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Risk Assessment and Mitigation Strategy in The Halal Broiler Supply Chain

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ABSTRACT

Indonesia's chicken meat supply chain usually starts from large-scale chicken farmers, distributed to medium-scale chicken agents/toke, traditional slaughter chicken traders, and then restaurants and homemakers as end customers. In such a long supply chain, contamination may cause the halal status of slaughtered chicken products to be questioned. The problem studied is the potential risk that can cause contamination of halal slaughtered chicken products from suppliers to end customers. Therefore, this study aims to identify the risk of contamination in the halal supply chain of slaughtered chicken products and obtain recommendations for corrective actions so that slaughtered chicken products are maintained halal. Data is processed using manual Interpretive Structural Modeling (ISM) methods, ISM Professional V 5.0 software, MICMAC Analysis, and Failure Mode and Effect Analysis (FMEA). The conclusions obtained from this study are the identification of the risk of contamination of the halal supply chain in slaughtered chicken products consisting of 26 risk elements, recommendations for corrective actions based on the assessment of contextual relationships between risk elements, among others, slaughterers should be given adequate rest time and the number of workers should be adjusted to the workload, and recommendations for corrective actions based on the assessment of the risk level of each element, among others, preferably slaughterers are given education and motivation; Every slaughterer should be required to attend halal slaughterer training; The slaughterer should be motivated to consistently apply the slaughter training he participates in; ante-mortem should be done before the chickens are delivered; it is best to provide enough containers for chickens after slaughter; And the chicken should be left for up to 3 minutes after massacre and make sure the chicken has completely died.

Keywords: Risk Mitigation, Halal Supply Chain, Slaughter Chicken, Interpretive Structural Modeling (ISM), MICMAC Analysis, Failure Mode and Effect Analysis (FMEA)

INTRODUCTION

The supply chain is a network of companies that work together to create and deliver a product to end users. These companies usually include suppliers, factories, distributors, stores, retail, and supporting companies such as logistics service companies [1][2].

In principle, The chicken slaughter business provides fresh chicken derived from healthy chickens, cut with halal and done cleanly and hygienically, commonly known as halal healthy safe products [3]. Chicken slaughtering business can be traditional without a feather lathe or using a feather lathe and a modern chicken cutting machine. For chicken slaughter businesses that want to get halal certification from LPPOM, MUI must carry out halal certification procedures, namely understanding halal certification requirements and attending halal assurance system (SJH) training, implementing SJH, preparing halal certification documents, registering for halal certification (uploading data through the www.e-lppommui.org website); conduct pre-audit monitoring and payment of certification contracts, conduct audits, conduct post-audit monitoring; Then you can get a halal certificate [4][5].

Based on observations, there is a potential cause of the risk of non-halal for slaughtered chicken products from suppliers to end customers, and it is necessary to conduct a risk analysis to find out which risks must be further corrected so that slaughtered chicken products are maintained halal. Some chicken slaughter businesses in Medan City still do not have halal certification for various reasons, including a lack of understanding of the halal concept, a lack of knowledge in obtaining information regarding the management of halal certification, finding it difficult to carry out halal certification procedures; not having enough time; does not have sufficient costs; lack of motivation to have halal certification; and so on. This raises the question of whether halal slaughtered chicken sold in chicken slaughter businesses that do not have halal certification and those who have not attended halal slaughterer training are halal.

Chicken slaughterhouses and slaughterers who do not have halal certificates cause consumers to doubt the halal status of slaughtered chicken products. Therefore, this study intends to conduct a halal supply chain analysis on slaughtered chicken products to determine what factors affect halal slaughtered chicken products [6][7]. This is supported by increasingly intense government action to encourage the process of halal chicken slaughter through PP No. 31 of 2019 concerning Implementing Regulations of Law No. 33 of 2014 concerning Halal Product Guarantee. This shows the importance of maintaining halal products, especially food, as a primary human need [8][9].

The terms halal and haram are widely used, one of which is related to food [10]. Both come from Arabic: halal means justified or permissible, while haram means not justified or forbidden. Risk management aims to know, analyze and control risks in every company activity for higher effectiveness and efficiency [11].

This research uses Interpretive Structural Modeling (ISM) and Failure Mode and Effect Analysis (FMEA) methods, and ISM is a modelling technique developed for strategic policy planning [12]. The advantages of ISM include developing structures that define relationships among elements in a set; being able to identify and conclude various kinds of relationships between factors in a particular problem or issue; being able to connect and organize ideas in visual map maps; Can decompose complex systems into sub-systems (elements) and build a multilevel structural model[13] [14].

Failure Mode and Effect Analysis (FMEA) is a method to identify and analyze potential failures and their consequences that aims to plan the production process well and can avoid production process failures and unwanted losses [15][16]. The advantages of FMEA or others can improve the reliability and quality of products/processes, increase customer satisfaction, quickly identify and reduce defects in products/processes, gain engineering or organizational learning, and emphasize preventing problems [17].

METHOD

Data Collection Techniques

1. Direct observation to obtain mapping data on the supply chain activity of slaughtered chicken products and the production process of slaughtered chicken [18].
2. Interviews and discussions with couriers, slaughtered chicken traders, halal auditors, academics, and Islamic teachers to obtain the necessary information to achieve goals. Interviews and discussions are needed as preliminary studies to find and compile influential variables to analyze the risk of non-halal slaughter chicken products [18].
3. Interpretive Structural Modeling (ISM) questionnaires were distributed to 30 respondents who understand halal supply chains and slaughtered chicken products to assess contextual relationships between risk elements [18].
4. Distribute the Failure Mode and Effect Analysis (FMEA) questionnaire to the same respondents to assess each element's risk level [18].

Data Processing Techniques

1. Interpretive Structural Modeling (ISM) model depiction to provide a clear picture of the elements of the system, the flow of relationships, and the level of risk.
2. The graphic depiction of MICMAC (Matrix of Cross Impact Multiplications Applied to Classification) is a cross-impact multiplication matrix consisting of four quadrants or sectors to see risk elements influencing halal slaughter chicken products.
3. Preparation of the Failure Mode and Effect Analysis Halal Supply Chain (FMEA) table on slaughtered chicken products to see the value of the Risk Priority Number (RPN), which is categorized as critical as the focus of improvement, as well as provide recommended actions that can be taken against these risks[19]–[24].

The data processing flowchart of this research can be seen in Figure 1

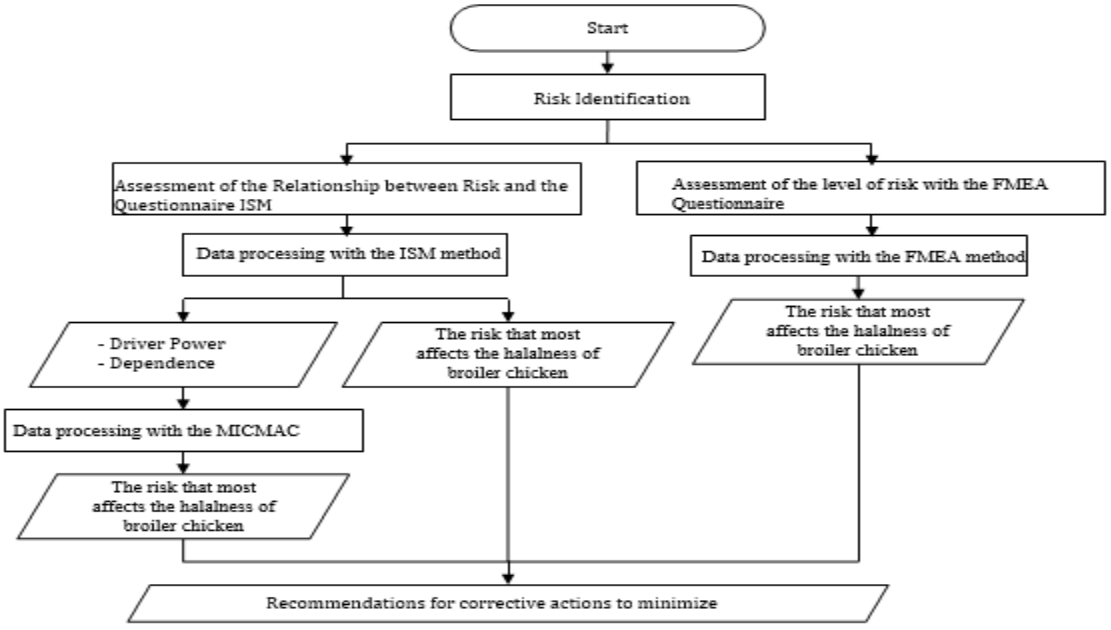


Figure 1. Data Processing Flowchart

RESULTS

Supply Chain Activity Mapping

Supply chain activities from downstream to upstream start from the leading supplier, the company PT. Charoen Pokphand Indonesia distributes to five large distributors in Medan. Then distributors send to slaughtered chicken entrepreneurs as soon as consumers receive slaughtered chicken through micro-scale slaughtered chicken entrepreneurs. The map of the information flow, material flow, and financial flow of the slaughtered chicken supply chain is shown in Figure 2.

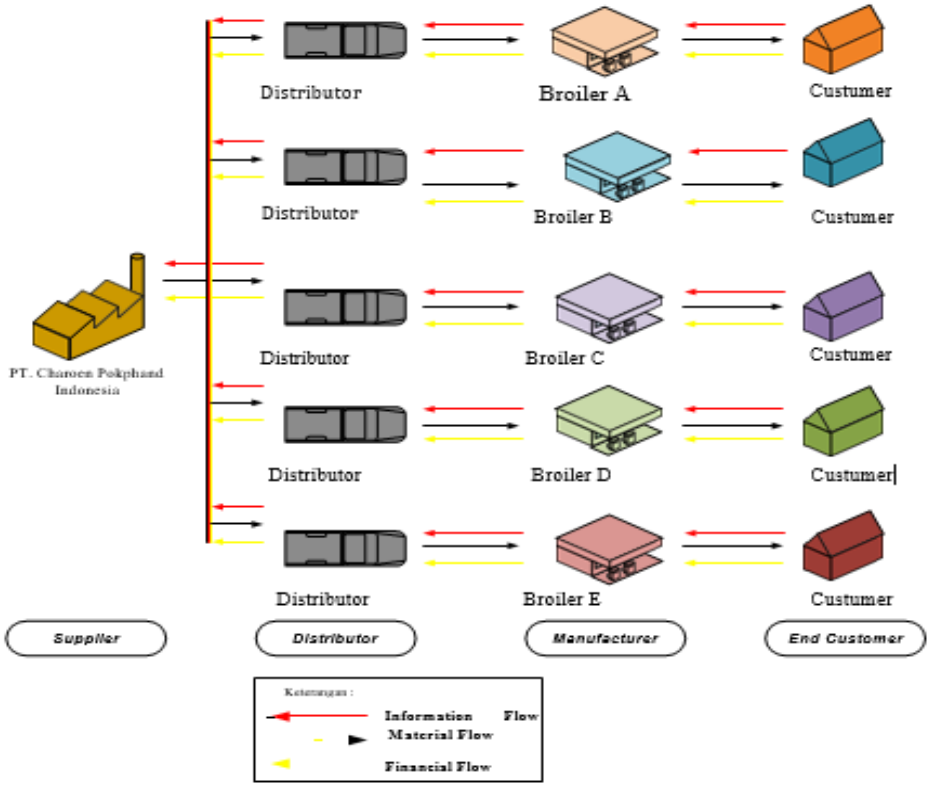


Figure 2. Slaughter Chicken Supply Chain Activities

Chicken Cutting Stages

Proper slaughtering of chickens will result in a final product in the form of whole carcasses or cut carcasses protected from infectious diseases. Chickens not meeting the requirements must be slaughtered separately after slaughtering healthy chickens. In RPA, which uses modern equipment, before slaughtering, the chickens are treated with electric shocks (stunning). The stages of killing chickens in a hygienic chicken slaughterhouse can be seen in Figure 3.

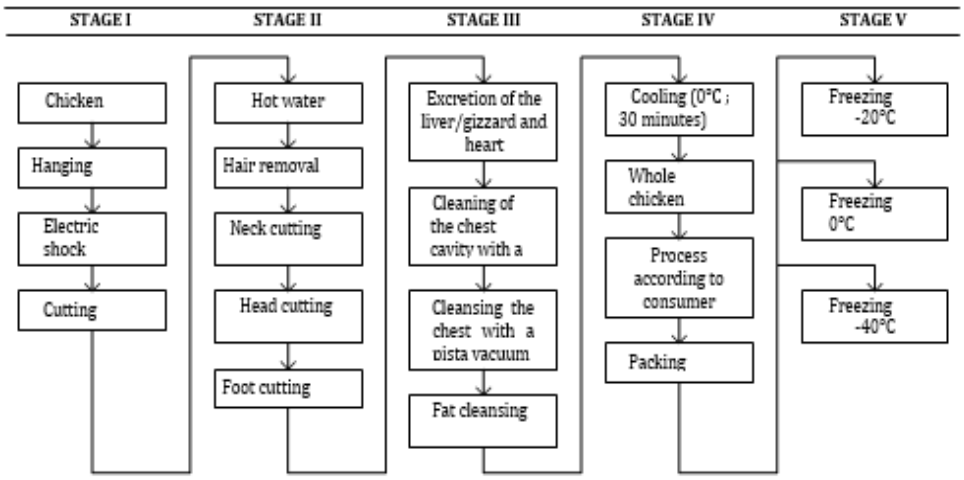


Figure 3. Stages of slaughtering chickens

Identify Potential Risks of Non-Halal in Slaughtered Chicken Supply Chain

Identification of halal slaughtered chicken starts with distribution activities, slaughter procedures, hygiene, work environment, and butcher. The results of identifying potential risks of non-halal in slaughtered chicken products are shown in Table 1.

Table 1 Identification of Potential Risk of Non-Halal in Slaughtered Chicken Supply Chain

Distribution	Supplier locations far from slaughtered chicken traders	E1	VALID
	Fatigue in chickens as a result of a considerable journey	E2	VALID
	Couriers are not careful in driving.	E3	VALID
	Couriers commit fraud	E4	VALID
	Chickens get sick on the way.	E5	VALID
	Chickens die on the way.	E6	VALID
Slaughter procedure	Not doing antemortem	E7	VALID
	Lack of accuracy when selecting quality Control chickens	E8	VALID
	Chickens are not given a rest period before slaughter	E9	VALID
	Slaughter is not by Islamic law.	E10	VALID
	Chickens die from stacking.	E11	VALID
	Chickens die from hot water decoction.	E12	VALID
Hygiene	Chicken boiling water is used repeatedly	E13	VALID
	Unhygienic hair removal machine	E14	VALID
	A chicken cutting knife is the same as a chicken slaughter knife	E15	VALID
	Unsold slaughtered chicken is frozen for sale the next day	E16	VALID
	There is residual dirt or blood on the innards of E17 VALID	E17	VALID
Milieu	Garbage of offal and chicken feathers scattered	E18	VALID
	The sewerage does not drain properly.	E19	VALID
	Dirty work environment	E20	VALID
Craftsman Slaughter	The slaughterer has not followed the halal slaughter certificate	E21	VALID
	Slaughterers do not apply Halal SOPs.	E22	VALID
	The slaughterer experiences fatigue.	E23	VALID

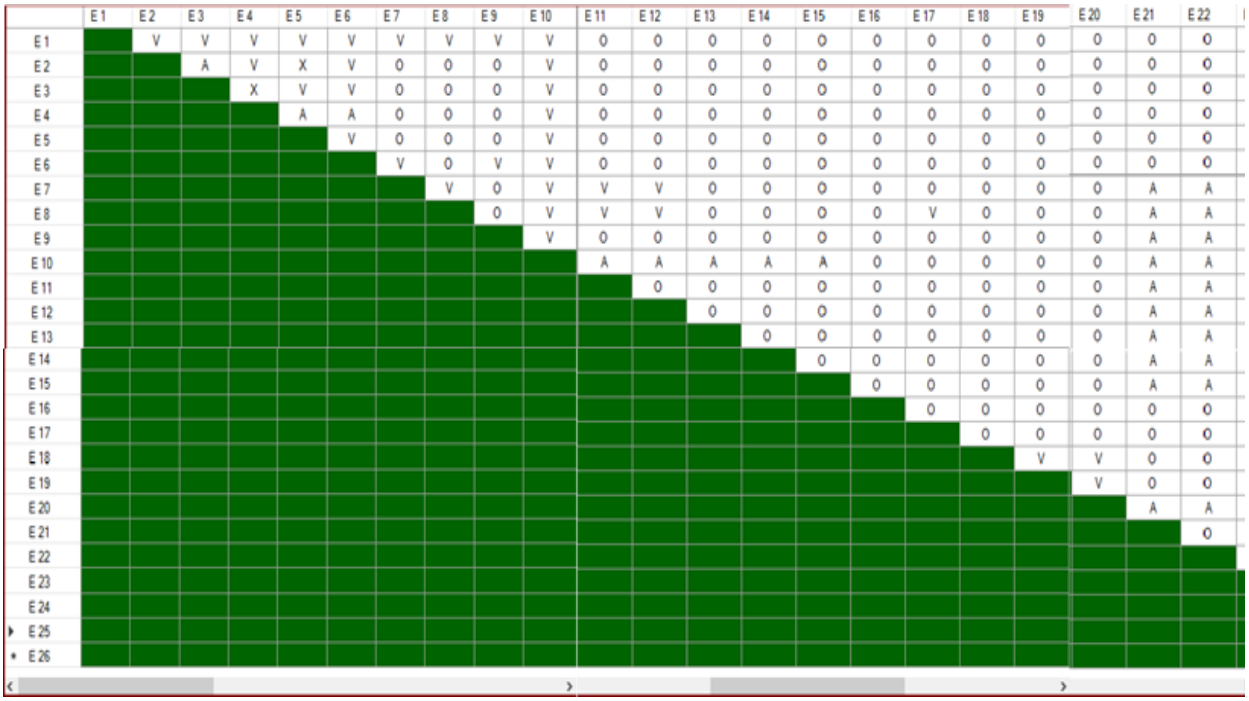
Lack of rest time for slaughterers	E24	VALID
Lack of workforce	E25	VALID
Overloaded workload	E26	VALID

Interpretive Structural Modeling (ISM)

Data processing using the ISM method will be carried out using ISM software. The stages carried out in the ISM method are step one of Risk Element Identification. This stage uses data to identify non-halal risks in slaughtered chicken products. Step 2 Contextual relationship: this stage of a contextual relationship is obtained from filling out the ISM questionnaire of 30 respondents. Step three is the Structural Self Interaction Matrix (SSIM). It is a matrix that will show the relationship between elements expressed in symbols V, A, X, and O, which have meanings, namely:

V= relationship from i to j, not vice versa
A= relationship from j to i, not vice versa
X = relationship from i to j, and vice versa
O= no relationship between i and j

The Reachability Matrix (RM) is constructed by converting SSIM symbols into binary numbers. Symbol V in SSIM: if eij=1 then eji=0, symbol A in SSIM: if eij=0 then eji=1, symbol X. The results of the Structural Self Interaction Matrix and Reachability Matrix (RM) are shown in Figure 4 and Figure 5.



	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15	E16	E17	E18	E19	E20	E21	E22
E1		V	V	V	V	V	V	V	V	V	O	O	O	O	O	O	O	O	O	O	O	O
E2			A	V	X	V	O	O	O	V	O	O	O	O	O	O	O	O	O	O	O	O
E3				X	V	V	O	O	O	V	O	O	O	O	O	O	O	O	O	O	O	O
E4					A	A	O	O	O	V	O	O	O	O	O	O	O	O	O	O	O	O
E5						V	O	O	O	V	O	O	O	O	O	O	O	O	O	O	O	O
E6							V	O	V	V	O	O	O	O	O	O	O	O	O	O	O	O
E7								V	O	V	V	V	O	O	O	O	O	O	O	O	A	A
E8									O	V	V	V	O	O	O	O	V	O	O	O	A	A
E9										V	O	O	O	O	O	O	O	O	O	O	A	A
E10											A	A	A	A	A	O	O	O	O	O	A	A
E11												O	O	O	O	O	O	O	O	O	A	A
E12													O	O	O	O	O	O	O	O	A	A
E13														O	O	O	O	O	O	O	A	A
E14															O	O	O	O	O	O	A	A
E15																O	O	O	O	O	A	A
E16																	O	O	O	O	O	O
E17																		O	O	O	O	O
E18																			V	V	O	O
E19																				V	O	O
E20																					A	A
E21																						O
E22																						
E23																						
E24																						
E25																						
E26																						

Figure 4. Structural Self-Interaction Matrix (SSIM)

	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15	E16	E17	E18	E19	E20	E21	E22	E23	E24
E1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E2	0	1	0	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E3	0	1	1	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E4	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E5	0	1	0	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E6	0	0	0	1	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E7	0	0	0	0	0	0	1	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
E8	0	0	0	0	0	0	0	1	0	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0
E9	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E10	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E11	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
E12	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
E13	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
E14	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0
E15	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
E16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
E17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
E18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
E19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
E20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
E21	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	1	1	0	0	0
E22	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	1	0	1	0	0
E23	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	1	1	1	0	1	1	1
E24	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	1	1	1	0	1	1	1
E25	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	1	1	1	0	1	1	1
E26	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	1	1	1	0	1	1	1
Dependence	1	4	3	6	4	5	9	9	5	21	5	5	3	3	3	1	2	5	6	9	1	5	4	4
Hiraki	8	5	6	3	5	4	2	2	4	1	4	4	6	6	6	8	7	4	3	2	8	4	5	5

Figure 5. Reachability Matrix (RM)

Based on Figure 4 and Figure 5 using ISM Professional V 5.0 software, it is obtained that the relationship between risks is divided into seven levels.

Modeling Interpretive Structural Modeling

This stage is the final stage of the ISM method, namely the drawing of the ISM model to provide a clear picture of the elements of the system and the flow of relationships. ISM modeling can be seen in Figure 6.

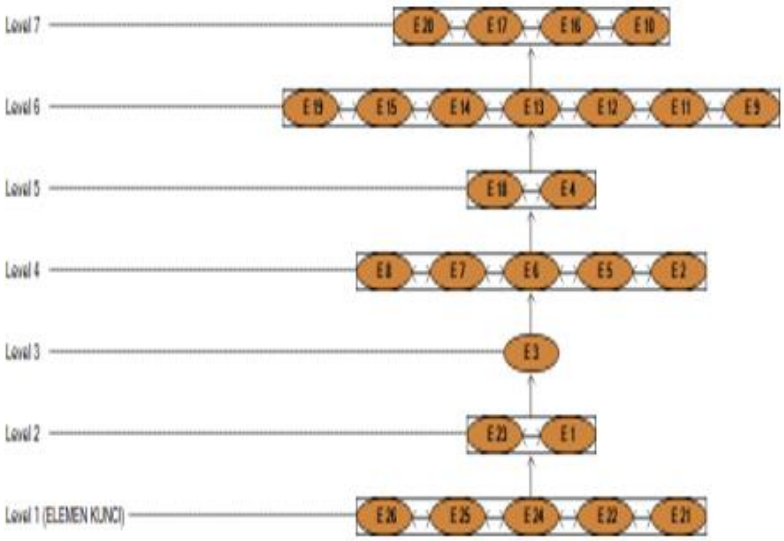


Figure 6. ISM Modeling with ISM Professional Software V 5.0

MICMAC Analysis

MICMAC Analysis is used to determine the relationship between development variables. Previously, these variables were grouped based on the dependence (dependence) and influence (influence) categories. MICMAC Analysis is shown in Figure 5.

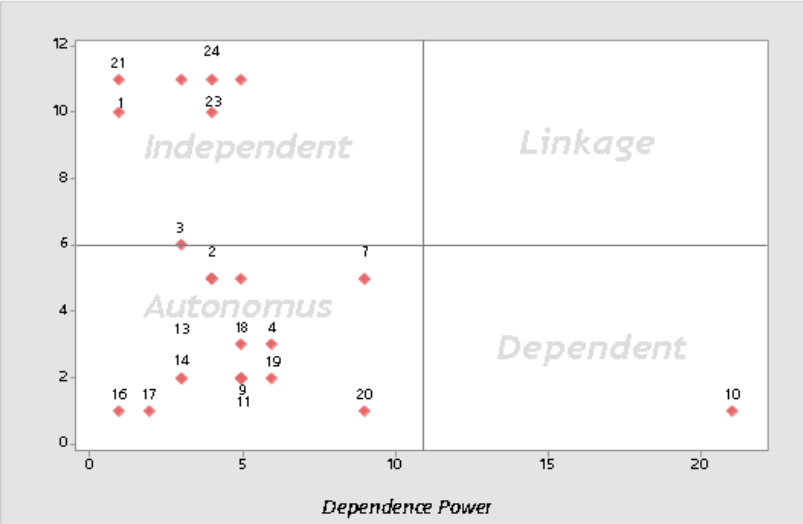


Figure 7. MICMAC Analysis

MICMAC (Matrix of Cross Impact Multiplications Applied to Classification) Analysis obtained that risk elements are categorized in four sectors VI-1 VI-2 or quadrants, namely sector 1 (autonomous), sector 2 (dependent), sector 3 (linkage), and sector 4 (independent).

Failure Mode and Effect Analysis (FMEA)

The stages carried out in the FMEA method are The process reviewed is the halal supply chain process for slaughtered chicken products, the potential failure mode in the halal supply chain process for slaughtered chicken products consists of distribution; slaughter procedure; hygiene; working environment; and butchers, identifying the potential effects of each potential failure mode, Determining Severity, Occurrence, Detection (SOD) Ratings. And recommendations for handling actions to avoid non-halal in the chicken supply chain. FMAE results and handling recommendations are shown in Table 2.

Table 2. FMAE Results And Handling Recommendations

Potential Failure Mode	Potential Effect	Potential Cause	S	O	D	RPN	Recommended actions for handling halal
Distribution	Supplier locations far from slaughtered chicken traders	Slaughter chicken traders do not consider location in supplier selection	4.8667	4.9	5.1667	124	We recommend that slaughtered chicken traders choose the nearest supplier from the business location.

	Fatigue in chickens as a result of a considerable journey	Slaughter chicken traders do not consider location in supplier selection	4.8	5.1667	4.2667	126	Slaughtered chicken traders choose the nearest supplier from the business location.
	Couriers are not careful when driving.	The courier does not have enough time to distribute the whole chicken.	4.4667	5	4.7667	107	Couriers are given sufficient delivery schedules
	Couriers commit fraud	The agent does not ask for proof of a report after the completion of delivery	4.8667	4.7667	4.5	105	The courier provides proof in the form of a report to the agent/toke after the completion of delivery.
	Chickens get sick on the way	Not conducting an antemortem before the delivery of chickens	5	5,4333	3,8333	105	Performing ante-more before chickens are delivered
	Chickens die on the way	Not conducting ante-more before the delivery of chickens	7.5333	6.6	5.7667	287	Performing ante-more before chickens are delivered
Slaughter procedure	Not doing antemortem	The operator rushes to unload chickens from the vehicle	4.8333	5.0333	4.8	117	Operators prioritize halal over time.
	Lack of accuracy when selecting quality Control chickens	The operator rushes to unload chickens from the vehicle	4.9667	5.1333	4.1667	107	Operators prioritize halal over time.
	Chickens are not given a rest period before slaughter	The distribution process has been delayed	5.0667	5.8667	4.3667	130	Couriers are given sufficient delivery schedules.
	Slaughter is not by Islamic law.	The slaughterer has not attended the training slaughter.	7.7333	7	5.5333	300	slaughterers are given Halal education
	Chickens die from stacking	Lack of containers for chickens after slaughter	7.9	6.7667	5.3	284	provided enough containers for chickens after slaughter
	Chickens die from hot water decoction	Operator in a hurry	7.6667	6.4333	5.7333	283	The chicken is left for up to 3 minutes after slaughter, and it is confirmed that it has completely died.

Hygiene	Chicken boiling water is used repeatedly	Chickens Contaminated with Manure	6.3	5.6	4.6	163	Chicken boiling water is only used once; the subsequent boiling is replaced with clean water.
	Unhygienic hair removal machine	Chickens Contaminated with Manure	5.5667	5.4667	4.70	144	Hair removal machine-cleaned daily
	A chicken cutting knife is the same as a chicken slaughter knife	Chickens Contaminated with Manure	5.6333	4.7	4.7333	126	Distinguished between a knife for slaughter and a knife for slaughtering chickens
	Unsold slaughtered chicken is frozen for sale the next day	Chickens Contaminated with Manure	5.6667	5.0667	4.7	135	Unsold slaughtered chicken is sold to restaurants that will directly process the chicken on the same day.
	There is residual dirt or blood on the viscera	Chickens Contaminated with Manure	5.3333	5.7333	5.1667	158	Chicken cutters are more thorough in cleaning the inside of the chicken
Milieu	Garbage of offal and chicken feathers scattered	Foreign bodies stick to chicken meat	5.5667	5.5667	4.9667	154	Provided Recycle Bins and accustomed to throwing garbage in the sampa basket
	Sewerage does not drain properly	Chicken skin is not washed off	5.4667	5.3333	5.5333	162	not throwing garbage into the sewer
	Dirty work environment	Mixed with feces	5.6667	5.4333	5.3	164	Cleaning the work environment every day
Butcher	The slaughterer has not followed the halal slaughter certificate	Slaughterers do not understand the importance of maintaining halal food	7.2667	6.9333	5.9	298	Every slaughterer is required to attend halal slaughterer training.
	Slaughterers do not apply Halal SOPs.	Violating Islamic Sharia	7.5	6.4	6.1	293	The slaughterer is always motivated to apply the slaughter training he follows.

The slaughterer experiences fatigue.	Not by Islamic Sharia	5.5	4.7667	4.8	126	The slaughterer is given enough rest time.
Lack of rest time for slaughterers	Incorrect Slaughter Technique Result	5.5333	5.1667	4.5	129	The slaughterer is given enough rest time.
Lack of workforce	Slaughter is not maximal	5.2	4.6	4.9667	119	Number of workers adjusted to the workload
Overloaded workload	Slaughter is not maximal	5.3667	4.6333	4.5667	114	Number of workers adjusted to the workload

DISCUSSION

Identification of the risk of contamination of the halal supply chain in broiler chicken products consists of 26 risk elements, recommendations for corrective action based on an assessment of the contextual relationship between risk elements, including butchers should be given sufficient rest time and the number of workers should be adjusted to the workload, as well as action recommendations improvement based on an assessment of the level of risk for each element, among others, it is better if the slaughterer is given education and motivation; it is better if every slaughterer is required to take part in halal slaughterman training; slaughterers should be motivated to consistently apply the slaughter training they participate in; should be done ante-mortem before the chicken is delivered; there should be sufficient containers for chickens after slaughter; and it is better if the chicken is left for up to 3 minutes after being slaughtered and it is ensured that the chicken is really dead, the findings and recommendations are also in accordance with the [25] study. The results showed 38 risk events and 27 risk agents for animal welfare, halal, and safety in the meat industry supply chain medium-scale broiler chickens. The risk agents with the highest ARP values are technical errors in broiler meat storage by retailers (A26), with an ARP value of 144, and management errors in broiler meat storage by chicken slaughterers (A15), with an ARP value of 126. These risk agents are also prioritized based on the Pareto chart with a cumulative value of 30.65% of the total ARP value. Recommendations for as many as six risk mitigation strategies were generated by brainstorming to prevent the emergence of priority risk agents in the supply chain of the medium-scale broiler meat industry. Meanwhile, research [26] The slaughter process that is not by Islamic law has the potential risk of decreasing product quality and being unclean because initially, a product with halal status will become haram if other substances with haram status are mixed with halal substances. The benefit that will be taken is the creation of consumer loyalty for broiler chicken products with a clear-cut method.

CONCLUSION

Risk identification of non-halal in slaughtered chicken products consists of 26 risk elements. The risks recommended to be the main focus in improvement are slaughter, not Islamic religious law. The slaughterer has not attended halal slaughterer training, and the slaughterer does not apply the slaughter training he followed, chickens dying on the way, chickens die from piling up, chickens die from hot water stew, lack of rest time for slaughterers, lack of labour, and excessive workload.

Recommendations for corrective actions to minimize risk are that slaughterers are given education and motivation, every slaughterer is required to attend halal slaughterer training, slaughterers are given motivation always to apply the slaughter training they follow, antemortem should be done before the chicken is delivered, enough containers are provided for chickens after slaughter,

chickens are left for up to 3 minutes after massacre, and it is confirmed that the chickens have completely died, Slaughterers should be given enough rest time, and the number of workers should be adjusted to the workload.

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