

**ENHANCING RISK MITIGATION STRATEGIES IN INNOVATIVE POULTRY
SLAUGHTERHOUSES: A HOUSE OF RISK METHOD APPROACH****Widi Astutik¹, Mujaddid², Januar Kulsaputro³, Asrul Fole⁴, Nurwindy Yanasim⁵**¹²³⁵) Study Program in Industrial Engineering, Institut Teknologi dan Bisnis Nobel Indonesia.⁴)Department of Industrial Engineering, Universitas Muslim Indonesia.Email: widiastutik@nobel.ac.id¹, mujaddid@nobel.ac.id², januar.kulsaputro@nobel.ac.id³, asrulfole@umi.ac.id⁴**Abstract**

The objective of this study is to identify and examine potential risk factors that could disrupt the production process at the Makassar poultry slaughterhouse. In the monthly risk evaluation, RPA currently conducts monthly risk assessments without identifying the root causes of issues. By applying the Current Reality Tree (CRT) and House of Risk (HOR) methods, 28 risk events and 23 risk agents have been successfully identified. After calculations using the HOR model, 12 risk agents were selected, contributing 80% of the total cumulative Aggregate Risk Potential (ARP) as priorities for handling. Thirteen action items have been ranked based on Expected Time to Danger (ETD) using HOR phase 2. As a recommendation, it is advised to implement the findings of this research and focus on departments relevant to the investigated risks. With an innovative and data-driven approach, it is expected that MPS can optimize its operations and enhance business sustainability in facing existing risk challenges.

Article History*Submitted: 27 July 2024**Accepted: 4 August 2024**Published: 5 August 2024***Key Words**

Risk, Current Reality Tree, House of Risk, Poultry Slaughterhouse.

1. Introduction

Products derived from poultry processing as the primary source of global animal protein consumption: A Review According to the United Nations' Food and Agriculture Organization (FAO) (Henchion et al., 2021). Poultry meat consumption in Indonesia is still below the global average (Uzundumlu & Dilli, 2023), which is 12.7 kg per capita compared to the global average of 15 kg per capita, despite an annual trend of 11.22% due to population growth (Faqih et al., 2020). The Ministry of Agriculture has called for an increase in the consumption and production of high-quality poultry meat because this figure is also significantly lower compared to the per capita consumption of poultry meat in neighboring countries, which is 38 kg (Sun et al., 2020).

The poultry industry in Indonesia is the most important sector in the national economy, contributing 65% of animal protein and employing 10% of the national workforce (Ilham et al., 2021). Makassar Poultry Slaughterhouse (MPS) prepares fresh chicken meat for consumer use. The company has an MPS that meets health, animal welfare, and halal standards (Kaco & Fitriana, 2020). Furthermore, we use cutting-edge technology and management systems to ensure the quality and quantity of our products. The company offers various types of fresh chicken, including carcasses, boneless cuts, breasts, thighs, wings, skin, feet, head, gizzard, liver, and spleen. Furthermore, the company maintains good relationships with suppliers, farmers, and customers. The company aims to provide the Indonesian community with fresh, healthy, and hygienic halal chicken products.

Due to the broad market, strong demand, and wide distribution reach, poultry slaughterhouses must maintain and improve the quality of their products (Kusuma, 2023). The goal of a poultry slaughterhouse is to avoid potential risks that can disrupt the production process. Maintaining and enhancing product quality always involves various potential risks (Jagtap et al., 2021). According to the definition in the Kamus Besar Bahasa Indonesia (KBBI), the risk is defined as "unpleasant consequences (dangerous, harmful) of an action or event". In the context of production systems, risk is considered detrimental if the production outcomes do not meet the desired standards (Sugianto et al., 2024). Therefore, risks in production activities encompass factors that directly or indirectly can lead to production outcomes not meeting the desired standards, such as microbial contamination, product quality decline, worker health and safety issues, supply chain disruptions, and regulatory violations (Fole, 2023).

For example, the risk of microbial contamination is a common potential risk in the meat processing industry, including poultry slaughterhouses, such as contamination with *Salmonella* or *E. coli* (Cegar et al., 2022). If not handled properly, such contamination can pose health risks to consumers who consume these products (Bravo et al., 2023). Additionally, the risk of product quality decline can occur during the production process due to uncontrolled temperature fluctuations and unhygienic handling (García-Díez et al., 2023). This can result in product spoilage, unpleasant odor, or poor texture (Meiramkulova et al., 2020). Production activities in poultry slaughterhouses also involve risks to worker health and safety, such as injuries from improper cutting and meat processing. There is also a danger of supply chain disruption, such as delays or failures in the delivery of fresh poultry or finished products, which can hurt product quality and availability. Furthermore, regulatory violations can lead to the risk of non-compliance, potentially resulting in legal sanctions, temporary closures, or loss of customer trust (Kiš et al., 2023). Implementing risk management is an effective way to mitigate these hazards.

Risk management is a set of actions that involve the identification, measurement, evaluation, response, and monitoring of risks associated with business or production operations (Kusrini et al., 2022). One step in risk management is the House of Risk (HOR). HOR is a modification of the Quality Work Arrangement (QFD) House of Quality (HOQ) concept combined with Disappointment Mode and Impacts Examination (FMEA) (Fole, 2023). It involves determining the impacts of risks, the probability of their occurrence, and their priority. To identify the root causes of risks, the Current Reality Tree (CRT) technique is used. CRT is a graph designed to identify the root causes of negative impacts (Diansyah & Adhiutama, 2023). The Future Reality Tree (FRT) is a chart that depicts the expected situation after taking action against the identified root problems in the CRT (Sumitro, 2022). MPS manages risk by assessing issues and occurrences at monthly meetings. However, the handling provided does not comprehensively include the identification of risks.

This study was carried out at MPS, as previously mentioned. This study will use the CRT approach to identify and investigate risk factors that may interrupt the MPS production process. Furthermore, this study uses the House of Risk technique to evaluate the priority sequence of risk agents and build appropriate risk mitigation solutions. The findings of this study are likely to help MPS reduce risks related to its production operations by using novel risk mitigation techniques.

2. Research Methods

This study is descriptive research conducted utilizing a survey research approach that includes a variety of questions, addressing issues from multiple perspectives, notably in revealing views, attitudes, and other factors. Data for this study were gathered through observations of activities in the Dirty Area, which included the Unloading Area, Killing Area, and Eviscerating Area, as well as the Clean Area, which included the Chilling Area, Cut-up Area, and Warehouse Area, accompanied and guided by responsible personnel and area supervisors at the Poultry Slaughterhouse. Furthermore, interviews and brainstorming sessions were done with expert guidance from company management and specialists familiar with the organization's business procedures. These interviews focused on risk incidents and sources in the supply chain. Data were then collected by filling out questionnaires, which included giving numbers to risk effect (severity), risk likelihood (occurrence), and the strength of correlation between risk occurrences and risk agents.

The data for this study were analyzed by identifying the production processes at the MPS. The data collected included risk events, their severity level, risk sources, occurrence frequency, correlation between risk events and risk sources, proposed proactive actions, correlation between risk sources and proactive actions, and the degree of difficulty associated with proactive actions. The data was then analyzed by mapping production operations, detecting risks using the Current Reality Tree, conducting risk analysis, evaluating and reducing hazards using the House of Risk technique, and developing Pareto diagrams and risk maps.

3. Results and Discussion

3.1. Results of identifying the chicken slaughterhouse production process

To identify risk agents and risk occurrences, the researcher made direct observations during production activities and interviewed and discussed them with respondents. The results of the production activities in the Dirty Area and Clean Area are presented in the following table 1.

Table 1. The Manufacturing Process of The Poultry Slaughterhouse

Activity	Description
Dirty Sector (Unloading)	The activities include receiving chickens from suppliers, inspecting the quality and health of the chickens, weighing, relaxing, hanging, and counting the quantity of chickens.
Dirty Sector (Killing)	Sorting chickens, killing, scorching, plucking feathers, and removing chicken necks and feet are among the duties.
Dirty Sector (Eviscerating)	These activities include byproduct elimination, gutting, crop removal, remaining offal chopping, and byproduct weighing.
Clear Sector (The chilling procedure)	The process involves the scalding tank, grading, and chilling.
Clear Sector (Cut-up)	Aside from special orders for complete carcasses, birds will be processed into boneless, parting, special finishing goods, and unique product requests.
Clear Sector (Warehouse)	MPS accepts orders for fresh chickens that will be delivered on the same day after processing, as well as frozen chickens for further distribution.

3.2. Results of Risk Identification

Risk identification is carried out utilizing the HOR method, which includes not only risk events but also risk agents. Risk occurrences are identified, as well as the associated risk agents or causes. The business process identifies the following risk events and risk agents. Using the CRT Model, 28 risk events and 23 risk agents are identified.

The risk events' intensity or impact (occurrence) will next be assessed. Table 2 shows the assessment of severity (risk impact).

Table 2. MPS Severity Assessment Findings

Code	Risk Event	Severity
E1	Accumulation during chicken getting from the supplier	7
E2	Inaccurate number of chickens from the supplier	7
E3	The mismatch in the standard quality of chickens	7
E4	Obstacle in Chicken Health check	3
E5	The chickens with damp feathers high	7
E6	The chicken resting stage is less than 15 minutes	4
E7	Miscalculation of the chicken amount	6
E8	The temperature of cut-up stage carcasses exceeds 4°C	7
E9	The labeling problems on packages	4
E10	There is a defect in the cut part	3
E11	Failure to meet the chicken amount throughout the production procedure	5
E12	Hindered mobility in crate movement	2
E13	Workplace accidents in the production process	6
E14	Idle workers in some areas	6
E15	Lack of concentration from workers in the production process	7
E16	Inability to meet target rate in the slaughtering process	6
E17	Retrieval of innards (spoon) damages the liver	3
E18	Trip to the plucking machine	4
E19	Chickens become stuck in the claw-cutting machine	1
E20	Chickens die during the bleeding process	7
E21	The check weigher machine for grading is damaged	7
E22	Insufficient quantities for various chicken categories	6
E23	Chicken quality deteriorates when frozen	6
E24	Defective packing	3
E25	Machines that are getting old	7
E26	Breakdown of the machinery	6
E27	Failure to discharge waste from blood and chicken feathers	7
E28	Inventory that remains unutilized	5

The following 23 risk agents can be identified based on the findings of the Current Reality Tree Model in the manufacturing process activities in the Clean Area and Dirty Area, as indicated in Table 3 below:

Table 3. Identification Risk Agent

Code	Risk Agent	Occurrence
A1	The chicken delivery process is experiencing a delay	3
A2	There was a mistake in communicating with the chicken supplier	2
A3	The chickens perished while being transported in a car	5
A4	Standard operating procedures (SOP) and the agreed-upon agreement were not followed by the supplier	3
A5	Five viral illnesses, including avian influenza, infectious bursal disease, Newcastle disease, cholera, and salmonellosis, are present in the hens	1
A6	The producing area's water faucet is damaged	1
A7	The employee is lacking in their area of competence	3
A8	The ice retrieval process causes the floor to become slick	2
A9	Regular machine checkups and maintenance were done incorrectly	3
A10	There is a problem with the air conditioner in the clean area	2
A11	The unloading procedure had a mistake	2
A12	The supervisor is not adequately monitoring the production area	1
A13	Consumer demand for the goods has suddenly increased	5
A14	There is a range of +/- 10% for usage homogeneity	9
A15	There aren't many slaughterhouses with Halal MUI certification	4
A16	The production department employees are feeling worn out	2
A17	The hens' size does not adhere to the specified standards	4
A18	The daily work schedule was not planned correctly	2
A19	The production area employees are not following the stated Standard Operating Procedures (SOP)	2
A20	The producing region does not exhibit a notable implementation of 5R / 5S	6
A21	In the production area, there is a power disruption	1
A22	Adding the most current data to the special orders category	2
A23	In the chicken processing house, there was a breakdown in communication between the departments	1

The next step is to use the HOR technique to make calculations based on the data collected from the respondents after determining the risk event and risk agent.

3.3. House of Risk Phase 1

The risk management process in House of Risk Phase 1 begins by creating a matrix to determine the relationship or linkage between risk events and risk agents. Then, the calculation of ARP (Aggregate Risk Potential) will be conducted, where the obtained ARP values will be used to determine the ranking of risk agents to identify the most dominant or priority risk agents for mitigation measures, as shown in Table 4 below:

Table 4. House of Risk (HOR) Matrix Phase 1

Risk Event	Risk Agent																							Severity
	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	A21	A22	A23	
E1	9			3			1									1							1	7
E2	9	3		9									1										3	7
E3			1	9	9					9				9										7
E4	1					9	3											3					3	3
E5				9																				7
E6	3	1														1								4
E7															1			3						6
E8							3			9						9				3				7
E9							9								1			9	3					4
E10							9								9				9					3
E11	9	1	9	3	9								9	1										5
E12								3										1	9					2
E13							9				3	9				3		3				1		6
E14	9	1		3	3	3						9				9		9				9		6
E15	9	1		3								9			3			9			1	9	3	7
E16					9										3	9			9				3	6
E17							3									9				3				3
E18								9		9						9			9				1	4
E19							9		3									9						1
E20	1	1	3	3					9														9	7
E21								9																7
E22													9	9								3		6
E23							1							1		1		3			9			6
E24										9						3		3	9	3				3
E25								9									3	3	9	3		9		7
E26									9												9			6
E27									3											9		1	1	7
E28	1			1			3						3											5
Occurrence	3	2	5	3	1	1	3	2	3	2	2	1	5	9	4	2	4	2	2	6	1	2	1	
ARP	945	100	365	870	180	27	660	120	720	180	162	108	920	1152	372	558	36	454	408	600	234	218	213	
Ranking	2	21	12	4	16	23	6	19	5	17	18	20	3	1	11	8	22	9	10	7	13	14	15	

In the House of Risk (HOR) Phase 1 matrix, the ARP values for each risk agent are determined. The ranking of risk agents based on ARP values is also identified. The ranking results of ARP will serve as input for the Pareto diagram to determine the most dominant risk agents that significantly impact the business processes and prioritize them for mitigation measures.

Risk evaluation is conducted by focusing on the most dominant or prioritized risk agents. The Pareto diagram is utilized to determine the dominant risk agents based on ARP values. The principle behind the Pareto diagram is the 80:20 rule, which states that 80% of the issues can be resolved by addressing 20% of the root causes (Herdianzah, 2020; Malik et al., 2024).

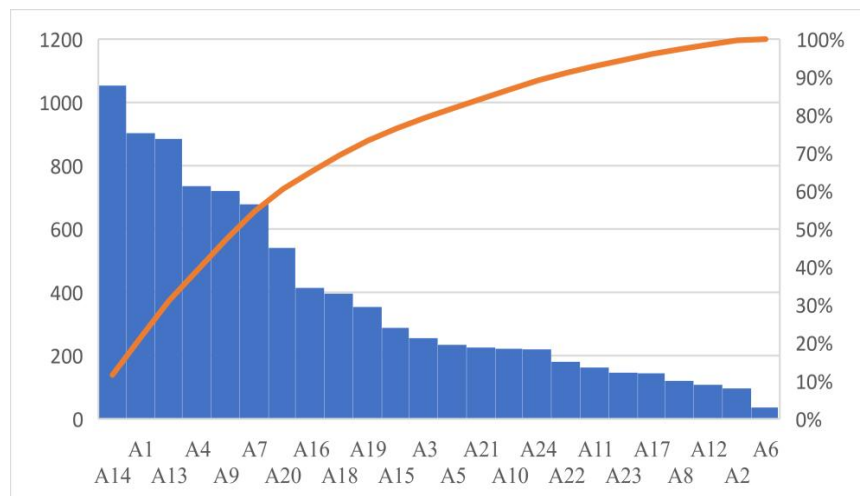


Figure. 1. Pareto Diagram Result of House Of Risk Phase 1

From the Pareto diagram results, the 12 Risk Agents that are taken to the next phase because they account for 80% of the issues are A14, A1, A13, A4, A9, A7, A20, A16, A18, A3, A19, and A15. These 12 risk agents are listed in Table 5 as follows:

Table 5. Risk Agents Meeting 80% of The Pareto Diagram

Rank	Code	Risk Agent	ARP	% ARP	Si	Oj
1	A14	The usage uniformity is within a range of +/- 10%	1152	12,02	7	9
2	A1	The chicken delivery process is experiencing a delay	945	9,86	7	3
3	A13	There is a sudden demand for the product from consumers	920	9,60	3	5
4	A4	The supplier did not comply with the standard operating procedures (SOP) or the agreed-upon agreement	870	9,08	8	3
5	A9	There was an error in conducting regular machine checks or maintenance	720	7,51	7	3
6	A7	The worker has a deficiency in their field of expertise	660	6,89	5	3
7	A20	The implementation of 5R / 5S is not prominently observed in the production area	600	6,26	3	6
8	A16	The workers in the production department are experiencing fatigue	558	5,82	6	2
9	A18	There was an error in planning the daily work schedule	454	4,74	7	2
10	A19	The workers in the production area are not complying with the established Standard Operating Procedures (SOP)	408	4,26	7	2
11	A15	The number of certified Halal MUI slaughterers is limited	372	3,88	4	4
12	A3	The chickens died during the transportation process using a vehicle	348	3,63	5	5

Next, we create a risk map as a risk assessment tool. The scales for severity and occurrence are changed to 5 categories of assessment levels according to the following criteria. The positions of the Risk Agents obtained and already included in the risk map are shown as follows in Table 6:

Table 6. Risk Map

Occurrence Level	Severity Level				
	1 Very Low	2 Low	3 Medium	4 High	5 Very High
5 Very High				A14	
4 High					
3 Medium		A13 A20	A15 A3		
2 Low			A7	A1 A9	A4
1 Very Low			A16	A18 A19	

3.4. *House of Risk Phase 2*

In House of Risk Phase 2, the processing is carried out by designing mitigation actions or preventive actions against dominant risk agents. The goal is to determine which mitigation actions or preventive actions will be prioritized in managing risks and reducing their impact.

Table 7. Preventive Action

Code	Preventive Action	Risk Agent
PA1	Implementing appropriate quality control methods to reduce undesired uniformity	A14
PA2	Supplier performance evaluation is conducted to assess their performance in delivering goods or services.	A1, A4, A7, A3
PA3	The development of binding SOPs is carried out towards suppliers as operational guidelines.	A1, A4, A7, A3
PA4	Safety stock procurement is conducted to ensure adequate supply availability.	A13
PA5	Performing scheduled preventive maintenance to ensure optimal performance.	A9
PA6	Providing TPM (Total Productive Maintenance) training to workers to improve productivity efficiency.	A9, A7, A20, A19
PA7	Improving the quality and quantity of the provided training.	A14, A9, A7, A20, A16, A18, A19, A15
PA8	Implementing a system of punishment and rewards as a motivational incentive for employees.	A9, A7, A20, A16, A18, A19
PA9	Implementing the 5R/5S methodology in the production area to maintain cleanliness and orderliness.	A9, A20
PA10	Conducting employee workload evaluation to measure the level of tasks undertaken.	A16, A19
PA11	Improving the quality of internal communication to enhance effectiveness and efficiency.	A9, A20, A18
PA12	Implementing an easily accessible interdepartmental information system	A9, A18
PA13	Increasing the number of workers with MUI halal certification is a requirement.	A15

After formulating mitigation or preventive actions, the degree of difficulty in performing the actions (D) will be assessed, followed by calculating the total effectiveness of the actions (TE) and the effectiveness to Difficulty (ETD) ratio. The processing will be carried out using the house of risk matrix phase 2, which will determine which mitigation or preventive actions should be prioritized in risk management, as shown in Table 8 below:

Table 8. House of Risk (HOR) Matrix Phase 2

Risk Agent	Preventive Action													ARP
	PA1	PA2	PA3	PA4	PA5	PA6	PA7	PA8	PA9	PA10	PA11	PA12	PA13	
A14	9						1							1152
A1		9	9											945
A13				9										920
A4		9	9											870
A9					9	9	3	1	3		3	1		720
A7		1	1			1	9	9						660
A20						3	1	1	9		1			600
A16							1	1		9				558
A18							1	1			9	9		454
A19						1	3	9		1				408
A15							1						9	372
A3		3	3											348
TE	10368	18039	18039	8280	6480	9348	12460	11944	7560	5430	6846	4806	3348	
D	4	3	3	4	3	5	3	2	3	2	4	4	3	
ETD	2592	6013	6013	2070	2160	1870	4153	5972	2520	2715	1712	1202	1116	
Ranking	6	3	4	9	8	10	2	1	7	5	11	12	13	

Based on the table above, the prioritized sequence of mitigation or preventive actions can be seen in the following Table 9:

Table 9. Ranking Preventive Action

Rank	Code	Preventive Action
1	PA8	Implementing a system of punishment and rewards as a motivational incentive for employees.
2	PA7	Improving the quality and quantity of the provided training.
3	PA2	Supplier performance evaluation is conducted to assess their performance in delivering goods or services
4	PA3	The development of binding SOPs is carried out towards suppliers as operational guidelines.
5	PA10	Conducting employee workload evaluation to measure the level of tasks undertaken.
6	PA1	Implementing appropriate quality control methods to reduce undesired uniformity
7	PA9	Implementing the 5R/5S methodology in the production area to maintain cleanliness and orderliness.
8	PA5	Performing scheduled preventive maintenance to ensure optimal performance.
9	PA4	Safety stock procurement is conducted to ensure adequate supply availability.
10	PA6	Providing TPM (Total Productive Maintenance) training to workers to improve productivity efficiency.
11	PA11	Improving the quality of internal communication to enhance effectiveness and efficiency.
12	PA12	Implementing an easily accessible interdepartmental information system
13	PA13	Increasing the number of workers with MUI halal certification is a requirement.

Implementation of proposed handling actions for risk agents in the red zone A14 involves performing PA1 and PA7. Meanwhile, risk agents in the orange zone A4 require performing PA2 and PA3. The implementation of these handling actions is expected to reduce the occurrence and severity levels as shown in the risk map Table 10 provided below.

Table 10. Risk Map After Proposed Handling Actions

Occurrence Level		Severity Level				
		1 Very Low	2 Low	3 Medium	4 High	5 Very High
5	Very High					
4	High					
3	Medium		A13 A20	A3 A7 A14		
2	Low			A15	A1 A9	
1	Very Low			A16	A4 A18 A19	

Based on the implemented mitigation actions, efforts have been made to reduce the risks associated with risk agents A14 and A4. For A14, the mitigation actions implemented include implementing appropriate quality control methods to reduce undesired uniformity and improving the quality and quantity of training provided. Although measurement of uniformity is still needed for chicken supplies from external sources, these steps have shown improvements in risk management. For A4, the mitigation action involves conducting supplier performance evaluations to assess their adherence to SOPs or agreements, minimizing any violations. While not fully achieving the green zone, these mitigation measures demonstrate an awareness of the importance of effective risk management. This reflects a focus and commitment to ongoing mitigation efforts and continuous improvement in reducing the associated risks of A14 and A4 risk agents.

3.5. Discussion on Risk Identification

The identification of risk agents and risk events is conducted using the Current Reality Tree (CRT) method, which involves discussions, interviews with field workers, managers, and supervisors, as well as a literature review. The results of this identification process consist of 28 risk events such as accumulation during chicken receiving from suppliers, inaccurate quantity of chickens from suppliers, mismatched standard quality of chickens, and so on. Additionally, there are 23 risk agents like delays in the chicken delivery process, mistakes in communicating with chicken suppliers, and chicken deaths during transportation using vehicles. The House of Risk (HOR) method is then used in the next step, specifically HOR Phase 1. In this phase, severity levels are assigned to risk events, and occurrence levels are determined to assess how often risk agents contribute to the occurrence of risk events. A scaling system from 1 to 9 is used for both categories, with 1 indicating a very low level and 9 indicating a very high level. The findings regarding risk events, risk agents, severity, and occurrence are incorporated into the HOR Phase 1 matrix to determine the correlation between each risk event and risk agent. This matrix provides an Aggregate Risk Potential (ARP) value, which is then utilized to prioritize mitigation plans for the existing risk agents.

The application of the House of Risk (HOR) method in Phase 1 resulted in a total of 12 risk agents, which encompassed 80% of the cumulative identified issues. These twelve risk agents were selected to be further processed in the subsequent phase.

Risk agent A14 is related to the usage uniformity within a range of +/- 10% during the unloading process that involves weighing chicken samples. In this stage, appropriate quality control methods are implemented to reduce undesired uniformity in the weight of chicken samples. Experts believe that the presence of uniformity within +/- 10% directly affects the desired weight category planning during forecasting and the planning of actual incoming chicken categories. Therefore, this activity is assessed with a severity level of 7 and an occurrence level of 9. When calculating the Aggregate Risk Potential (ARP), a value of 1152 is obtained, which is equivalent to 12.02% of the total identified risk agents, as previously conducted by (Sumitro, 2022).

Risk agent A1 is related to the chicken delivery process experiencing a delay, which leads to consequences such as waiting time and disruptions in production schedules. Evaluating delays caused by internal factors is easier compared to delays caused by external factors. Experts believe that internal delays are rare, while delays are more likely to originate from external parties, considering the supplier's performance evaluation in delivering goods or services, and the development of standard operating procedures (SOPs) as operational guidelines towards suppliers. Therefore, this risk agent is assigned an occurrence value of 3. If this risk agent occurs, it can have a significant impact on overall production activities, and experts assign a severity value of 7 to this risk agent. When calculating the Aggregate Risk Potential (ARP), a value of 945 is obtained, which is equivalent to 9.86% of the total identified risk agents, as previously conducted by (Leng & Corman, 2020).

Risk agent A13 is related to the sudden demand for the product from consumers. Since RPA Makassar implements a Make to Order (MTO) system, the production process relies on customer orders. Sudden consumer demand can impact production processes and planning. When the product is not available to meet the sudden demand, there is a potential missed opportunity for increased profits (Dulam et al., 2021). However, since the company maintains inventory in the warehouse, the impact of this event is not significantly detrimental, and experts assign a severity value of 3. The experts also assign an occurrence value of 5 to this risk agent, as such occurrences are relatively infrequent. When calculating the Aggregate Risk Potential (ARP), a value of 920 is obtained, which is equivalent to 9.60% of the total identified risk agents.

Risk agent A4 is related to the supplier's non-compliance with the standard operating procedures (SOP) or the agreed-upon agreement. Incidents such as suppliers arriving earlier than promised, leading to congestion in the unloading area, as well as sudden and unilateral delivery cancellations, have occurred according to experts, albeit infrequently, and are assigned a value of 3 for occurrence. Although the occurrence rate of this risk is low, its impact is significant as it directly affects several risk events, such as congestion in the unloading area, non-compliance with planned production quantities, and idle workers when deliveries are canceled (Nafi'ah & Mahbubah, 2021). Therefore, the experts assign a severity value of 8 to this risk agent. When calculating the Aggregate Risk Potential (ARP), a value of 870 is obtained, which is equivalent to 9.08% of the total identified risk agents.

Risk agent A9 is related to errors in conducting regular machine checks or maintenance. The production process at RPA Makassar heavily relies on the use of machines. Some machines play vital roles, and if they experience damage, it can hinder or even halt production activities. These machines include the Shackle, which is essential for transferring chickens between workstations, the scalding machine for boiling slaughtered chickens, the plucked machine for feather removal, the Chilling Tank for washing, cleaning, and maintaining the chicken's temperature at $\leq 40^{\circ}\text{C}$, the Check Weigher for automated grading, and the Metal Detector during the packaging stage. Errors in machine maintenance are rare, so the experts assign an occurrence value of 3. However, if such errors occur, they can have a significant impact, leading the experts to assign a severity value of 7 to this risk agent. When calculating the Aggregate Risk Potential (ARP), a value of 720 is obtained, which is equivalent to 7.51% of the total identified risk agents, as previously conducted by (Mahmoodzadeh et al., 2020).

Risk agent A7 is related to workers having deficiencies in their field of expertise, specifically referring to a small portion of temporary workers involved in activities in the cutting or cut-up area. The majority of employed workers have sufficient experience, and the addition of less experienced workers is only done when production targets are higher than usual (Giermindl et al., 2022). Experts believe that this occurrence is not very frequent and assign an occurrence value of 3. The impact of worker skill deficiencies is relatively minor, leading the experts to assign a severity value of 5. When calculating the Aggregate Risk Potential (ARP), a value of 660 is obtained, which is equivalent to 6.89% of the total identified risk agents.

Risk agent A20 is related to the inadequate implementation of 5R/5S in the production area. The company has implemented certain aspects of 5S, such as labeling tools, signage for pedestrian pathways, and signage for product bins. However, some violations occur, such as workers crossing marked lines on the floor, hindering the use of carts for transporting products, and some signs have faded, particularly in the Dirty Area, which includes unloading, slaughtering, cutting, and offal disposal. Experts believe that this risk agent does not significantly impact production activities because workers are well-trained to work in their respective areas, and equipment movement and storage are well-established. However, due to the somewhat broad scope of 5S/5R issues, an occurrence value of 6 is assigned. When calculating the Aggregate Risk Potential (ARP), a value of 600 is obtained, which is equivalent to 6.26% of the total identified risk agents, as previously conducted by (Sagandira et al., 2020).

Risk agent A16 is related to workers in the production department experiencing fatigue. Worker fatigue can occur if one or more of the following events happen: sudden customer demands, planning errors by the planning department resulting in fewer scheduled workers than necessary, or experienced workers facing obstacles and needing to be replaced by less skilled workers (Ferreira & Gomes, 2022). However, even when these events occur, it is rare for workers to be affected to the point of experiencing fatigue, leading the experts to assign an occurrence value of 2. Meanwhile, a severity value of 6 is assigned at a moderate level because fatigued workers can result in a loss of concentration or errors in production activities. As the workers typically affected by fatigue are less skilled, they are more focused on routine cutting activities rather than special orders that require extra precision. When calculating the Aggregate

Risk Potential (ARP), a value of 558 is obtained, which is equivalent to 5.82% of the total identified risk agents.

Risk agent A18 is related to errors in planning the daily work schedule. The planning activities involve determining the number of workers to be employed in a given week according to the production targets to be achieved. If the planned number of workers is fewer than necessary, workers may experience fatigue. However, if the number of workers exceeds the required amount, it not only leads to idle workers but also contributes to additional costs borne by the company (Li et al., 2023). Considering these factors, the experts assign a relatively high severity value of 7. This risk agent occurs infrequently, so an occurrence value of 2 is given. When calculating the Aggregate Risk Potential (ARP), a value of 454 is obtained, which is equivalent to 4.74% of the total identified risk agents.

Risk agent A19 is related to workers in the production area not complying with established Standard Operating Procedures (SOP). Each production stage has its standard procedures that have been provided to all workers during training and development. The workers have received adequate qualifications from the training period (Kotak et al., 2023). This risk agent occurs infrequently and is assigned an occurrence value of 2 by the experts. However, if it does occur, it can have a significant impact on the production process, and the severity value assigned by the experts is 7. This risk agent also encompasses the occurrence of workplace accidents, as almost all workplace accidents are caused by workers deviating from the implemented standard procedures. The calculation of the Aggregate Risk Potential (ARP) for risk agent A19 yields a value of 408, which is equivalent to 4.26% of the total identified risk agents.

Risk agent A15 is related to the limited number of certified Halal MUI slaughterers. The activity of chicken slaughtering is required to be performed by workers who have obtained Halal MUI certification (Thaha et al., 2023). In this study, the Chicken Slaughterhouse has 8 workers with this certification, with a rotation of 2-3 individuals per shift per day. The number of workers is sufficient to meet the company's production targets. However, in the event of absences from these workers, which occur infrequently and are assigned an occurrence value of 4 by the experts, there will be an additional burden on the available workers with certification. To minimize the impact, the company also brings in certified workers from external sources, as they have been doing so far (Mustafa, 2023). Based on these considerations, the experts assign a severity value of 4. When calculating the Aggregate Risk Potential (ARP) for this risk agent, a value of 372 is obtained, which is equivalent to 3.88% of the total identified risk agents

Risk agent A3 is related to chickens dying during the transportation process using a vehicle. The transportation activity of chickens from both internal and external farms has the potential for chicken mortality during the journey. This event consistently occurs with each transportation, but the number of occurrences is relatively small compared to the total chicken orders overall (Rezende et al., 2023). This event is more likely to occur with chickens from external farms that have longer distances to travel. The experts assign an occurrence value of 5 and a severity value of 5 to this risk agent. The impact of this risk agent is a reduction in the number of chickens that can be processed for fresh chicken orders and a decrease in the number of special orders. To mitigate the impact, the planning department has included this variable in the chicken ordering process from the farms (Pratiwi et al., 2023). Therefore, the influence of this risk agent is

considered low, in line with the severity value provided by the experts. When calculating the Aggregate Risk Potential (ARP) for this risk agent, a value of 348 is obtained, which is equivalent to 3.63% of the total identified risk agents.

3.6. Risk Mitigation Discussion

In the House of Risk phase 2 results, 13 mitigation actions were identified to address the 12 priority risk agents. These actions have been ranked based on the ETD (Effectiveness to Difficulty) rating.

PA8, which involves implementing a system of punishment and rewards as a motivational incentive for employees, has the highest ETD (Effectiveness to Difficulty) value among the mitigation actions. Implementing this action has a significant impact, with a score of 9, on two risk agents: A7 (workers lacking expertise in their field) and A19 (workers not complying with SOPs in the production area). The presence of rewards provides additional motivation for employees to perform their best, while punishments are expected to encourage workers to be more careful in following SOPs and invest more effort in training to reduce mistakes while working (Ali et al., 2021). This mitigation action also has a minor impact on A9 (errors in conducting regular machine checks or maintenance), A16 (workers experiencing fatigue in the production department), A18 (errors in planning the daily work schedule), and A20 (lack of prominent implementation of 5S/5R in the production area). Implementing this action is considered easy, with a weight of 2 in the Degree of Difficulties (D). The calculated ETD value for this action is 5972.

PA7, which involves improving the quality and quantity of training provided, is a mitigation action that impacts the improvement of job quality. The implementation of this action has the greatest influence on the risk agent A7 (workers lacking expertise in their field), followed by A9 (errors in conducting regular machine checks or maintenance), A14 (usage uniformity within a range of +/- 10%), A15 (limited number of certified Halal MUI slaughterers), A18 (errors in planning the daily work schedule), A19 (workers in the production area not complying with SOPs), and A20 (lack of prominent implementation of 5S/5R in the production area). Implementing this action is considered relatively easy, with a weight of 3 in the Degree of Difficulties (D). The training conducted by the company has been proven effective, especially in enhancing the capabilities of new workers to reach the overall standard competency limit (Mail et al., 2019). Improving the quality of training for experienced workers can enhance their overall competency limit (Studer et al., 2021). This mitigation action also has a minor impact on A14 (usage uniformity within a range of +/- 10%), A20 (lack of implementation of 5S/5R), A16 (worker fatigue in the production area), A18 (errors in planning the daily work schedule), and A15 (limited number of certified Halal MUI slaughterers). In the ETD calculation for this mitigation action, a value of 4153 is obtained.

PA2, which involves supplier performance evaluation, is a mitigation action that provides an opportunity to improve the productivity of suppliers in delivering materials according to agreements. The largest impact of this mitigation action is on the risk agents A1 (delay in the chicken delivery process), A3 (chickens dying during transportation using a vehicle), and A4 (supplier non-compliance with SOPs or agreed-upon agreements). Performance evaluation is

necessary to determine which external suppliers are suitable for establishing long-term binding agreements (Kuwornu et al., 2023). This mitigation action also has a minor impact on A7 (workers lacking expertise in their field). Implementing this action is considered relatively easy, with a weight of 3 in the Degree of Difficulties (D). In the ETD calculation for this mitigation action, a value of 5169 is obtained.

PA3, the development of binding SOPs towards suppliers as operational guidelines, is a mitigation action carried out for A1 (The chicken delivery process is experiencing a delay), A3 (The chickens died during the transportation process using a vehicle), A4 (The supplier did not comply with the standard operating procedures (SOP) or the agreed-upon agreement), and A7 (The worker has a deficiency in their field of expertise) in the procurement of chickens from external farms only in situations where internal farm supplies are insufficient. Contracts formed under such circumstances do not have excessively high levels of binding, so errors occurring from external suppliers are considered reasonable. Implementing binding SOPs can improve transportation quality, reduce transportation delays, enhance transportation quality, and strengthen the trust bond between both parties (Kato et al., 2022). Implementing this action is considered relatively easy, with a weight of 3 in the Degree of Difficulties (D). In the ETD calculation for this mitigation action, a value of 6013 is obtained.

PA10, conducting employee workload evaluation to measure the level of tasks undertaken, is a mitigation action that can be implemented to address risk agents A16 (The workers in the production department are experiencing fatigue) and A19 (The workers in the production area are not complying with the established Standard Operating Procedures (SOP)). The evaluation results of employee workload can be used by the planning department to implement more suitable work schedules, ensuring that workers are not burdened beyond their capacity. This mitigation action is assigned a value of 2 in the Degree of Difficulties (D), indicating a low level of difficulty, as the calculation only considers workload calculation without incorporating scheduling factors. Scheduling is done after obtaining the results of the workload evaluation (Bekishev et al., 2023). In the ETD calculation, this mitigation action obtains a value of 2715.

PA1, implementing appropriate quality control methods to reduce undesired uniformity, is a mitigation action that can be undertaken based on the redundancy of activities, where the company has already calculated the usage uniformity within a range of +/- 10% from internal farms. By limiting this activity only to external farm sources, a specific reduction in uniformity usage is carried out, which has a significant impact on risk agent A14 (Usage uniformity is within a range of +/- 10%). This action has a high level of difficulty and is assigned a value of 4 in the Degree of Difficulties (D), as it involves reforming worker SOPs, recalculating orders to align with operational time and workload, and evaluating external farm parties (Kato et al., 2022). In the ETD calculation, this mitigation action obtains a value of 2592.

PA9, implementing the 5R/5S methodology in the production area to maintain cleanliness and orderliness, is a mitigation action that can address A9 (There was an error in conducting regular machine checks or maintenance) and A20 (The implementation of 5R/5S is not prominently observed in the production area), which is assigned a value of 3 in the Degree of Difficulties (D), indicating a relatively low level of difficulty or ease of implementation. This is because most of the production floor already has markings, but many of them have faded,

especially in the Dirty Area. Reevaluation of the markings is also necessary due to changes in the production floor area since the last implementation of the 5S/5R markings (Fole & Kulsaputro, 2023). In the ETD calculation, this mitigation action obtains a value of 6013.

PA5, performing scheduled preventive maintenance to ensure optimal performance, is a mitigation action that can address risk agent A9 (There was an error in conducting regular machine checks or maintenance). The mitigation action involves conducting preventive maintenance by the technical department, which includes scheduled periodic checks, lubrication, cleaning, and replacement when the machine has reached its end-of-life, even if it is still functional (Assaf & Assaad, 2023). The implementation of this mitigation action is assigned a value of 3 in the Degree of Difficulties (D), indicating a moderate level of difficulty, as the training is conducted within the scope of the technical department. In the ETD calculation, this mitigation action obtains a value of 2160.

PA4, conducting safety stock procurement to ensure an adequate supply availability, is a mitigation action that directly addresses risk agent A13 (There is a sudden demand for the product from consumers). The main challenge in implementing this action is determining the appropriate quantity to avoid excessive stock that could lead to waste, while also ensuring it is not too low to meet sudden demand (Gonçalves et al., 2020). Therefore, this mitigation action is assigned a value of 4 in the Degree of Difficulties (D), indicating a high level of difficulty due to its complexity. In implementing this action, regular evaluation and data development following market trends are necessary. In the ETD calculation, this mitigation action obtains a value of 2070.

PA6, providing TPM (Total Productive Maintenance) training to workers to improve productivity efficiency, is a mitigation action that can address A9 (There was an error in conducting regular machine checks or maintenance), A7 (The worker has a deficiency in their field of expertise), A19 (The workers in the production area are not complying with the established Standard Operating Procedures (SOP)), and A20 (The implementation of 5R/5S is not prominently observed in the production area) by focusing on the implementation of TPM. TPM is a comprehensive maintenance activity carried out by all elements of the workforce with the main basis of implementing 5S/5R. The main challenge in implementing TPM is providing education and training to all elements of the workforce to recognize, understand, care for, and optimize the work environment, including production machines so that they feel a sense of responsibility and are proactive in communicating with the technical maintenance department (Pinto et al., 2020). Due to its implementation covering all production activities, this mitigation action is difficult to execute and is assigned a value of 5 in the Degree of Difficulties (D). In the ETD calculation, this mitigation action obtains a value of 1870.

PA11, improving the quality of internal communication to enhance effectiveness and efficiency, is a mitigation action aimed at addressing issues related to A9 (There was an error in conducting regular machine checks or maintenance), A18 (There was an error in planning the daily work schedule), and A20 (The implementation of 5R/5S is not prominently observed in the production area) caused by communication errors between departments. The risk agent that can be addressed or influenced by this mitigation action is A18 (errors in daily work planning). The implementation of this action is considered moderately difficult due to limited alternative options

for internal communication, such as the company's intranet and social media groups (Ober & Kochmanska, 2022). Therefore, this mitigation action is assigned a value of 4 in the Degree of Difficulties (D). In the ETD calculation, this mitigation action obtains a value of 1712.

PA12, implementing an easily accessible interdepartmental information system, is a mitigation action that is similar and aligned with the mitigation action in PA11 (Improving the quality of internal communication to enhance effectiveness and efficiency). The implementation of this action is considered moderately difficult due to the limited alternative options for internal communication, which only consist of the company's intranet and social media groups (Cosa et al., 2021). Therefore, this mitigation action is assigned a value of 4 in the Degree of Difficulties (D). In the ETD calculation, this mitigation action obtains a value of 1202.

PA13, increasing the number of workers with MUI Halal certification as a requirement, is a mitigation action specifically designed to address risk agent A15 (The number of certified Halal MUI slaughterers is limited). Two approaches can be taken: providing training to existing workers to obtain MUI Halal certification or recruiting external workers who already possess the certification (Harapan et al., 2022). If the company chooses either or both of these options, this mitigation action is considered relatively easy to implement and is assigned a value of 3 in the Degree of Difficulties (D). In the ETD calculation, this mitigation action obtains a value of 1116.

4. Conclusion

The research conducted at the Makassar Chicken Slaughterhouse aims to identify and study potential risk agents that may disrupt the production process. The Current Reality Tree method is utilized for risk identification analysis, while the House of Risk method determines risk priorities and mitigation strategies. The research findings are expected to reduce operational risks through innovative risk mitigation approaches. Based on the results and discussions, this study concludes that the Makassar Chicken Slaughterhouse only conducts monthly risk evaluations without identifying the root causes. The Current Reality Tree and House of Risk identified 28 risk events and 23 risk agents. After calculating using the House of Risk model, 12 risk agents were selected, contributing to 80% of the total cumulative Aggregate Risk Potential (ARP). The prioritization of mitigation actions is based on the highest ARP. There are 13 mitigation actions recommended, ranked by ETD (Estimated Time to Detect) using the House of Risk stage 2. It is advised to implement the research findings and focus on the relevant departments associated with the studied risks. Next research recommendations: in-depth study of main risk agents, analysis of root causes of risk events, evaluation of mitigation actions, involvement of relevant departments, utilization of alternative methods, and engagement of stakeholders. The aim is to enhance risk understanding and develop effective mitigation strategies.

Acknowledgments

We would like to express our sincere gratitude to Widi Astutik, Mujaddid, Januar Kulsaputro, Nurwindy Yanasim, and Asrul Fole for their valuable contribution to the research on enhancing risk mitigation strategies in innovative poultry slaughterhouses using the House of Risk method approach. Your dedication and expertise have greatly enriched the study. Thank

you for your remarkable collaboration and commitment to advancing this important field of research.

References

- Ali, R. F., Dominic, P. D. D., Ali, S. E. A., Rehman, M., & Sohail, A. (2021). Information security behavior and information security policy compliance: a systematic literature review for identifying the transformation process from noncompliance to compliance. In *Applied Sciences (Switzerland)* (Vol. 11, Issue 8, pp. 1–38). MDPI AG. <https://doi.org/10.3390/app11083383>
- Assaf, G., & Assaad, R. H. (2023). Optimal Preventive Maintenance, Repair, and Replacement Program for Catch Basins to Reduce Urban Flooding: Integrating Agent-Based Modeling and Monte Carlo Simulation. *Sustainability (Switzerland)*, *15*(11), 1–27. <https://doi.org/10.3390/su15118527>
- Bekishev, Y., Pisarenko, Z., & Arkadiev, V. (2023). FMEA Model in Risk Analysis for the Implementation of AGV/AMR Robotic Technologies into the Internal Supply System of Enterprises. *Risks*, *11*(10), 1–31. <https://doi.org/10.3390/risks11100172>
- Bravo, F. I., Calvo, E., López-Villalba, R. A., Torres-Fuentes, C., Muguera, B., García-Ruiz, A., & Morales, D. (2023). Valorization of Chicken Slaughterhouse Byproducts to Obtain Antihypertensive Peptides. *Nutrients*, *15*(2), 1–24. <https://doi.org/10.3390/nu15020457>
- Cegar, S., Kuruca, L., Vidovic, B., Antic, D., Hauge, S. J., Alvseike, O., & Blagojevic, B. (2022). Risk categorisation of poultry abattoirs on the basis of the current process hygiene criteria and indicator microorganisms. *Food Control*, *132*(108530), 1–8. <https://doi.org/10.1016/j.foodcont.2021.108530>
- Cosa, S., Ogbeifun, E., & Pretorius, J. H. C. (2021). Managing inter-departmental project delivery to enhance customer satisfaction. *Engineering Management in Production and Services*, *13*(4), 39–56. <https://doi.org/10.2478/emj-2021-0030>
- Diansyah, F. N., & Adhiutama, A. (2023). International Journal of Current Science Research and Review Total Productive Maintenance Strategy to Increase Overall Equipment Effectiveness of Integrated Filling Machine N2 Vaccine Production Pt. Xyz. *International Journal of Current Science Research and Review*, *6*(7), 4794–4809. <https://doi.org/10.47191/ijcsrr/V6-i7-97>
- Dulam, R., Furuta, K., & Kanno, T. (2021). Consumer panic buying: Realizing its consequences and repercussions on the supply chain. *Sustainability (Switzerland)*, *13*(8), 1–24. <https://doi.org/10.3390/su13084370>
- Faqih, M. A., Praptono, B., & Sagita, B. H. (2020). Analisis Kelayakan Pembukaan Rumah Makan Yakane Ditinjau Dari Aspek Teknis, Aspek Finansial Dan Aspek Pasar. *E-Proceeding of Engineering*, *7*(1), 1735–1741. <https://openlibrarypublications.telkomuniversity.ac.id/index.php/engineering/article/view/11873>
- Ferreira, P., & Gomes, S. (2022). Temporary Work, Permanent Strain? Personal Resources as Inhibitors of Temporary Agency Workers' Burnout. *Administrative Sciences*, *12*(3), 1–13. <https://doi.org/10.3390/admsci12030087>
- Fole, A. (2023). Perancangan Strategi Mitigasi Risiko Pada Proses Bisnis CV. JAT Menggunakan Metode House of Risk. *JIEI: Journal of Industrial Engineering Innovation* *1*(02), 54–64. <https://doi.org/10.58227/jiei.v1i02.109>

- Fole, A., & Kulsaputro, J. (2023). Implementasi Lean Manufacturing Untuk Mengurangi Waste Pada Proses Produksi Sirup Markisa. *JIEI: Journal of Industrial Engineering Innovation*, 1(1), 23–29. <https://doi.org/10.58227/jiei.v1i1.59>
- García-Díez, J., Saraiva, S., Moura, D., Grispoldi, L., Cenci-Goga, B. T., & Saraiva, C. (2023). The Importance of the Slaughterhouse in Surveilling Animal and Public Health: A Systematic Review. In *Veterinary Sciences* (Vol. 10, Issue 2, pp. 1–42). MDPI. <https://doi.org/10.3390/vetsci10020167>
- Giermindl, L. M., Strich, F., Christ, O., Leicht-Deobald, U., & Redzepi, A. (2022). The dark sides of people analytics: reviewing the perils for organisations and employees. In *European Journal of Information Systems* (Vol. 31, Issue 3, pp. 410–435). Taylor and Francis Ltd. <https://doi.org/10.1080/0960085X.2021.1927213>
- Gonçalves, J. N. C., Sameiro Carvalho, M., & Cortez, P. (2020). Operations research models and methods for safety stock determination: A review. In *Operations Research Perspectives* (Vol. 7, Issue 100164, pp. 1–14). Elsevier Ltd. <https://doi.org/10.1016/j.orp.2020.100164>
- Harapan, H., Sallam, M., Fathima, R., Kusuma, H. I., Anwar, S., Nalapraya, W. Y., Wibowo, A., Kumara Wati, K. D., Medina, A., Defrita, A. H., Astri, Y., Prasetyowati, A., Nurfarahin, N., Khusna, A., Oktariana, S., Anwar, S., Yussar, M. O., Khotimah, S., Maria Nainggolan, B. W., ... Mudatsir, M. (2022). Willingness to Pay (WTP) for COVID-19 Vaccine Booster Dose and Its Determinants in Indonesia. *Infectious Disease Reports*, 14(6), 1017–1032. <https://doi.org/10.3390/idr14060101>
- Henchion, M., Moloney, A. P., Hyland, J., Zimmermann, J., & McCarthy, S. (2021). Review: Trends for meat, milk and egg consumption for the next decades and the role played by livestock systems in the global production of proteins. In *Animal* (Vol. 15, pp. 1–14). Elsevier B.V. <https://doi.org/10.1016/j.animal.2021.100287>
- Herdianzah, Y. (2020). KRI Design And Mitigation Strategy on Water Distribution of Perumda Air Minum Makassar Regional IV: A Case Study. *Journal of Industrial Engineering Management*, 5(2), 70–79. <https://doi.org/10.33536/jiem.v5i2.672>
- Ilham, N., Mardianto, S., & Sumedi, N. (2021). Komparasi Biaya Produksi Ayam Broiler Indonesia dan Brasil Untuk Antisipasi Impor Daging Ayam. *Analisis Kebijakan Pertanian*, 19(1), 33–44. <https://doi.org/10.21082/akp.v19n1.2021.33-44>
- Jagtap, S., Bader, F., Garcia-Garcia, G., Trollman, H., Fadiji, T., & Salonitis, K. (2021). Food Logistics 4.0: Opportunities and Challenges. *Logistics*, 5(1), 1–19. <https://doi.org/10.3390/logistics5010002>
- Kaco, S., & Fitriana, N. (2020). Praktik Penyeembelihan dan Pengolahan Ayam di Rumah Potong Ayam Kecamatan Polewali (Tinjauan Undang-Undang Nomor 33 Tahun 2014 tentang Jaminan Produk Halal). *J-ALIF Jurnal Penelitian Hukum Ekonomi Syariah Dan Sosial Budaya Islam*, 5(2), 148–156. <https://doi.org/10.35329/jalif.v5i2.1845>
- Kato, T., Wang, J. J., & Tsai, N. Y. (2022). Elements of standard operating procedures and flexibility issues in emergency management: A Japan-Taiwan comparison. *International Journal of Disaster Risk Reduction*, 71(102831), 1–14. <https://doi.org/10.1016/j.ijdr.2022.102813>

- Kiš, M., Fuštin, D., & Zdolec, N. (2023). Relevance of Meat Juice Seroprevalence and Presence of *Yersinia enterocolitica* and *Salmonella* spp. in Pig Tonsils for Risk Management at Slaughter. *Processes*, 11(8), 1–10. <https://doi.org/10.3390/pr11082234>
- Kotak, J., Habler, E., Brodt, O., Shabtai, A., & Elovici, Y. (2023). Information Security Threats and Working from Home Culture: Taxonomy, Risk Assessment and Solutions. *Sensors*, 23(8), 1–25. <https://doi.org/10.3390/s23084018>
- Kusrini, E., Safitri, K. N., & Fole, A. (2022). Mitigasi Resiko di Distribusi Sustainable Supply Chain Management Menggunakan Metode House Of Risk (HOR). *Integrasi: Jurnal Ilmiah Teknik Industri*, 7(1), 14–23. <https://doi.org/https://doi.org/10.32502/js.v7i1.4348>
- Kusuma, Y. (2023). Analisis Risiko dan Rekayasa Sistem Pada Pemotongan Ayam Berdasarkan Prinsip Halal Supply Chain (Studi Kasus: Rumah Pemotongan Ayam XYZ). *TALENTA Conference Series: Energy & Engineering*, 6(1), 1125–1130. <https://doi.org/10.32734/ee.v6i1.1929>
- Kuwornu, J. K. M., Khaipetch, J., Gunawan, E., Bannor, R. K., & Ho, T. D. N. (2023). The adoption of sustainable supply chain management practices on performance and quality assurance of food companies. *Sustainable Futures*, 5(100103), 1–11. <https://doi.org/10.1016/j.sftr.2022.100103>
- Leng, N., & Corman, F. (2020). The role of information availability to passengers in public transport disruptions: An agent-based simulation approach. *Transportation Research Part A: Policy and Practice*, 133, 214–236. <https://doi.org/10.1016/j.tra.2020.01.007>
- Li, S., Zheng, P., Liu, S., Wang, Z., Wang, X. V., Zheng, L., & Wang, L. (2023). Proactive human–robot collaboration: Mutual-cognitive, predictable, and self-organising perspectives. In *Robotics and Computer-Integrated Manufacturing* (Vol. 81, Issue 102510, pp. 1–30). Elsevier Ltd. <https://doi.org/10.1016/j.rcim.2022.102510>
- Mahmoodzadeh, Z., Wu, K. Y., Droguett, E. L., & Mosleh, A. (2020). Condition-based maintenance with reinforcement learning for dry gas pipeline subject to internal corrosion. *Sensors (Switzerland)*, 20(19), 1–26. <https://doi.org/10.3390/s20195708>
- Mail, A., Chairany, N., & Fole, A. (2019). Evaluation of Supply Chain Performance through Integration of Hierarchical Based Measurement System and Traffic Light System: A Case Study Approach to Iron Sheet Factory. *Int. J. Sup. Chain. Mgt Vol 8*, no. 5 (2019), 79–85. <https://doi.org/10.59160/ijscm.v8i5.2584>
- Malik, R., Ihwan Safutra, N., Fole, A., & Amal Pangestu, F. (2024). Improving Resilience in Water Distribution Systems: An Application of the House of Risk Method at PDAM Gowa Unit Tompobulu. *Jurnal Sistem Teknik Industri*, 26(2), 199–209. <https://doi.org/10.32734/jsti.v26i2.16171>
- Meiramkulova, K., Zorpas, A. A., Orynbekov, D., Zhumagulov, M., Saspugayeva, G., Kydyrbekova, A., Mkilima, T., & Inglezakis, V. J. (2020). The effect of scale on the performance of an integrated poultry slaughterhouse wastewater treatment process. *Sustainability (Switzerland)*, 12(11), 1–14. <https://doi.org/10.3390/su12114679>
- Mustafa, E. A. (2023). A Review: The Concept Of Quality Assurance In Halal Meat. *World Journal of Pharmaceutical Research Wwww.Wjpr.Net* |, 12, 149. <https://doi.org/10.20959/wjpr20239-28332>

- Nafi'ah, A., & Mahbubah, N. A. (2021). Journal Knowledge Industrial Engineering Managing Risk on A Pharmacy Enterprise Supply Chain Using House of Risk Approach. *Journal Knowledge Industrial Engineering*, 8(3), 167–182. <https://doi.org/10.35891/jkie.v8i3.2692>
- Ober, J., & Kochmańska, A. (2022). Adaptation of innovations in the it industry in poland: The impact of selected internal communication factors. *Sustainability (Switzerland)*, 14(1), 1–18. <https://doi.org/10.3390/su14010140>
- Pratiwi, D., Andarwangi, T., Tantriadisti, S., Ulfah, M., & Lampung, P. N. (2023). Integrasi Pasar Daging Ayam Ras (Broiler) di Pasar Modern Indonesia Market Integration of Broiler Chicken Meat in Modern Indonesian Market. *Journal of Food System and Agribusiness (JoFSA)*, 7(2), 153–158. <https://doi.org/10.25181/jofsa.v7i2.3233>
- Rezende, H. C. de, Lima, M. de, & Santos, L. D. (2023). Peracetic acid application as an antimicrobial and its residual (HEDP): a holistic approach on the technological characteristics of chicken meat. In *Poultry Science* (Vol. 102, Issue 10, pp. 1–16). Elsevier Inc. <https://doi.org/10.1016/j.psj.2023.103003>
- Sagandira, C. R., Mathe, F. M., Guyo, U., & Watts, P. (2020). The evolution of Tamiflu synthesis, 20 years on: Advent of enabling technologies the last piece of the puzzle? In *Tetrahedron* (Vol. 76, Issue 37, pp. 1–23). Elsevier Ltd. <https://doi.org/10.1016/j.tet.2020.131440>
- Studer, S., Bui, T. B., Drescher, C., Hanuschkin, A., Winkler, L., Peters, S., & Müller, K. R. (2021). Towards CRISP-ML(Q): A Machine Learning Process Model with Quality Assurance Methodology. *Machine Learning and Knowledge Extraction*, 3(2), 392–413. <https://doi.org/10.3390/make3020020>
- Sugianto, Aqatih, S. N., & Jalil HSB, E. G. (2024). Proses Manajemen Risiko Bisnis Syariah. *INNOVATIVE: Journal Of Social Science Research*, 4(1), 1–11. <https://doi.org/10.31004/innovative.v4i1.7832>
- Sumitro, M. K. (2022). *Penerapan House Of Risk Dan Current Reality Tree Untuk Menentukan Prioritas Aksi Mitigasi Risiko*. <https://dspace.uui.ac.id/handle/123456789/40139>
- Sun, Z., Scherer, L., Tukker, A., & Behrens, P. (2020). Linking global crop and livestock consumption to local production hotspots. *Global Food Security*, 25, 1–9. <https://doi.org/10.1016/j.gfs.2019.09.008>
- Thaha, A. H., Hafisah, Amin, A. R. M., & Ahmad, A. (2023). Critical control point in the provision of halalan thayyiban poultry meat at the slaughterhouse. *Journal of Islam and Science*, 10(2), 76–82. <https://doi.org/10.24252/jis.v10i2.37807>
- Uzundumlu, A. S., & Dilli, M. (2023). Estimating Chicken Meat Productions of Leader Countries for 2019-2025 Years. *Ciencia Rural*, 53(2), 1–12. <https://doi.org/10.1590/0103-8478cr20210477>