Analysis of interplay between food safety systems

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Analysis of interplay between food safety systems and *halal* standards in Indonesia

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Abstract

The present work aimed to develop a comprehensive certification process for *halal* food products within the Indonesian agribusiness, which integrates food safety and *halal* standards. The objective was to reduce financial barriers, certification burden, and workforce shortages currently impeding the establishment of quality *halal* food supply chains. To achieve this aim, Interpretive Structural Modelling (ISM) was used to elucidate the complex relationships between decision variables in the *halal* certification process. Data collection included interviews with sectoral experts overseeing food safety and *halal* compliance. The present work identified 17 strategic variables crucial to integrating the Halal Assurance System (HAS) with food safety using ISM analysis. The findings of the ISM model showed 11 hierarchical levels of integration between the HAS and food safety, identifying key factors influencing produce security mechanisms. Additionally, the present work emphasised the significance of transparency, proper handling of produce, and efficient certification processes for businesses operating in the global food sector. This proposed framework not only offers practical guidance for enhancing food security, but also correlated certification processes with supply chain objectives, thereby bridging the gap between theory and practice.

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Introduction

The needs of the growing global Muslim community are stimulating unprecedented consumption of *halal* products (Verbeke *et al*., 2013; Wilson, 2014; Zailani *et al*., 2015). As a response, numerous Asian countries with sizable Muslim communities are taking initiatives to institute *halal* food handling regulations. Specifically, Indonesia, through Indonesian Ulama Council (*Majlis Ulama Indonesia*; MUI), and Malaysia, through Department of Islamic Development Malaysia (*Jabatan Kemajuan Islam Malaysia*; JAKIM), made efforts to ensure the excellence, safety, and integrity of *halal* goods. Jurisdictions within non-Muslim majority are also taking significant steps to strengthen *halal* food standards as the population seeks to export food products to these burgeoning Muslim markets (Khan and Haleem, 2016). Furthermore, there is also a trend evolving around non-Muslim *halal* food consumption which correlates with a heightened sense of consumer awareness. This arises due to the claim that '*halal*' now connotes an assurance of food safety, integrity, and cleanliness (Poniman *et al*., 2015).

Food safety plays a crucial role in world trade, and serves as a required precursor for developing high level of trust in the food supply chain. This role has direct social and economic impacts on the distribution network, specifically in low and middle-income countries (Hoffmann *et al*., 2019). Meals that do not meet the requisite food safety standards of trading jurisdictions will be legally withdrawn by regulators, an action leading to irreparable reputation damage for food production companies (Kong *et al*., 2019). With the added overlay of strict *halal* certification regarding religious food requirements, the complexity related to *halal* food chains becomes significantly magnified.

Muslims place significant trust in the authenticity of *halal* standards to guarantee not just

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the quality of food, but also adherence to religious practices. Consequently, implementing a unified and transparent system is essential to guarantee meaningful consumption (Khan and Haleem, 2016; Tran *et al*., 2022). Moreover, systematic food safety and *halal* certification systems have a positive impact on the food sector by enhancing corporate image, assuring consumer confidence, and ensuring quality products. These systems imply reliable corporate governance, and improve product competitiveness (Henderson, 2016; Evans *et al*., 2021). Despite these benefits, challenges are presented to the industry by the complexity and cost of implementing, as well as maintaining the certification process. This is also followed by the occasional lack of corporate commitment (Escanciano and Vijande, 2014; Wannasiri, 2021). The burden of complying with the two certification systems significantly impacts the long-term sustainability and financial viability of *halal* industry. Therefore, the present work aimed to develop a unified certification process to alleviate financial obstacles, reduce certification burdens, and address human resource challenges, thereby facilitating the consistent establishment of quality *halal* food supply chains.

Literature review

Halal food standards and traceability

Study into the development of *halal* food product standardisation recently received increased attention from both academics and practitioners. van der Spiegel *et al*. (2012) asserted that three key requirements are necessary to ensure a product adheres to halal requirements. Initially, *halal* food products should not contain ingredients considered unlawful/prohibited/non-*halal* (*haram*), nor incorporated elements prohibited by Islamic law (*shari'ah*). The food products also should avoid contact with *haram* substances during production and distribution, nor should have been stored alongside *haram* products. In this regard, Bonne and Verbeke (2008) further emphasised the importance of heightened awareness to prevent alcohol, pork, blood, and meat from cadavers which are not slaughtered according to Islamic rules from entering the *halal* food chain.

Gellynck and Verbeke (2001) showed that the concept of traceability implies the capability of an external body to accurately trace food ingredients through all facets of the supply chain network. Bahrudin *et al*. (2011) further explained the definition of traceability as documenting the origins and history of a food product transparently from production to consumption. *Halal* food traceability study was primarily focused on tracing food, feed, food-producing animals, or substances throughout all stages of production, processing, and distribution of foodstuffs before consumption. This action plays significant role in ensuring the guarantee of safety performance, and maintaining the integrity of practice and compliance with regulations pertinent to the food supply chain and religious requirements (Samsi *et al*., 2012; Handayani *et al*., 2022).

Relationship between food safety system and halal standards

Adhering to *halal* food status is crucial for ensuring food safety and maintaining integrity (Alzeer *et al*., 2018). Karim *et al*. (2018) found a significant relationship between *halal* standards and food safety which led to higher level of trust due to certification. Trienekens and Zuurbier (2008) further concluded that well-functioning food safety systems played an essential role in enhancing total food quality. Additionally, Wahyuni *et al*. (2020) asserted that all stakeholders in the *halal* food sector play significant role in ensuring supply chain integrity.

However, the positioning of the food safety regulations within *halal* standard requirements still lacks clarity (Demirci *et al*., 2016). This ambiguity in the practice concerning *halal* food standards was exemplified in the CAC/GL 24-1997 article titled "General Guidelines for Use of the Term *Halal*", which surprisingly lacked any direct reference to food safety. Based on Malaysian standards, *halal* food is expected to be safe for consumption, non-poisonous, non-intoxicating, and non-hazardous to health. The absence of integration of food safety into *halal* standard requirements was of considerable importance, and widely discussed by academics. For instance, Latif *et al*. (2014) proposed seven attributes of *halal* food standards, including (i) cleanliness of premises, (ii) qualified Muslims' slaughter of all birds and animals, (iii) non-contamination of facilities and equipment by non-*halal* items, (iv) use of only *halal* ingredients for production of *halal* products, (v) sourcing *halal* animal-based ingredients, (iv) ensuring packaging materials are free from non-*halal* and harmful ingredients, and (vii) preventing contamination between *halal* and non-*halal* products during storage handling, transporting, and manufacturing. However, Demirci *et al*. (2016)

observed that only four aspects overlapped with Good Manufacturing Practices (GMP) and Good Hygiene Practices (GHP), while the two required by the Hazard Analysis and Critical Control Points (HACCP) system were not considered *halal* standards.

Integrating HACCP principles into halal food standards

HACCP plays crucial role in the context described by Alzeer *et al*. (2018), as well as in subsequent academic discussions regarding the integration of food safety within *halal* food standards. The significance of the relationship between *halal* food standards and food safety was emphasised by Demirci *et al*. (2016). HACCP was particularly relevant in the present work as it provided a systematic approach to identifying and controlling food safety hazards in the production process.

As indicated in CAC/GL 24-1997, the lack of clarity and correlation between *halal* food safety regulations and the standard requirements underscored the importance of integrating principles from HACCP into *halal* food standards. While *halal* standards are focused on religious requirements and attributes, HACCP is concentrated on identifying and mitigating potential hazards in food production. Therefore, combining the two frameworks could help ensure that *halal* products were not only compliant with religious laws, but also safe for consumption.

In the context of the seven attributes proposed by Latif *et al*. (2014) for *halal* food standards, the incorporation of HACCP principles could significantly enhance food safety aspects. For instance, HACCP could address issues related to the cleanliness of premises (attribute i), prevention of contamination (attributes iii and vii), and ensuring proper handling and transportation (attribute vii). By applying HACCP principles, *halal* food producers could systematically identify and control critical points in the processes to reduce the risk of contamination and ensure food safety.

However, not all aspects of HACCP are perfectly correlated with *halal* standards (Demirci *et al*., 2016). This indicates the need for a comprehensive and integrated approach that recognises the unique requirements of both *halal* certification and food safety. Developing a framework that combines elements of *halal* standards and HACCP could help bridge this gap. Furthermore, the systems could ensure that *halal* foods not only adhere to religious principles, but also comply with the highest food safety standards. This integration is particularly crucial in regions such as Malaysia, where *halal* foods are required to be safe, non-poisonous, non-intoxicating, and non-hazardous to health.

Interpretive Structural Modelling (ISM) in halal systems

ISM is a modelling method for developing direct and indirect relationships between structural variables using rankings and directions (Tan *et al*., 2019). It functions as a modelling technique, representing specific relationships and the total structure through a digraph model. This method serves to bring clarity and direction to the intricate web of relationships within the system. While primarily designed as a group learning process, individuals could also apply the method for personal purposes, and ISM could be used to map out hierarchical connections between factors based on data obtained from expert opinions (Shakerian *et al*., 2019). This method has proven successful in various fields, including understanding the constraints within the remanufacturing process (Singhal *et al*., 2018). The results of this study further identified 14 factors impeding remanufacturing development activities, such as unclear government policies, environmental negligence, and a lack of visionary management. ISM was also instrumental in identifying obstacles to implementing the Lean Six Sigma standard in the supply chain, including a lack of supervision by line managers, employee resistance, and insufficient knowledge (Ali *et al*., 2020).

In the *halal* system, ISM has been used to identify the success factors in implementing product traceability in the *halal* supply chain system (Khan *et al*., 2018). By conducting a comprehensive literature review and considering independent expert reviews, the study identified 12 critical success factors that could be leveraged for the company's benefit. Additionally, Khan *et al*. (2019) used ISM to eliminate trade barriers related to *halal* products, and ensure the availability of suitable materials for development. These findings strengthen strategic coordination and collaboration in international trade for *halal* commodities. Therefore, the innovation aspects of the present work lay in the methodology, specifically the use of ISM to determine the collaborative relationship between food safety and *halal* standards. It is suggested that simultaneous meeting of these two standards during implementation would enhance the effectiveness and efficiency of the company's business processes.

Study methodology

The present work focused on the implementation of food safety system and *halal* certification process in Indonesian agribusiness. Data collection included the engagement of sectoral experts responsible for ensuring food safety and *halal* compliance in Indonesia. The selected sectoral experts actively participated in the field observation process, providing first-hand experiences and insights. This method fostered a deep understanding of the challenges and opportunities faced by the experts in ensuring food safety and *halal* compliance. The purposive selection of experts was based on the established competence and strong reputation of respective companies within the food sector. This ensured that the data collected during field observations were from individuals with extensive knowledge and expertise, thereby enhancing the reliability and validity of the findings.

Data collection was carried out by distributing questionnaires to respondents, and using a Likert scale response to each item, with scores ranging from 1 (very unrelated) to 4 (very related). Even-numbered Likert scales were adopted to capture strong feedback without including a neutral response option. This scale enables scholars to measure the degrees of importance effectively. The integrated study variables were referred to ISO 22000:2018 for the food safety system, while the *Halal* Product Assurance System (SJPH) was suggested for *halal* standards. Given the complexity of implementing *halal* systems alongside food safety and *halal* standards, an effective method for describing the dynamic environments in the present work was required. In this context, the use of Interpretive Structural Modelling (ISM) served as a strong method in enabling a better understanding of the complex relationships between decision variables in a dynamic environment such as *halal* certification (Khan *et al*., 2020). Tan *et al*. (2019) also asserted that ISM aided in analysing the inter-relationships between various factors within complex systems.

The investigation aimed to develop a concrete method for safe food handling that supply chain companies could implement to (i) improve food security mechanisms, (ii) enable transparent and open handling of food products at all stages of the chain, and (iii) streamline and codify the certification processes required to meet *halal* standards. To achieve these objectives, the present work was conducted in three stages, as depicted in Figure 1.

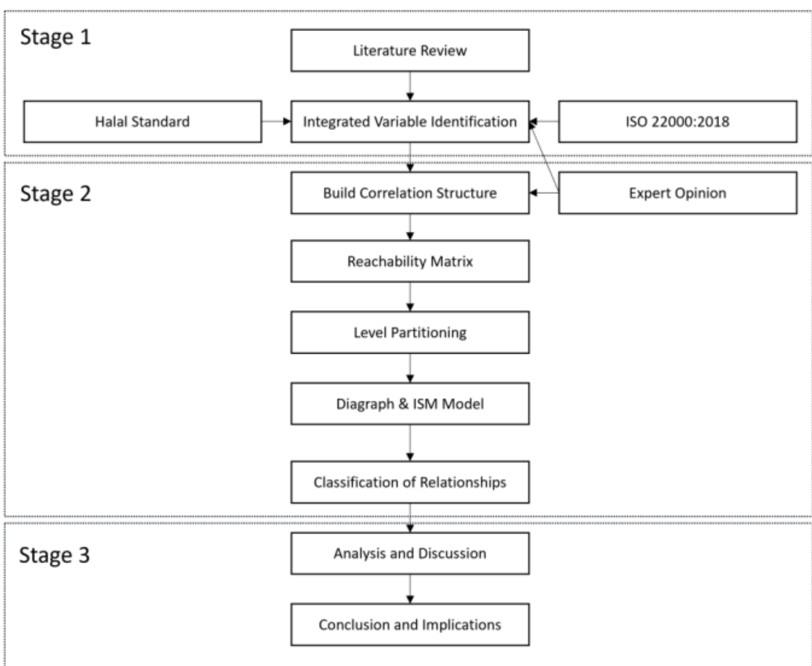

Figure 1. Flow diagram for model preparation.

The stages included variable identification, ISM model development for food supply chain, and the evaluation of the results. The variable identification stage included an investigation of the relevant key literature and policies related to the food safety system and the *halal* standards currently implemented in Indonesia. At this stage, field observations were also carried out to determine the compatibility between the formulated variables and the selected company's conditions.

The study methodology offered at least two advantageous characteristics when compared to similar approach. The benefit included simplicity, as the method did not require advanced mathematical expertise, and efficiency in conserving computer processing time. Tan *et al*. (2019) proposed five key steps for developing the ISM model in the second stage of the study.

Step 1. Build correlation structure

Based on various management techniques such as brainstorming and the nominal group method, the ISM methodology proposed the use of expert opinions to establish contextual relationships among variables. To achieve the objective, it was crucial to engage experts from both industry and academia who possessed deep understanding of the problem. The selection between the contextual relationship types, 'leads to' or 'influences', depended on the premise that one factor affected another. Consequently, these identified factors were connected based on the contextual relationships.

Determining the direction of the relationship between any two factors (i and j) included the use of four symbols, namely (a) 'V' indicated a relationship from factor i to j, showing that factor i influenced factor j; (b) 'A' indicated a relationship from factor j to factor i, showing that factor i was impacted by factor j; (c) 'X' indicated a bidirectional relationship, showing that factors i and j mutually influenced each other; and (d) 'O' indicated no relationship between the factors, showing that both factors were unrelated. The development of the Structural Self-Instructional Matrix (SSIM) was guided by these contextual relationships, and required further discussion by a group of experts to reach a consensus.

Step 2. Reachability matrix

The subsequent step in the ISM method comprised creating an initial reachability matrix based on the SSIM. To accomplish this, the SSIM was transformed into the initial reachability matrix by substituting the four symbols– V, A, X, and O in the SSIM with either 1s or 0s in the initial reachability matrix.

The substitution rules were as follows, (a) when the (i, j) entry in the SSIM indicated V, the corresponding entry in the reachability matrix was set to 1, and the (j, i) entry set at 0; (b) when the (i, j) entry in the SSIM indicated A, the corresponding entry in the matrix became 0, and the (j, i) entry set at 1; (c) in cases where the (i, j) entry in the SSIM indicated X, both the (i, j) and the (j, i) entries in the matrix was set to 1; and (d) when the (i, j) entry in the SSIM indicated O, both entries in the matrix were set at 0. To account for transitivity, 1* entries were included to bridge any gaps in opinions collected during the SSIM's development. After incorporating transitivity as described, the final reachability matrix was obtained.

Step 3. Level partitions

The final reachability matrix yielded two essential sets for each factor, namely the reachability and the antecedent sets. The reachability set comprised the factor and any influenced elements, while the antecedent set included the component and potential impacting attributes. Subsequently, the intersection of these sets determined various levels for each factor. Elements with identical reachability and intersection sets occupied the highest level in the ISM hierarchy, signifying the non-hierarchical influence.

After identifying the top-level factor, and accounting for the influence, the sets were removed from further consideration. The iterative process was subsequently repeated to identify factors at the next level until the hierarchical level of each element was determined. These hierarchical levels were crucial in constructing both the digraph and the ISM model, offering a structured representation of the relationships between factors.

Step 4. ISM model

Based on the level partitioning result, relations were positioned in the initial graph to present the chain of influence. Arrows indicated the direction of influence, and the bidirectional arrows signified mutual effects. The diagram contained direct and indirect transitivity, facilitating the transfer to the

ISM model by adjusting the nodes within the statement.

Step 5. Classification of relationships

The relations were further classified by converting the range matrix into a diagram, aiding in evaluating relations in ISM implementation. Generally, relations with higher dependency strength suggested that some others could be omitted. Relationships with higher driving forces showed that eliminating the relations could affect others, thus requiring compatibility checks in the ISM. Following the ISM model development stage, the next phase comprised analysing the results to be correlated with real conditions. This correlation was crucial for formulating the implications of study results on the company, offering a concrete set of steps for process improvement, or streamlining based on the study findings.

Results and discussion

Stage 1: Variable identification

The results were based on analyses of responses obtained from interviews with expert industry practitioners in *Halal* Assurance Systems (HAS) and food safety. The interview was conducted with five experts, including a management representative, an Internal *Halal* Audit Coordinator (KAHI), two heads of the department for food management systems, and an internal food safety auditor. The insights obtained from these interviews were synthesised into 17 strategic variables influencing the performance of both HAS and food safety, as detailed in Table 1.

Table 1. Integration of variables of *halal* assurance and food safety systems.

Variable of *halal* assurance and food safety systems	**Code**
Halal assurance system policy and food safety	A1
Management	A2
Internal auditor	A3
Producer traceability	A4
System coordinator	A5
Production facility	A6
Logistic traceability	A7
Rework/exceptional release	A8
Product destruction due to substandard quality	A9
Control document	A10
Documented Information	A11
Supplier traceability	A12
Management review	A13
Distribution traceability	A14
Internal audit schedule	A15
Internal training	A16
Internal audit instrument	A17

Stage 2: ISM model

Structural Self-Interaction Matrix (SSIM)

Data processing was conducted using ISM Professional 2.0 Software to generate several key matrices and graphs, including the Structural Self-Interaction Matrix (SSIM), the Final Reachability Matrix (RM), a Canonical Matrix, and an ISM graph. Contextual relationships were established through Focus Group Decisions (FGD) with four experts, who provided insights into the connections between each variable. These discussions yielded the SSIM, which was further processed using the online version of ISM Professional 2.0 Software, as shown in Table 2.

In the SSIM, relationships between factors were represented by codes X, V, O, and A. For instance, in the first row, the relationship between A1 representing HAS policy and food safety to A2 signifying representative management was denoted as X, indicating equal importance and interconnectedness. Similarly, the relationship

Table 2. Structural Self-Interaction Matrix (SSIM) showing the map between factors of *halal* assurance system and food safety regulations.

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17
A1		X	V	O	X	V	V	V	O	A	V	V	X	O	X	V	O
A2			O	X	V	V	X	V	V	V	O	A	V	V	X	O	X
A3				V	O	O	X	V	V	X	V	V	V	O	A	V	V
A4					X	O	X	V	O	O	X	V	V	X	V	V	V
A5						O	A	V	V	X	O	X	V	O	O	X	V
A6							V	X	V	V	V	O	A	V	V	X	O
A7								X	V	O	O	X	V	V	X	V	V
A8									V	O	A	V	V	X	O	X	V
A9										O	O	X	V	V	X	V	V
A10											V	O	A	V	V	X	O
A11												X	V	O	O	X	V
A12													V	X	V	V	V
A13														O	A	V	V
A14															X	O	X
A15																V	O
A16																	O
A17																	

between A1 and A3 signifying internal auditors showed that A1 was more influential than A3, denoted by V. The relationship between A1 and A9 representing product destruction due to substandard quality was A1 showing no connection, denoted by O. Finally, the relationship between A1 and A10 signifying control document showed that A10 had a greater influence on A1, marked as A.

Reachability Matrix (RM)

The Reachability Matrix (RM) was derived by converting the SSIM into a binary matrix. The symbols V, A, X, and O were further transformed into binary numbers 1 and 0 using the online version of the ISM Professional 2.0 Software, with the results presented in Table 3.

Canonical Matrix

The Canonical matrix represented a compilation of variables based on the levels identified in the Final Reachability Matrix. The matrix was compiled using ISM Professional 2.0 Software's online version, as depicted in Table 4.

ISM graph

The ISM graph visually represented the findings derived from the Canonical matrix, and was generated using ISM Professional 2.0 Software's online version, as depicted in Figure 2.

The graphical representation of the canonical matrix features four quadrants. Significantly, the graph showed factors categorised as 'independent,' 'linkage,' 'autonomous,' and 'dependent,' each comprising various elements with distinct degrees of influence.

Interpretive Structural Model (ISM)

Interpretive Structural Modelling (ISM) generates the hierarchical levels, offering a pictorial representation of the ISM model. This depiction enhances comprehension of the system's elements and the interconnections, as shown in Figure 3.

The integration of HAS featured 11 hierarchical levels, depicting the comprehensive structure. At the first level, the crucial element was the policy of HAS and food safety, followed by management representatives (A2) at the second level. The third level comprised internal auditors (A3) and traceability producers (A4), while system coordinators (A5) and traceability logistics (A7) were at the fourth level. Production facilities (A6) occupied the fifth level, and document control (A10) along with supplier traceability (A12) were on the sixth level. The seventh level comprised rework/essential release

Table 3. Final Reachability Matrix (RM).

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17
A1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
A2	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
A3	0	0	1	1	1	0	1	1	0	1	1	1	1	1	1	1	1
A4	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
A5	1	0	0	1	1	0	0	1	1	1	1	1	1	1	1	1	1
A6	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
A7	0	1	1	1	1	0	1	1	1	0	0	1	1	1	1	1	1
A8	0	0	0	0	0	1	1	1	1	0	0	1	1	1	1	1	1
A9	0	0	0	0	0	0	0	0	1	0	0	1	1	1	1	1	1
A10	1	0	1	0	1	0	0	0	0	1	1	1	1	1	1	1	1
A11	0	0	0	1	0	0	0	1	0	0	1	1	1	1	1	1	1
A12	0	1	0	0	1	0	1	0	1	0	1	1	1	1	1	1	1
A13	1	0	0	0	0	1	0	0	0	1	0	0	1	0	0	1	1
A14	0	0	0	1	0	0	0	1	0	0	0	1	0	1	1	1	1
A15	1	1	1	0	0	0	1	0	1	0	0	0	1	1	1	1	0
A16	0	0	0	0	1	1	0	1	0	1	1	0	0	0	0	1	0
A17	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1

Table 4. Canonical Matrix.

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	DP	R
A1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17	1
A2	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16	2
A3	0	0	1	1	1	0	1	1	0	1	1	1	1	1	1	1	1	14	3
A4	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	14	3
A5	1	0	0	1	1	0	0	1	1	1	1	1	1	1	1	1	1	13	4
A6	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	12	5
A7	0	1	1	1	1	0	1	1	1	0	0	1	1	1	1	1	1	13	4
A8	0	0	0	0	0	1	1	1	1	0	0	1	1	1	1	1	1	10	7
A9	0	0	0	0	0	0	0	0	1	0	0	1	1	1	1	1	1	7	9
A10	1	0	1	0	1	0	0	0	0	1	1	1	1	1	1	1	1	11	6
A11	0	0	0	1	0	0	0	1	0	0	1	1	1	1	1	1	1	9	8
A12	0	1	0	0	1	0	1	0	1	0	1	1	1	1	1	1	1	11	6
A13	1	0	0	0	0	1	0	0	0	1	0	0	1	0	0	1	1	6	10
A14	0	0	0	1	0	0	0	1	0	0	0	1	0	1	1	1	1	7	9
A15	1	1	1	0	0	0	1	0	1	0	0	0	1	1	1	1	0	9	8
A16	0	0	0	0	1	1	0	1	0	1	1	0	0	0	0	1	0	6	10
A17	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	3	11
D	6	7	5	8	9	6	9	11	11	9	10	13	14	15	14	16	15		
L	10	9	11	8	7	10	7	5	5	7	6	4	3	2	3	1	2		

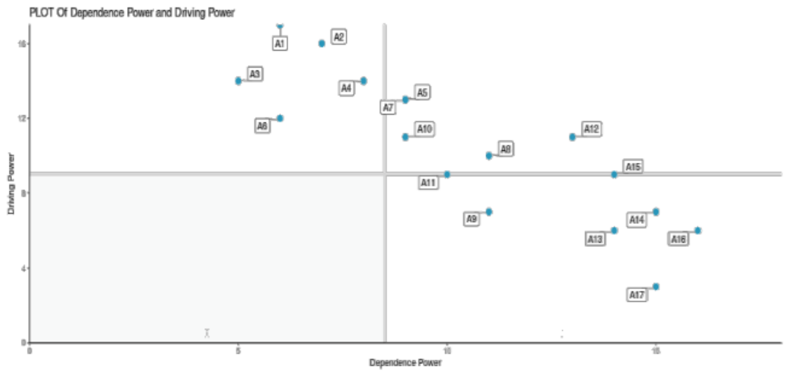

Figure 2. Graphical representation of ISM.

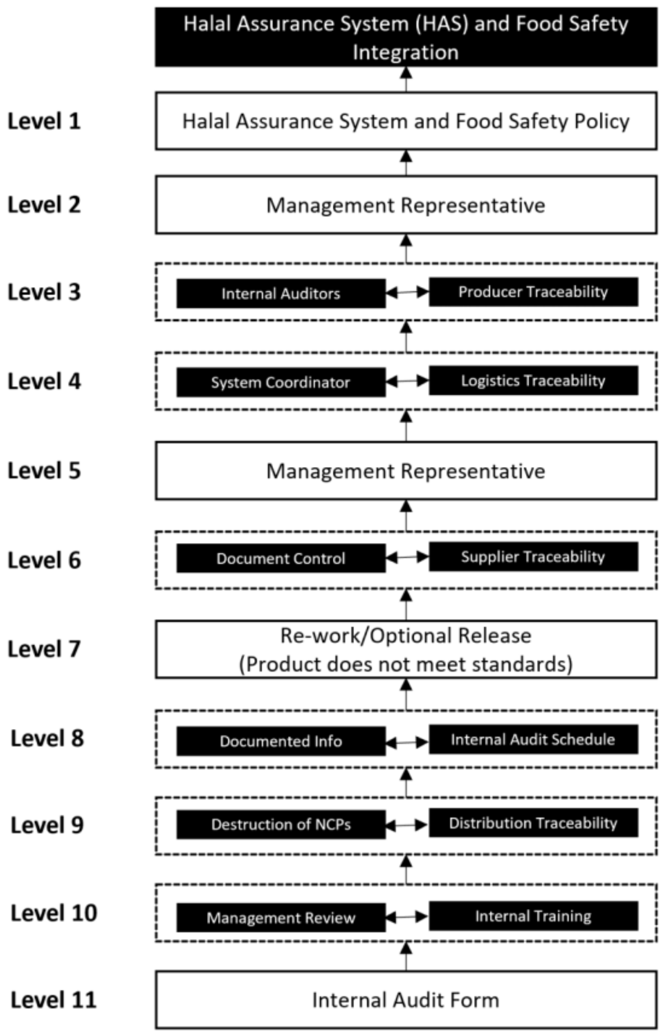

Figure 3. Level hierarchy model.

due to non-compliant products (A8), while documented information (A11) and internal audit schedules (A15) were at the eighth level. Product destruction due to substandard quality (A9) and distribution traceability (A14) were at the ninth level, followed by management reviews and training (A13 and A16) at the tenth level. Internal audit forms (A17) constituted the eleventh and weakest level in the integration of the HAS and food safety. Entirely, the hierarchical model showed that the relationships between these integrated factors were organised into 11 levels.

Within the ISM-generated hierarchy model, the significance of each level was evident, with Level 1 representing the crucial policy of HAS and food safety. This policy comprised the quality objectives of both systems, aiming to implement HAS and food safety effectively. Significantly, the internal audit form held the least influence, as it pertained to the form issued by LPPOM MUI for HAS, and simplify the clause implementation for food safety audits.

Coordination of HAS was managed by the R&D section, while food safety was overseen by the management system. These management perspectives were enriched and strengthened by the insights gained from the ISM process. Both systems could be effectively managed by the management system section, which was tasked with ensuring efficient operation. Typically, this section appointed a team proficient in both HAS and food safety, with staff competency further bolstered through participation in external training programs.

Managerial implications

The present work demonstrated significant managerial implications, extending beyond the ethical considerations of food security in the supply chain industry, particularly within agribusiness. Companies specialising in food supply chains were urged to acknowledge that enhancing food security was not just a moral responsibility, but also a critical strategic necessity. With the identification of 11 levels of action and organisational elements within HAS, supply chain managers were presented with a comprehensive blueprint to enhance the safety and reliability of food products. It was emphasised that the effective operation of this system required consistent dedication to rigorous monitoring and management at every stage of the supply chain (Khan *et al*., 2022). This implied that food safety was not merely a standalone concern but continuous effort beginning with the sourcing of raw materials and extending to product distribution. Furthermore, the present work showed that adhering to HAS framework could confer a competitive advantage to supply chain businesses in an increasingly discerning and socially conscious consumer market. Chen (2008) believed that in today's consumer landscape, individuals closely examined not just the quality and flavour, but also demanded transparency and honesty in tracing the journey from the farm to the plate. Therefore, investing in food security was not just a cost but an investment in brand reputation, customer loyalty, and long-term sustainability. By correlating the practices with HAS framework, businesses had the opportunity to position the entity as leaders in food safety (Abd Rahman *et al*., 2017). This action further fosters confidence in consumers seeking more transparency and responsibility in food preferences. Additionally, the present work underscored the interdependence of global supply chains and the cascading impacts of food safety lapses. A breach in food security at any supply chain stage could trigger consequences ranging from health risks to legal liabilities and reputational damage (Lessard, 2013). Understanding the strategic implications, supply chain companies should view the adoption of HAS principles as a holistic transformation of operational philosophy rather than an isolated initiative. This method not only safeguarded the interests but also contributed to the broader mission of enhancing food security, thereby protecting consumer well-being, and preserving the integrity of the global food supply chain.

The findings of the present work underscored the critical importance of transparency and open handling of food products in daily complex supply chain landscape. Maintaining transparency throughout the supply chain was crucial in an era where consumers are increasingly conscious of product origins and quality consumed. To achieve this transparency, managers were motivated to invest in advanced technologies and robust processes that facilitated real-time tracking and traceability of products from farm to table. This technological advancement not only fostered consumer confidence and trust, but also empowered businesses to swiftly detect and address any evolving problems or inconsistencies throughout the manufacturing, as well as distribution stages (Masudin *et al*., 2021; Yacoub and Castillo, 2022). Additionally, achieving a high level of transparency necessitated effective communication and collaboration among supply chain partners. Managers should acknowledge that the business operates within a complex network of suppliers, distributors, and retailers, all playing crucial roles in the journey of food products. Building and nurturing strong relationships with these partners were essential. Fawcett *et al*. (2011) argued that by fostering a culture of cooperation and mutual trust, businesses could ensure seamless information flows across the supply chain, enhancing visibility and enabling proactive responses to challenges. In an era where transparency and accountability were essential for success, managers should fully accept the principles, not only to satisfy consumer expectations, but also to strengthen the resilience and effectiveness of supply chains.

Another finding of the present work suggested that streamlining and codifying certification processes to adhere to *halal* standards had significant benefits for businesses operating in the global agribusiness, including a particularly clear advantage of cost savings. When managers established clear protocols and standardised procedures for obtaining and maintaining *halal* certification, the business could eliminate redundancies and reduce the time as well as resources required for compliance. This further led to lower operational costs as companies could allocate resources more efficiently, focusing on product quality and innovation rather than navigating complex certification processes (Tieman, 2017). Additionally, these streamlined processes could enhance operational efficiency, enabling businesses to respond more effectively to market demands and changes in regulations (Gupta and Kohli, 2006). Zulfikar *et al*. (2014)'s standardised certification procedures contributed to enhanced transparency and trust in the food supply chain. When a well-defined and consistently applied *halal* certification process was observed by consumers in a company, the authenticity of the products was more likely to be trusted. This trust was particularly crucial in daily diverse and interconnected world, where consumers came from various cultural and religious backgrounds. By accepting a holistic method to food security, transparency, and certification, businesses not only met the demands of the target market, but also positioned the entities as responsible and ethical players in global agribusiness.

Theoretical contributions

In the present work, two significant theoretical contributions were considered, each offering valuable insights and frameworks to advance understanding and practices within the respective domains. Firstly, the present work offered a new framework for enhancing food security mechanisms within the context of the food supply chain. It provided a structured method for assessing and enhancing food security practices by delineating 11 levels of action and organisational components, thereby offering thorough comprehension of HAS. This framework categorised the levels into 'independent' steps, 'linkage' factors, and actions for addressing breakdowns in the chain. This category offered a systematic way for supply chain companies to assess and enhance food security measures. The contribution was particularly valuable in the contemporary world, where food security was a critical global concern, providing practical guidance for organisations to strengthen food security mechanisms, and ensuring safe and consistent supply of food products. The availability, accessibility, and adequacy of food resources had become central to the stability and well-being of countries and communities worldwide (Berry *et al*., 2015). Given this context, the practical guidance offered within this contribution assumed immense importance.

Secondly, the integration of HAS and food safety using the Interpretive Structural Modelling (ISM) method presented a ground-breaking methodological contribution. The present work showed how the effective use of ISM streamlined and codified certification processes required to meet *halal* standards by merging the two distinct. Nirmal *et al*. (2023) believed that integration not only enhanced the transparency and open handling of food products throughout the supply chain, but also facilitated a more efficient operational system. This methodological innovation could be applied beyond the *halal* context, serving as a blueprint for integrating specific quality and safety standards within supply chain management. The method offered a valuable approach for organisations seeking to correlate the certification processes with broader supply chain objectives while maintaining high levels of transparency and safety, making the approach a significant contribution to both academia and industry.

Conclusion

The surge in consumption stimulated by the rapidly growing global Muslim community's demand for *halal* products prompted countries such as Indonesia and Malaysia to establish stringent *halal* food handling standards. These standards not only ensure food quality, but also address religious observance requirements. However, the complexity and cost of dual certification systems– food safety and halal, pose significant challenges to the industry's sustainability. The present work offered a valuable solution by developing a unified certification process through Interpretive Structural Modelling (ISM). The model categorised 17 strategic variables affecting the Halal Assurance System (HAS) and food safety into 11 levels of action, as well as organisational components. This structured framework provided a practical guide for supply chain companies to enhance food security mechanisms and streamline certification processes, eventually improving food safety as well as transparency in the global food supply chain.

The present work further emphasised the importance of transparency and open handling of food products in the contemporary supply chain landscape. It indicated the need for real-time tracking and traceability of products, effective communication among supply chain partners, and the adoption of technology to maintain reliability throughout the supply chain. These practices not only met consumer expectations but also strengthened supply chain resilience and effectiveness. Additionally, the present work underscored the benefits of streamlining and codifying certification processes, reducing operational costs, enhancing transparency, and building consumer trust. Significantly, the present work contributed valuable theoretical frameworks and practical insights to enhance food security, transparency, and certification processes in the global food supply chain. Further research could explore the impact of evolving technologies such as blockchain and the Internet of Things (IoT) on improving transparency and traceability in the global food supply chain, which could offer valuable insights into potential benefits. The implementation challenges, cost-effectiveness, and scalability of the technologies could be explored further. Additionally, the potential to revolutionise food supply chain management, and stimulate consumer confidence in product authenticity and safety warrants further investigation.

References

Abd Rahman, A., Singhry, H. B., Hanafiah, M. H. and Abdul, M. 2017. Influence of perceived benefits and traceability system on the readiness for Halal Assurance System implementation among food manufacturers. Food Control 73: 1318-1326.

Ali, S. M., Hossen, M. A., Mahtab, Z., Kabir, G., Paul. S. K. and Adnan, Z. H. 2020. Barriers to Lean Six Sigma implementation in the supply chain: An ISM model. Computers and Industrial Engineering 149: 1-13.

Alzeer, J., Rieder, U. and Abou Hadeed, K. 2018. Rational and practical aspects of Halal and Tayyib in the context of food safety. Trends in Food Science and Technology 71: 264-267.

Bahrudin, S. S. M., Illyas, M. I. and Desa, M. I. 2011. Tracking and tracing technology for Halal product integrity over the supply chain. In the Proceedings of the 2011 International Conference on Electrical Engineering and Informatics. Bandung, Indonesia.

Berry, E. M., Dernini, S., Burlingame, B., Meybeck, A. and Conforti, P. 2015. Food security and sustainability: Can one exist without the other? Public Health Nutrition 18(13): 2293-2302.

Bonne, K. and Verbeke, W. 2008. Religious values inform Halal meat production and the control and delivery of Halal credence quality. Agriculture and Human Values 25(1): 35-47.

Chen, M.-F. 2008. Consumer trust in food safety—A multidisciplinary approach and empirical evidence from Taiwan. Risk Analysis 28(6): 1553-1569.

Demirci, M. N., Soon, J. M. and Wallace, C. A. 2016. Positioning food safety in Halal assurance. Food Control 70: 257-270.

Escanciano, C. and Vijande, M. L. S. 2014. Reasons and constraints to implementing an ISO 22000 Food Safety management system: Evidence from Spain. Food Control 40: 50-57.

Evans, E. W., Lacey, J. and Taylor, H. R. 2021. Development and piloting of a support package to enable small and medium-sized food and drink manufacturers to obtain third-party food safety certification. Food Control 127: 1-12.

Fawcett, S. E., Wallin, C., Allred, C., Fawcett, A. M. and Magnan, G. M. 2011. Information technology as an enabler of supply chain collaboration: A dynamic-capabilities perspective. Journal of Supply Chain Management 47(1): 38-59.

Gellynck, X. and Verbeke, W. 2001. Consumer perception of traceability in the meat chain. German Journal of Agricultural Economics 50: 368-374.

Gupta, M. and Kohli, A. 2006. Enterprise resource planning systems and their implications for operations function. Technovation 26(5): 687-696.

Handayani, D. I., Masudin, I., Haris, A. and Restuputri, D. P. 2022. Ensuring the Halal integrity of the food supply chain through Halal suppliers: A bibliometric review. Journal of Islamic Marketing 13(7): 1457-1478.

Henderson, J. C. 2016. Halal food, certification, and Halal tourism: Insights from Malaysia and Singapore. Tourism Management Perspectives 19 (Part B): 160-164.

Hoffmann, V., Moser, C. and Saak, A. 2019. Food safety in low and middle-income countries: The evidence through an economic lens. Word Development 123: 1-14.

Karim, R. A., Nawi, N. M., Abd Razak, N., Marmaya, N. H. and Ridzuan, A. R. B. 2018. The relationship between food products with the JAKIM Halal certification and the performance of certified Halal food manufacturers. International Journal of Academic Research in Business and Social Sciences 8(10): 629-639.

Khan, M. I. and Haleem, A. 2016. Understanding "Halal" and "Halal Certification and Accreditation System"- A brief review. Saudi Journal of Business and Management Studies 1(1): 32- 42.

Khan, M. I., Khan, S. and Haleem, A. 2019. Using integrated weighted IRP-Fuzzy TISM approach towards evaluation of initiatives to harmonize Halal standards. Benchmarking - An International Journal 26(2): 434- 451.

Khan, M. I., Khan, S. and Haleem, A. 2022. Analyzing barriers towards management of Halal supply chain: A BWM approach. Journal of Islamic Marketing 13(1): 66-80.

Khan, S., Haleem, A., Khan, M. I., Abidi, M. H. and Al-Ahmari, A. 2018. Implementing traceability systems in specific Supply Chain Management (SCM) through Critical Success Factors (CSFs). Sustainability 10: 1-26.

Khan, W., Akhtar, A., Ansari, S. A. and Dhamija, A. 2020. Enablers of Halal food purchase among Muslim consumers in an emerging economy: an Interpretive Structural Modeling approach. British Food Journal 122(7): 2273-2287.

Kong, D., Shi, L. and Yang, Z. 2019. Product recalls, corporate social responsibility, and firm value: Evidence from the Chinese food industry. Food Policy 83: 60-69.

Latif, I. A., Mohamed, Z., Sharifuddin, J., Abdullah, A. M. and Ismail, M. M. 2014. A comparative analysis of global Halal certification requirements. Journal of Food Products Marketing 20: 85-101.

Lessard, D. R. 2013. Uncertainty and risk in global supply chains. MIT Sloan School Working Paper 4991-13: 1-40.

Masudin, I., Ramadhani, A., Restuputri, D. P. and Amallynda, I. 2021. The effect of traceability system and managerial initiative on Indonesian food cold chain performance: A Covid-19 Pandemic perspective. Global Journal of Flexible Systems Management 22(4): 331-356.

Nirmal, D. D., Nageswara Reddy, K., Sohal, A. S. and Kumari, M. 2023. Development of a framework for adopting Industry 4.0 integrated sustainable supply chain practices: ISM-MICMAC approach. Annals of Operations Research 2023: 1-69.

Poniman, D., Purchase, S. and Seddon, J. 2015. Traceability systems in the Western Australia Halal food supply chain. Asia Pacific Journal of Marketing and Logistics 27(22): 324-348.

Samsi, S. Z. M., Ibrahim, O. and Tasnim, R. 2012. Review on knowledge management as a tool for effective traceability system in Halal food industry supply chain. Journal of Research and Innovation in Information Systems 1: 78-85.

Shakerian, M., Jahangiri, M., Alimohammadlou, M., Nami, M. and Choobineh, A. 2019. Individual cognitive factors affecting unsafe acts among Iranian industrial workers: An Integrative meta synthesis Interpretive Structural Modeling (ISM) approach. Safety Science 120: 89-98.

Singhal, D., Triphaty, S., Jena, S. K., Nayak, K. K. and Dash, A. 2018. Interpretive Structural Modeling (ISM) of obstacles hindering the manufacturing practices in India. Procedia Manufacturing 20: 452- 457.

Tan, T., Chen, K., Xue, F. and Lu, W. 2019. Barriers to Building Information Modeling (BIM) implementation in China's prefabricated construction: An Interpretive Structural Modeling (ISM) approach. Journal of Cleaner Production 219: 949-959.

Tieman, M. 2017. Halal risk management: combining robustness and resilience. Journal of Islamic Marketing 8(3): 461-475.

Tran, N., Shikuku, K. M., Hoffmann, V., Lagerkvist, C. J., Pincus, L., Akintola, S. L., … and Bailey, C. 2022. Are consumers in developing countries willing to pay for aquaculture food safety certification? Evidence from a field experiment in Nigeria. Aquaculture 550: 1-10.

Trienekens, J. and Zuurbier, P. 2008. Quality and safety standards in the food industry, developments and challenges. International Journal of Production Economics 113(1): 107-122.

van der Spiegel, M., van der Fels-Klerx, H. J., Sterrenburg, P., van Ruth, S. M., Scholtens-Toma, I. M. J. and Kok, E. J. 2012. Halal assurance in food supply chains: Verification of Halal certificates using audits and laboratory analysis. Trends in Food Science and Technology 27(2): 109-119.

Verbeke, W., Rutsaert, P., Bonne, K. and Vermeir, I. 2013. Credence quality coordination and consumers' willingness-to-pay for certified Halal labeled meat. Meat Science 95(4): 790-797.

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 21(4): 260-273.

Wannasiri, W. 2021. Challenges to obtaining Halal certification among restaurants in northeast Thailand. Journal of Islamic Marketing 14(2): 607-621.

Wilson, J. A. 2014. The Halal phenomenon: An extension or a new paradigm? Social Business 4: 255-271.

Yacoub, G. and Castillo, M. 2022. Blockchain in your grocery basket: Trust and traceability as a strategy. Journal of Business Strategy 43(4): 247-256.

Zailani, S., Kanapthi, K., Iranmanesh, M. and Tieman, M. 2015. Drivers of Halal orientation strategy among Halal food firms. British Food Journal 117(8): 2143-2160.

Zulfikar, M. H., Anuar, M. M. and Talib, M. S. A. 2014. Conceptual framework on Halal food supply chain integrity enhancement. Procedia - Social and Behavioral Sciences 121: 58-67.

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