineering Technology*, Vol. 8 No. 1, pp. 7-12.

Orriss, G.D. and Whitehead, A.J. (2000), "Hazard analysis and critical control point (HACCP) as a part of an overall quality assurance system in international food trade", *Food Control*, Vol. 11 No. 5, pp. 345-351.

Prakash, S., Soni, G., Rathore, A.P.S. and Singh, S. (2017), "Risk analysis and mitigation for perishable food supply chain: a case of dairy industry", *Benchmarking: An International Journal*, Vol. 24 No. 1, pp. 2-23.

Pujawan, IN. and Geraldin, L.H. (2009), "House of risk: a model for proactive supply chain risk management", *Business Process Management Journal*, Vol. 15 No. 6, pp. 953-967.

Ramona, S.E. (2011), "Advantages and disadvantages of quantitative and qualitative information risk approaches", *Chinese Business Review*, Vol. 10 No. 12, pp. 1106-1110.

Ramos, E., Pettit, T.J., Habib, M. and Chavez, M. (2021), "A model ISM-MICMAC for managing risk in Agri-food supply chain: an investigation from the Andean region of Peru", *International Journal of Value Chain Management*, Vol. 12 No. 1, pp. 62-85.

Regenstein, J.M., Chaudry, M.M. and Regenstein, C.E. (2003), "The kosher and halal food laws", *Comprehensive Reviews in Food Science and Food Safety*, Vol. 2 No. 3, pp. 111-127.

Rowe, G. and Wright, G. (1999), "The delphi technique as a forecasting tool: issues and analysis", *International Journal of Forecasting*, Vol. 15 No. 4, pp. 353-375.

Ruslan, A.A.A., Kamarulzaman, N.H. and Sanny, M. (2018), "Muslim consumers' awareness and perception of halal food fraud", *International Food Research Journal*, Vol. 25, pp. S87-S96.

Rusydiana, A.S., Irfany, M.I., As-Salafiyah, A. and Tieman, M. (2023), “Halal supply chain: a bibliometric analysis”, *Journal of Islamic Marketing*, *Ahead-of-Print*, Vol. 14 No. 12.

Schlundt, J. (1999), “Principles of food safety risk management”, *Food Control*, Vol. 10 No. 4-5, pp. 299-302.

Septiani, W., Marimin, M., Herdiyeni, Y. and Haditjaroko, L. (2016), “Method and approach mapping for Agri-food supply chain risk management: a literature review”, *International Journal of Supply Chain Management*, Vol. 5 No. 2, pp. 51-64.

Shafaghat, A. (2010), “Phytochemical investigation of quranic fruits and plants”, *Journal of Medicinal Plants*, Vol. 9 No. 35, pp. 61-66.

Singh, V.K., Singh, P., Karmakar, M., Leta, J. and Mayr, P. (2021), “The journal coverage of web of science, scopus and dimensions: a comparative analysis”, *Scientometrics*, Vol. 126 No. 6, pp. 5113-5142.

Smith, R. and Sharif, N. (2007), “Understanding and acquiring technology assets for global competition”, *Technovation*, Vol. 27 No. 11, pp. 643-649.

Sudarsono, H., Ikawati, R., Kurnia, A., Azizah, S.N. and Kholid, M.N. (2023), “Effects of religiosity, halal knowledge and halal certification on the intention of Muslims to use the halal vaccine during covid-19 pandemic”, *Journal of Islamic Marketing*, Vol. 15 No. 1.

Tieman, M. (2011), “The application of halal in supply chain management: in-depth interviews”, *Journal of Islamic Marketing*, Vol. 2 No. 2, pp. 186-195.

Tieman, M. (2017), “Halal risk management: combining robustness and resilience”, *Journal of Islamic Marketing*, Vol. 8 No. 3, pp. 461-475.

Tieman, M., van Der Vorst, J.G.A.J. and Ghazali, M.C. (2012), “Principles in halal supply chain management”, *Journal of Islamic Marketing*, Vol. 3 No. 3, pp. 217-243, doi: 10.1108/17590831211259727.

van Eeuwijk, P. and Angehrn, Z. (2017), *How to … Conduct a Focus Group Discussion (FGD). Methodological Manual*, University of Basel, Basel.

Vanany, I., Soon-Sinclair, J.M. and Rahkmawati, N.A. (2024), “Assessment of halal blockchain in the Indonesian food industry”, *Journal of Islamic Marketing*, Vol. 15 No. 6.

Wahyuni, H.C., Vanany, I. and Ciptomulyono, U. (2018), “Food safety and halal food risks in Indonesian chicken meat products: an exploratory study”, 2018 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM), pp. 1011-1015, *IEEE*.

Wahyuni, H.C., Vanany, I., Ciptomulyono, U. and Purnomo, J.D.T. (2020), “Integrated risk to food safety and halal using a bayesian network model”, *Supply Chain Forum: An International Journal*, Vol. 21 No. 4, pp. 260-273.

Wu, W.S., Yang, C.F., Chang, J.C., Château, P.A. and Chang, Y.C. (2015), “Risk assessment by integrating interpretive structural modeling and bayesian network, case of offshore pipeline project”, *Reliability Engineering and System Safety*, Vol. 142, pp. 515-524.

Yaacob, T.Z., Rahman, F.A. and Jaafar, H.S. (2018), “Risk categories in halal food transportation: a preliminary findings”, *International Journal of Supply Chain Management*, Vol. 7 No. 6, pp. 453-461.

Zaidi, M.F.A. (2020), “Propositions on the relationships between technology complexity, industry 4.0, and halal sustainability”, *J. Eng. Sci. Res*, Vol. 4 No. 1, pp. 52-58.

Appendix 1

Table A1. Interview guide

Section of the interview	Questions
Business demographics and interviewees information	1. In what year did this business start operating? 2. What is the role of this business in the broiler supply chain? 3. What are your main products? 4. What is your position in this company? 5. How long have you worked here? 6. What is your last education?
Food safety awareness	1. What is this business food safety system certification? 2. In what year did this business get its food safety system certification? 3. To what extent does your customer aware about food safety? 4. To what extent does this business responsible to food safety? 5. Are you willing to give an experience of food safety incident that your business has been involved? 6. What food safety risks does your business face?
Halal awareness	1. Has this business implemented a halal assurance system? 2. Is the product halal-certified? 3. To what extent does your customer aware about the halalness of your product? 4. To what extent does this business responsible to product halalness? 5. Are you willing to give an experience of contamination of halal products that your business has been involved? 6. What halalness risks does your business face?

Source: Authors' own work

Appendix 2. Discussion guide

Table A2. What do you think about the influence of X on Y in the halalness and food safety risks?

No.	X	Code	Y	Code
1	Death during the stunning process	TH1	Dull cutting equipment (knife)	TH2
2	Death during the stunning process	TH1	Difficulty in plucking chicken's feathers	TF1
3	Death during the stunning process	TH1	Microbial contamination	TF2
4	Death during the stunning process	TH1	Temperature instability in the cold carrier	TF3
5	Death during the stunning process	TH1	Foreign object contamination in the vehicle during transportation	TF4
6	Death during the stunning process	TH1	Temperature instability in the cold storage	TF5
7	Death during the stunning process	TH1	Incomplete boiling process	TF6
8	Death during the stunning process	TH1	Incorrect slaughter process	HH1
9	Death during the stunning process	TH1	The chicken is still alive when boiled	HH2
10	Death during the stunning process	TH1	Incorrect packaging process	HF1
11	Death during the stunning process	TH1	Unclean plucking of chicken's feathers	HF2
12	Death during the stunning process	TH1	Incomplete draining process	HF3
13	Death during the stunning process	TH1	Residual blood in the chicken	HF4
14	Death during the stunning process	TH1	Contamination of haram products	IH1
15	Death during the stunning process	TH1	Inaccurate chicken health information	IF1
16	Death during the stunning process	TH1	Information about the chicken's bruise	IF2
17	Death during the stunning process	TH1	No information about the chicken's bruise	IF3
18	Death during the stunning process	TH1	No information about chicken's physical handicaps	IF4
19	Death during the stunning process	TH1	No information about the chicken's limpness	IF5
20	Death during the stunning process	TH1	The butcher's insufficient knowledge of the slaughter process	OH1
21	Dull cutting equipment (knife)	TH2	Difficulty in plucking chicken's feathers	TF1
22	Dull cutting equipment (knife)	TH2	Microbial contamination	TF2
23	Dull cutting equipment (knife)	TH2	Temperature instability in the cold carrier	TF3
24	Dull cutting equipment (knife)	TH2	Foreign object contamination in the vehicle during transportation	TF4
25	Dull cutting equipment (knife)	TH2	Temperature instability in the cold storage	TF5
26	Dull cutting equipment (knife)	TH2	Incomplete boiling process	TF6
27	Dull cutting equipment (knife)	TH2	Incorrect slaughter process	HH1
28	Dull cutting equipment (knife)	TH2	The chicken is still alive when boiled	HH2
29	Dull cutting equipment (knife)	TH2	Incorrect packaging process	HF1
30	Dull cutting equipment (knife)	TH2	Unclean plucking of chicken's feathers	HF2
31	Dull cutting equipment (knife)	TH2	Incomplete draining process	HF3
32	Dull cutting equipment (knife)	TH2	Residual blood in the chicken	HF4
33	Dull cutting equipment (knife)	TH2	Contamination of haram products	IH1
34	Dull cutting equipment (knife)	TH2	Inaccurate chicken health information	IF1
35	Dull cutting equipment (knife)	TH2	Information about the chicken's bruise	IF2
36	Dull cutting equipment (knife)	TH2	No information about the chicken's bruise	IF3
37	Dull cutting equipment (knife)	TH2	No information about chicken's physical handicaps	IF4
38	Dull cutting equipment (knife)	TH2	No information about the chicken's limpness	IF5
39	Dull cutting equipment (knife)	TH2	The butcher's insufficient knowledge of the slaughter process	OH1
40	Difficulty in plucking chicken's feathers	TF1	Microbial contamination	TF2
41	Difficulty in plucking chicken's feathers	TF1	Temperature instability in the cold carrier	TF3
42	Difficulty in plucking chicken's feathers	TF1	Foreign object contamination in the vehicle during transportation	TF4
43	Difficulty in plucking chicken's feathers	TF1	Temperature instability in the cold storage	TF5
44	Difficulty in plucking chicken's feathers	TF1	Incomplete boiling process	TF6
45	Difficulty in plucking chicken's feathers	TF1	Incorrect slaughter process	HH1

(continued)

Table A2. Continued

No.	X	Code	Y	Code
46	Difficulty in plucking chicken's feathers	TF1	The chicken is still alive when boiled	HH2
47	Difficulty in plucking chicken's feathers	TF1	Incorrect packaging process	HF1
48	Difficulty in plucking chicken's feathers	TF1	Unclean plucking of chicken's feathers	HF2
49	Difficulty in plucking chicken's feathers	TF1	Incomplete draining process	HF3
50	Difficulty in plucking chicken's feathers	TF1	Residual blood in the chicken	HF4
51	Difficulty in plucking chicken's feathers	TF1	Contamination of haram products	IH1
52	Difficulty in plucking chicken's feathers	TF1	Inaccurate chicken health information	IF1
53	Difficulty in plucking chicken's feathers	TF1	Information about the chicken's bruise	IF2
54	Difficulty in plucking chicken's feathers	TF1	No information about the chicken's bruise	IF3
55	Difficulty in plucking chicken's feathers	TF1	No information about chicken's physical handicaps	IF4
56	Difficulty in plucking chicken's feathers	TF1	No information about the chicken's limpness	IF5
57	Difficulty in plucking chicken's feathers	TF1	The butcher's insufficient knowledge of the slaughter process	OH1
58	Microbial contamination	TF2	Temperature instability in the cold carrier	TF3
59	Microbial contamination	TF2	Foreign object contamination in the vehicle during transportation	TF4
60	Microbial contamination	TF2	Temperature instability in the cold storage	TF5
61	Microbial contamination	TF2	Incomplete boiling process	TF6
62	Microbial contamination	TF2	Incorrect slaughter process	HH1
63	Microbial contamination	TF2	The chicken is still alive when boiled	HH2
64	Microbial contamination	TF2	Incorrect packaging process	HF1
65	Microbial contamination	TF2	Unclean plucking of chicken's feathers	HF2
66	Microbial contamination	TF2	Incomplete draining process	HF3
67	Microbial contamination	TF2	Residual blood in the chicken	HF4
68	Microbial contamination	TF2	Contamination of haram products	IH1
69	Microbial contamination	TF2	Inaccurate chicken health information	IF1
70	Microbial contamination	TF2	Information about the chicken's bruise	IF2
71	Microbial contamination	TF2	No information about the chicken's bruise	IF3
72	Microbial contamination	TF2	No information about chicken's physical handicaps	IF4
73	Microbial contamination	TF2	No information about the chicken's limpness	IF5
74	Microbial contamination	TF2	The butcher's insufficient knowledge of the slaughter process	OH1
75	Temperature instability in the cold carrier	TF3	Foreign object contamination in the vehicle during transportation	TF4
76	Temperature instability in the cold carrier	TF3	Temperature instability in the cold storage	TF5
77	Temperature instability in the cold carrier	TF3	Incomplete boiling process	TF6
78	Temperature instability in the cold carrier	TF3	Incorrect slaughter process	HH1
79	Temperature instability in the cold carrier	TF3	The chicken is still alive when boiled	HH2
80	Temperature instability in the cold carrier	TF3	Incorrect packaging process	HF1

(*continued*)

Table A2. Continued

No.	X	Code	Y	Code
81	Temperature instability in the cold carrier	TF3	Unclean plucking of chicken's feathers	HF2
82	Temperature instability in the cold carrier	TF3	Incomplete draining process	HF3
83	Temperature instability in the cold carrier	TF3	Residual blood in the chicken	HF4
84	Temperature instability in the cold carrier	TF3	Contamination of haram products	IH1
85	Temperature instability in the cold carrier	TF3	Inaccurate chicken health information	IF1
86	Temperature instability in the cold carrier	TF3	Information about the chicken's bruise	IF2
87	Temperature instability in the cold carrier	TF3	No information about the chicken's bruise	IF3
88	Temperature instability in the cold carrier	TF3	No information about chicken's physical handicaps	IF4
89	Temperature instability in the cold carrier	TF3	No information about the chicken's limpness	IF5
90	Temperature instability in the cold carrier	TF3	The butcher's insufficient knowledge of the slaughter process	OH1
91	Foreign object contamination in the vehicle during transportation	TF4	Temperature instability in the cold storage	TF5
92	Foreign object contamination in the vehicle during transportation	TF4	Incomplete boiling process	TF6
93	Foreign object contamination in the vehicle during transportation	TF4	Incorrect slaughter process	HH1
94	Foreign object contamination in the vehicle during transportation	TF4	The chicken is still alive when boiled	HH2
95	Foreign object contamination in the vehicle during transportation	TF4	Incorrect packaging process	HF1
96	Foreign object contamination in the vehicle during transportation	TF4	Unclean plucking of chicken's feathers	HF2
97	Foreign object contamination in the vehicle during transportation	TF4	Incomplete draining process	HF3
98	Foreign object contamination in the vehicle during transportation	TF4	Residual blood in the chicken	HF4
99	Foreign object contamination in the vehicle during transportation	TF4	Contamination of haram products	IH1
100	Foreign object contamination in the vehicle during transportation	TF4	Inaccurate chicken health information	IF1
101	Foreign object contamination in the vehicle during transportation	TF4	Information about the chicken's bruise	IF2
102	Foreign object contamination in the vehicle during transportation	TF4	No information about the chicken's bruise	IF3
103	Foreign object contamination in the vehicle during transportation	TF4	No information about chicken's physical handicaps	IF4
104	Foreign object contamination in the vehicle during transportation	TF4	No information about the chicken's limpness	IF5
105	Foreign object contamination in the vehicle during transportation	TF4	The butcher's insufficient knowledge of the slaughter process	OH1
106	Temperature instability in the cold storage	TF5	Incomplete boiling process	TF6
107	Temperature instability in the cold storage	TF5	Incorrect slaughter process	HH1

(*continued*)

Table A2. Continued

No.	X	Code	Y	Code
108	Temperature instability in the cold storage	TF5	The chicken is still alive when boiled	HH2
109	Temperature instability in the cold storage	TF5	Incorrect packaging process	HF1
110	Temperature instability in the cold storage	TF5	Unclean plucking of chicken's feathers	HF2
111	Temperature instability in the cold storage	TF5	Incomplete draining process	HF3
112	Temperature instability in the cold storage	TF5	Residual blood in the chicken	HF4
113	Temperature instability in the cold storage	TF5	Contamination of haram products	IH1
114	Temperature instability in the cold storage	TF5	Inaccurate chicken health information	IF1
115	Temperature instability in the cold storage	TF5	Information about the chicken's bruise	IF2
116	Temperature instability in the cold storage	TF5	No information about the chicken's bruise	IF3
117	Temperature instability in the cold storage	TF5	No information about chicken's physical handicaps	IF4
118	Temperature instability in the cold storage	TF5	No information about the chicken's limpness	IF5
119	Temperature instability in the cold storage	TF5	The butcher's insufficient knowledge of the slaughter process	OH1
120	Incomplete boiling process	TF6	Incorrect slaughter process	HH1
121	Incomplete boiling process	TF6	The chicken is still alive when boiled	HH2
122	Incomplete boiling process	TF6	Incorrect packaging process	HF1
123	Incomplete boiling process	TF6	Unclean plucking of chicken's feathers	HF2
124	Incomplete boiling process	TF6	Incomplete draining process	HF3
125	Incomplete boiling process	TF6	Residual blood in the chicken	HF4
126	Incomplete boiling process	TF6	Contamination of haram products	IH1
127	Incomplete boiling process	TF6	Inaccurate chicken health information	IF1
128	Incomplete boiling process	TF6	Information about the chicken's bruise	IF2
129	Incomplete boiling process	TF6	No information about the chicken's bruise	IF3
130	Incomplete boiling process	TF6	No information about chicken's physical handicaps	IF4
131	Incomplete boiling process	TF6	No information about the chicken's limpness	IF5
132	Incomplete boiling process	TF6	The butcher's insufficient knowledge of the slaughter process	OH1
133	Incorrect slaughter process	HH1	The chicken is still alive when boiled	HH2
134	Incorrect slaughter process	HH1	Incorrect packaging process	HF1
135	Incorrect slaughter process	HH1	Unclean plucking of chicken's feathers	HF2
136	Incorrect slaughter process	HH1	Incomplete draining process	HF3
137	Incorrect slaughter process	HH1	Residual blood in the chicken	HF4
138	Incorrect slaughter process	HH1	Contamination of haram products	IH1
139	Incorrect slaughter process	HH1	Inaccurate chicken health information	IF1
140	Incorrect slaughter process	HH1	Information about the chicken's bruise	IF2
141	Incorrect slaughter process	HH1	No information about the chicken's bruise	IF3
142	Incorrect slaughter process	HH1	No information about chicken's physical handicaps	IF4
143	Incorrect slaughter process	HH1	No information about the chicken's limpness	IF5
144	Incorrect slaughter process	HH1	The butcher's insufficient knowledge of the slaughter process	OH1
145	The chicken is still alive when boiled	HH2	Incorrect packaging process	HF1
146	The chicken is still alive when boiled	HH2	Unclean plucking of chicken's feathers	HF2

(*continued*)

Table A2. Continued

No.	X	Code	Y	Code
147	The chicken is still alive when boiled	HH2	Incomplete draining process	HF3
148	The chicken is still alive when boiled	HH2	Residual blood in the chicken	HF4
149	The chicken is still alive when boiled	HH2	Contamination of haram products	IH1
150	The chicken is still alive when boiled	HH2	Inaccurate chicken health information	IF1
151	The chicken is still alive when boiled	HH2	Information about the chicken's bruise	IF2
152	The chicken is still alive when boiled	HH2	No information about the chicken's bruise	IF3
153	The chicken is still alive when boiled	HH2	No information about chicken's physical handicaps	IF4
154	The chicken is still alive when boiled	HH2	No information about the chicken's limpness	IF5
155	The chicken is still alive when boiled	HH2	The butcher's insufficient knowledge of the slaughter process	OH1
156	Incorrect packaging process	HF1	Unclean plucking of chicken's feathers	HF2
157	Incorrect packaging process	HF1	Incomplete draining process	HF3
158	Incorrect packaging process	HF1	Residual blood in the chicken	HF4
159	Incorrect packaging process	HF1	Contamination of haram products	IH1
160	Incorrect packaging process	HF1	Inaccurate chicken health information	IF1
161	Incorrect packaging process	HF1	Information about the chicken's bruise	IF2
162	Incorrect packaging process	HF1	No information about the chicken's bruise	IF3
163	Incorrect packaging process	HF1	No information about chicken's physical handicaps	IF4
164	Incorrect packaging process	HF1	No information about the chicken's limpness	IF5
165	Incorrect packaging process	HF1	The butcher's insufficient knowledge of the slaughter process	OH1
166	Unclean plucking of chicken's feathers	HF2	Incomplete draining process	HF3
167	Unclean plucking of chicken's feathers	HF2	Residual blood in the chicken	HF4
168	Unclean plucking of chicken's feathers	HF2	Contamination of haram products	IH1
169	Unclean plucking of chicken's feathers	HF2	Inaccurate chicken health information	IF1
170	Unclean plucking of chicken's feathers	HF2	Information about the chicken's bruise	IF2
171	Unclean plucking of chicken's feathers	HF2	No information about the chicken's bruise	IF3
172	Unclean plucking of chicken's feathers	HF2	No information about chicken's physical handicaps	IF4
173	Unclean plucking of chicken's feathers	HF2	No information about the chicken's limpness	IF5
174	Unclean plucking of chicken's feathers	HF2	The butcher's insufficient knowledge of the slaughter process	OH1
175	Incomplete draining process	HF3	Residual blood in the chicken	HF4
176	Incomplete draining process	HF3	Contamination of haram products	IH1
177	Incomplete draining process	HF3	Inaccurate chicken health information	IF1
178	Incomplete draining process	HF3	Information about the chicken's bruise	IF2
179	Incomplete draining process	HF3	No information about the chicken's bruise	IF3
180	Incomplete draining process	HF3	No information about chicken's physical handicaps	IF4
181	Incomplete draining process	HF3	No information about the chicken's limpness	IF5

(*continued*)

Table A2. Continued

No.	X	Code	Y	Code
182	Incomplete draining process	HF3	The butcher's insufficient knowledge of the slaughter process	OH1
183	Residual blood in the chicken	HF4	Contamination of haram products	IH1
184	Residual blood in the chicken	HF4	Inaccurate chicken health information	IF1
185	Residual blood in the chicken	HF4	Information about the chicken's bruise	IF2
186	Residual blood in the chicken	HF4	No information about the chicken's bruise	IF3
187	Residual blood in the chicken	HF4	No information about chicken's physical handicaps	IF4
188	Residual blood in the chicken	HF4	No information about the chicken's limpness	IF5
189	Residual blood in the chicken	HF4	The butcher's insufficient knowledge of the slaughter process	OH1
190	Contamination of haram products	IH1	Inaccurate chicken health information	IF1
191	Contamination of haram products	IH1	Information about the chicken's bruise	IF2
192	Contamination of haram products	IH1	No information about the chicken's bruise	IF3
193	Contamination of haram products	IH1	No information about chicken's physical handicaps	IF4
194	Contamination of haram products	IH1	No information about the chicken's limpness	IF5
195	Contamination of haram products	IH1	The butcher's insufficient knowledge of the slaughter process	OH1
196	Inaccurate chicken health information	IF1	Information about the chicken's bruise	IF2
197	Inaccurate chicken health information	IF1	No information about the chicken's bruise	IF3
198	Inaccurate chicken health information	IF1	No information about chicken's physical handicaps	IF4
199	Inaccurate chicken health information	IF1	No information about the chicken's limpness	IF5
200	Inaccurate chicken health information	IF1	The butcher's insufficient knowledge of the slaughter process	OH1
201	Information about the chicken's bruise	IF2	No information about the chicken's bruise	IF3
202	Information about the chicken's bruise	IF2	No information about chicken's physical handicaps	IF4
203	Information about the chicken's bruise	IF2	No information about the chicken's limpness	IF5
204	Information about the chicken's bruise	IF2	The butcher's insufficient knowledge of the slaughter process	OH1
205	No information about the chicken's bruise	IF3	No information about chicken's physical handicaps	IF4
206	No information about the chicken's bruise	IF3	No information about the chicken's limpness	IF5
207	No information about the chicken's bruise	IF3	The butcher's insufficient knowledge of the slaughter process	OH1
208	No information about chicken's physical handicaps	IF4	No information about the chicken's limpness	IF5
209	No information about chicken's physical handicaps	IF4	The butcher's insufficient knowledge of the slaughter process	OH1
210	No information about the chicken's limpness	IF5	The butcher's insufficient knowledge of the slaughter process	OH1

Source: Authors' own work

Corresponding author
Iwan Vanany can be contacted at: vanany@ie.its.ac.id

For instructions on how to order reprints of this article, please visit our website:
www.emeraldgrouppublishing.com/licensing/reprints.htm
Or contact us for further details: **permissions@emeraldinsight.com**

Improving halalness and food safety management systems in the Indonesian broiler supply chain: an interpretive structural modeling and Bayesian network approach

ORIGINALITY REPORT

3%	1%	5%	0%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Ivan Gunawan, Iwan Vanany, Erwin Widodo. "The influence of traceability system practice to product recall capability in bulk food industry: Observation and interview", 2017 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM), 2017 Publication	1%
2	Ivan Gunawan, Iwan Vanany, Erwin Widodo. "Typical traceability barriers in the Indonesian vegetable oil industry", British Food Journal, 2020 Publication	1%
3	Lusia Permata Sari Hartanti, Ig. Jaka Mulyana, Ivan Gunawan, Herwinarso .. "Managing the 8 Wastes of Lean at a Higher Education Institution: An ISM-MICMAC Approach", KnE Social Sciences, 2022 Publication	1%
4	Nor Aida Abdul Rahman, Kamran Mahroof, Azizul Hassan. "Technologies and Trends in the Halal Industry", Routledge, 2023 Publication	1%

5	Nor Aida Abdul Rahman, Azizul Hassan, Mohammad FakhrulNizam Mohammad. "Halal Logistics and Supply Chain Management in Southeast Asia", Routledge, 2020 Publication	1%

Exclude quotes	On	Exclude matches	< 1%
Exclude bibliography	On		