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# Analysis of Risk Mitigation in the Halal Food Supply Chain at CV. XYZ Using House of Risk and Probability Impact Matrix Methods

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**ABSTRACT**

CV. XYZ is a frozen seafood processing company that has implemented a Halal Product Assurance System (SJPH). However, non-conformities to halal standards are still found, including traces of dirt, insects entering production areas, improper washing of dropped shrimp, and foreign objects in products. Deploying a dual framework of House of Risk alongside the Probability Impact Matrix facilitates the systematic identification, evaluation, and formulation of preventive measures within halal food distribution networks. Operational workflows are categorized across planning, sourcing, manufacturing, delivery, and return cycles using the SCOR structural model. Empirical data synthesis relies on field observations, stakeholder dialogues, and structured survey tools. The investigation isolates 35 distinct risk occurrences linked to 38 underlying causative drivers. Based on calculated Aggregate Risk Potential metrics, ten primary drivers demand prioritized intervention, led by code A9 (non-compliance with operational standards and insufficient staff training) registering an index value of 816. In HOR Phase 2, 16 mitigation strategies were formulated with top priorities being worker training on good halal manufacturing (ETD=2119,50), enhanced supervision (ETD=2085,75), and SOP auditing with refresher training (ETD=1836). PIM mapping based on estimated values after mitigation showed that High-risk agents were projected to decrease to Moderate, Low, and Very Low categories. This study provides structured mitigation recommendations to control priority risk agents and maintain product quality and halal integrity.

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## 1. Introduction

Meeting consumer requirements while preserving rigorous standards of quality and safety across distribution networks depends heavily on the frozen seafood processing domain (Kuncorosidi et al., 2025). Preventing contamination and maintaining strict compliance with Islamic legal standards from initial production to final consumption requires the comprehensive management of product movements throughout all distribution phases, commonly defined as a halal supply chain (Agustina &

Cakravastia, 2023). Overseeing the transformation of raw inputs into compliant end products aligned with religious dietary codes constitutes halal supply chain management (Masudin et al., 2025). Given that operational complexities introduce various vulnerabilities capable of undermining halal integrity, conducting rigorous risk evaluations and executing strategic mitigation becomes vital to sustain market competitiveness and protect consumer confidence (Asrory et al., 2023).

CV. XYZ is a frozen seafood processing company in Gresik, East Java, producing shrimp, fish fillets, and crabs with frozen shrimp as its primary commodity. Based on internal company production records in 2025, shrimp production reached 2,805.931 tons per year, significantly higher than fish fillets (730 tons) and crabs (146 tons). Shrimp products are produced daily, while other products are made based on customer orders, making shrimp operations more dominant and having greater halal supply chain risk potential. Based on internal company records, the company exports approximately 1,800 metric tons annually to the United States, Europe, Asia, and Australia.

The company's supply chain activities include raw material procurement, receiving, sorting, peeling, soaking, cooking, freezing, packing, cold storage, and distribution. As a company with Halal Product Assurance System (SJPH) certification, all production activities must comply with BPJPH Decree Number 20 of 2023. However, observations and interviews revealed several non-conformities including dirt traces in production areas, insects entering production areas, improper washing of dropped shrimp, and foreign objects in products. These issues indicate suboptimal sanitation, supervision, and process control, potentially causing contamination that affects product quality, safety, and halal integrity, while also threatening consumer trust and export market compliance (Fole, 2023).

Overcoming these operational vulnerabilities is achievable through a structured analytical approach combining the House of Risk framework with the Probability Impact Matrix. By mapping the intricate interdependencies between causative drivers and risk occurrences, the House of Risk approach establishes clear mitigation hierarchies derived from calculated Aggregate Risk Potential values (Savitri et al., 2025; Fahruddin & Pulansari, 2026). PIM helps map risk probability and impact levels, classifying risks into priority categories. Previous studies by Widyaningsih and Nugroho (2024) and Lestari et al., (2021) successfully applied these methods in halal food supply chains, identifying human resource factors as dominant risk agents requiring priority mitigation through training and supervision programs.

Despite its utility, applying integrated House of Risk and Probability Impact Matrix methods within halal supply chain research has historically overlooked the unique operational characteristics inherent to frozen seafood processing, particularly surrounding raw shrimp production and handling workflows. To illustrate, Lestari et al. (2021), implemented this joint framework within bakery supply chains, capturing vulnerabilities tied to vastly different manufacturing and storage conditions. Therefore, this study addresses the gap by examining operational risks specific to frozen shrimp processing, where improper handling of fallen shrimp, animal entry, contaminated transportation, dirty equipment, and the use of non-food-grade stationery may compromise halal assurance through potential contamination and inadequate control of halal handling conditions. Consequently, these vulnerabilities transcend general food safety concerns, directly threatening the continuity of halal compliance across the entire distribution network. This investigation adds value by exposing specific risk configurations and primary causative drivers impacting halal integrity within frozen shrimp processing facilities, while evaluating targeted interventions to lessen both their likelihood and operational fallout. Thus, the contribution extends beyond applying HOR and PIM to a different research object by providing empirical insights into halal-related operational risks specific to frozen seafood processing.

## 2. Literature Review

Various theoretical perspectives explain that the supply chain encompasses a series of integrated business processes that connect end-consumer needs with initial material providers to generate added value for all stakeholders. According to Ridwan dan Gaffar (2022) the management of these operational activities is often referred to as Supply Chain Management (SCM), which refers to the arrangement of goods movement from the initial supplier to consumers to determine distribution patterns, location points, and timeliness of inventory allocation efficiently. On the other hand, Yusuf dan Soediantono (2022) explain that SCM is a series of stages that include product development, material procurement, operational planning, to distribution so that all involved elements mutually support in creating high-quality output that can be accessed by consumers effectively and economically. The application of SCM is also understood as a systematic method in controlling the flow of materials, financial data, and information within organizational ecosystems that synergize from supplier level to end consumers, where its scope is not limited to the company's internal domain but includes cross-organizational coordination to maximize value for customers (Kuntoro et al., 2025). The main objective of this management system is to balance market demand levels and supply capacity optimally, although in practice there are still various critical obstacles that often arise along the operational flow (Lumbanraja et al., 2025).

Risk mitigation encompasses strategies and actions to reduce or manage potential risks in organizations or projects by identifying, analyzing, and implementing measures to minimize risk effects and likelihood (Geofanny & Tanaamah, 2022; Royyan, 2023). Irham et al., (2024) describe mitigation as developing and implementing action strategies to reduce adverse events' impact on organizational goals through controls such as policies, procedures, and technology. Risk mitigation strategies are divided into five types: reducing likelihood, reducing impact, sharing risk, avoiding risk, and accepting risk (Zega, 2023). In supply chain contexts, mitigation is part of Supply Chain Risk Management (SCRM), categorized into proactive strategies (supplier development, contracts, process management) and reactive strategies (disaster management, demand management) (Khussurur et al., 2024). Proactive strategies emphasize supply chain control while reactive strategies address more difficult-to-control outsourced risks (Illaritzqi et al., 2024; Rizqi et al., 2023).

Conceptualized as a strategic mechanism, halal supply chain management governs resource procurement and processing operations to ensure all outputs strictly conform to Islamic sharia standards (Pramesti & Amir, 2023). This domain involves supervising raw material transformations into finished, permissible consumables from early production stages through to consumer presentation (Rizqi et al., 2023). Fueling substantial economic expansion across the global halal sector over recent decades, the Halal Food Supply Chain serves a vital strategic purpose. Driven by expanding Muslim demographics and heightened consumer discernment, this supply chain transcends its role as a basic distribution pathway, functioning instead as a structural trust system that guarantees total religious compliance from initial procurement to final delivery (Kurniawati et al., 2023). HFSC differs from general supply chains by incorporating additional requirements across all SCOR processes: Plan includes SJPH and halal audit planning; Source requires halal raw material selection and traceability; Make demands contamination prevention, halal additives, and sanitation; Deliver necessitates separation of halal/non-halal products and clean transportation; Return requires evaluation of potential halal contamination during product returns.

Formulated to drive proactive operational protection, the House of Risk framework offers an end to end methodology for evaluating supply chain vulnerabilities (Syaputra et al., 2025). This approach integrates Failure Mode Effect Analysis for quantitative evaluation with House of Quality principles to rank causative drivers and guide intervention choices. While standard Failure Mode Effect Analysis calculates Risk Priority Numbers through probability, severity, and detection values, the House of Risk framework relies on an Aggregate Risk Potential index incorporating severity, probability, and correlation strength between risk occurrences and causative drivers (Prasetyo et al., 2022). The initial phase identifies dominant causative drivers through severity, occurrence, and correlation assessments filtered via the Pareto principle (80/20 rule) (Adelia & Widiasih, 2023). Severity ratings use a 1 to 10 scale for impact, occurrence ratings apply a 1 to 10 scale for probability, and correlation values follow a 0, 1, 3, 9 hierarchy (Prasetyo et al., 2022). The second phase devises action plans for high-priority drivers, evaluating action-to-driver correlations using 0, 1, 3, 9 scales alongside Degree of Difficulty metrics spanning 3, 4, 5 scales. Determining which interventions merit immediate implementation depends on quantifying Total Effectiveness of Action values alongside Effectiveness to Difficulty ratios (Asrory et al., 2023).

The Probability Impact Matrix (PIM) is a tool for mapping risk probability and impact on project objectives, enabling classification into risk levels and priority determination (Siregar et al., 2022). Irham et al., (2024) describe PIM as a matrix expressing risk importance by combining probability and impact values. The matrix integrates these values to determine risk levels based on occurrence and severity assessments. Severity and occurrence values are converted into five risk levels using specified scales:

Table 1. Conversion of Severity and Occurrence Values to Risk Levels

| Level | *Impact (Severity)* | *Probability (Occurance)* | *Scale* |
|---|---|---|---|
| 1 – *Very Low* | 1-2 | 1-2 | 0-20% |
| 2 – *Low* | 3-4 | 3-4 | 20-40% |
| 3 – *Moderate* | 5-6 | 5-6 | 40-60% |
| 4 – *High* | 7-8 | 7-8 | 60-80% |
| 5 – *Very High* | 9-10 | 9-10 | 80-100% |

Source : (Lestari et al., 2021).

Table 2. Risk Level Based on the Probability-Impact Matrix (PIM)

| *Probability Rating (Occurrence)* | *Impact Rating (Severity)* | | | | |
|---|---|---|---|---|---|
| | 1 – *Very Low* | 2 – *Low* | 3 – *Moderate* | 4 – *High* | 5 – *Very High* |
| 5 – *Very High* | | | | | |
| 4 – *High* | | | | | |
| 3 – *Moderate* | | | | | |
| 2 – *Low* | | | | | |
| 1 – *Very Low* | | | | | |

Source : (Lestari et al., 2021).

## 3. Methodology

This research was conducted at CV. XYZ, located on Gresik, East Java. The research period was carried out from February 2026 to June 2026. This research uses a quantitative approach with a case study method. The research variables consist of dependent and independent variables. The dependent variable is the risk level in the halal food supply chain, measured based on severity, occurrence, and risk level. The independent variables are risk events and risk agents. Data collection techniques in this research include:

- Observation: Direct observation of operational activities from raw material receiving to distribution.
- Interview: Direct interviews with production, Quality Control (QC), and sanitation departments.
- Questionnaire: Questionnaires were distributed to the Head of High Risk Production, Deputy Head of Quality Control, and Head of Sanitation to assess severity, occurrence, correlation between risk events and risk agents, degree of difficulty, and probability and impact after mitigation.

As shown in the flowchart in Figure 1, the research methodology is systematically structured into a series of consecutive stages.

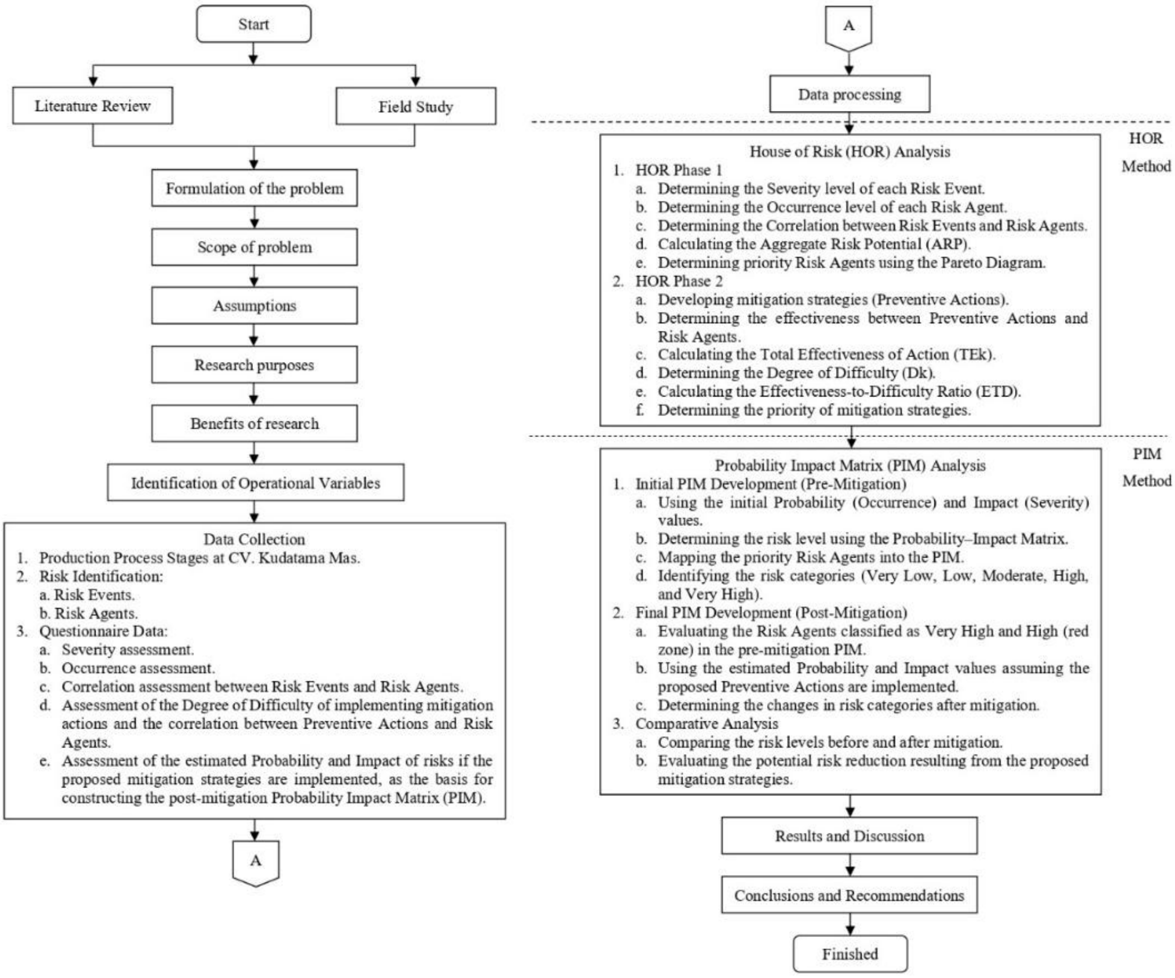


Figure 1. Flowchart
Source: Developed by the authors (2026).

## 4. Results and Discussion

Mapping operational workflows via the SCOR model structured the halal supply chain at CV. XYZ across five core dimensions: Plan, Source, Make, Deliver, and Return. This structural decomposition spanned three hierarchical tiers, progressing from major process definitions at Level 1, to sub-process specifications at Level 2, down to discrete activity details at Level 3. Identifying potential vulnerabilities involved direct field observation and stakeholder interviews, corroborated by internal standard operating procedures and regulatory halal requirements. Analyzing mapped activities yielded potential risk occurrences alongside corresponding causative drivers, which subsequently underwent validation by qualified company personnel to guarantee alignment with actual operational conditions. This preliminary phase finalized a foundation of 35 risk event and 38 risk agent for downstream analytical processing.

Table 3. Classification of Halal Supply Chain Activities Based on the SCOR Model

| Major Process | Sub Process | Activity Details |
|---|---|---|
| Plan | Planning material standard | Determining the need for raw shrimp materials according to the production plan |
| | Planning production | Develop production schedules and targets based on customer requests |
| | Planning delivery product | Make a schedule delivery product shrimp in accordance request customers and availability vehicle |
| Source | Procurement material standard | Determination timetable delivery material standard from supplier |
| | | Checking the quality, quantity, physical condition (damage), and aroma of raw materials according to the request specifications |

| Major Process | Sub Process | Activity Details |
|---|---|---|
| Make | Preparation Production | Ensure that the water used in the production process meets quality standards. |
| | | Use of masks, gloves, head coverings, and work shoes |
| | | Personal hygiene check of workers before entering the production area |
| | | Verify vaccination status and access eligibility of workers before entering the cooking area. |
| | | Monitoring the condition of the production area for potential pest entry |
| | Production Equipment and Machinery Control | Regular cleaning and maintenance of the machine |
| | | Using production equipment according to its function |
| | | Using markers or other writing instruments in production areas that have the potential for direct contact with shrimp products |
| | Receiving Process | Measurement of chlorine levels in raw material washing water |
| | | Supervision washing water quality For washing material standard |
| | | Provide labels containing truck number, box number, shrimp handling, and UR value (shrimp size uniformity ratio) |
| | Peeling Process | Control temperature shrimp during the peeling process |
| | | Peeling shrimp using appropriate tools |
| | | Shrimp gutting in accordance process standards |
| | Grading Process | Setting and checking the condition of the grading machine before the sorting process takes place |
| | | The operator monitors the condition of the grader machine, including monitoring vibration, speed, and accuracy of shrimp size separation. |
| | | Label the grading results containing the UR value, splash number adjusted to the size of the shrimp, and the yield of the peeling results. |
| | Soaking Process | Measurement and control of the concentration of additional materials in the soaking solution |
| | | Provide a label containing the time of immersion, the time of exiting the immersion, and the final yield. |
| | Cooking Process | Checking the temperature and pressure of the boiler machine |
| | Freezing Process | Thickness monitoring layer glazing during the freezing process |
| | Packing Process | Checking the condition of shrimp products before packaging |
| | | Check the condition of the packaging (damage, leaks, loose seal) |
| | Handling Product Shrimp Fall | Implementation of SOP for handling fallen shrimp during the production process |
| | Storage product So | Monitoring the temperature conditions of finished product storage rooms |
| Deliver | Delivery product | Inspection and sanitation of transport vehicles before use for product delivery |
| | | Checking vehicle usage history to ensure the vehicle complies with halal requirements |
| | | Supervision of product handling during the trip by the driver |
| | | Pay attention to environmental factors during the trip |
| | | Temperature monitoring in container |
| Return | Return product So from customer | Customer order specifications |

Source: Data processing results (2026).

## House Of Risk

Initiating the primary phase of the House of Risk framework requires gathering Severity, Occurrence, and Correlation data to prioritize vulnerabilities across the halal distribution network. Administering targeted questionnaires to key company stakeholders supplied these evaluation metrics. Impact intensity for risk occurrences and probability levels for causative drivers were rated using separate 1 to 10 scales. Meanwhile, correlation strength connecting occurrences with underlying drivers was evaluated using discrete values of 0, 1, 3, and 9. Synthesizing these survey inputs provided the necessary foundation to compute Aggregate Risk Potential values and establish high-priority causative drivers.

Table 4. Results of the Severity Assessment Questionnaire

| Major Process | Sub Process | Code | Risk Event | Severity |
|---|---|---|---|---|
| Plan | Planning material standard | E1 | Lack of raw materials to carry out the production process | 1 |
| | Planning production | E2 | Sudden change of production plan | 1 |
| | Planning delivery product | E3 | Happen change or mismatch timetable delivery product shrimp | 1 |
| Source | Procurement material standard | E4 | Delay arrival material standard | 1 |
| | | E5 | Inbound raw materials fail to satisfy defined operational criteria, exhibiting non-compliance in technical quality, quantity discrepancies, physical damage, or off-odors. | 4 |
| Make | Preparation Production | E6 | Raw water contains sediment / soil particles / sand | 2 |
| | | E7 | PPE not used or not clean | 9 |
| | | E8 | Workers enter production areas without initial sanitation procedures | 7 |
| | | E9 | Cooking area workers Not yet vaccine typhoid | 5 |
| | | E10 | Traces of animal waste were found in the production area. | 7 |
| | | E11 | Entry of animals (rats, insects, cats, etc.) into the production room | 7 |
| | Production Equipment and Machinery Control | E12 | Machines/equipment in dirty/rusty condition due to poor maintenance | 6 |
| | | E13 | Production equipment is used for other purposes | 5 |
| | | E14 | non-food grade markers that have the potential for direct contact with the product | 4 |
| | Receiving Process | E15 | Chlorine levels in washing water are not controlled | 2 |
| | | E16 | Risk of contamination from washing water | 5 |
| | | E17 | Incorrect writing of truck/box number or UR value | 1 |
| | Peeling Process | E18 | Shrimp temperature during the peeling process rises above 5°C | 5 |
| | | E19 | Shrimp meat is damaged/cut during peeling | 1 |
| | | E20 | Shrimp intestines are not completely excised | 1 |
| | Grading Process | E21 | Shrimp fall / bounce from machine during the sorting process | 6 |
| | | E22 | The operator was late or negligent in detecting abnormalities in the machine. | 1 |
| | | E23 | Labels are mixed up or attached incorrectly to different splashes. | 1 |
| | Soaking Process | E24 | Shrimp taste changed (too salty/chemical) | 4 |
| | | E25 | The writing on the label is not clearly visible | 1 |
| | Cooking Process | E26 | Boiler temperature / pressure is not in accordance so that shrimp undercooked or overcooked | 3 |
| | Freezing Process | E27 | Uneven glazing layer (too thin or too thick) | 1 |
| | Packing Process | E28 | Foreign objects present (hair, plastic fragments, paper, metal) | 7 |
| | | E29 | Leaking packaging or damaged | 5 |
| | Handling Product Shrimp Fall | E30 | Handling of fallen shrimp not according to procedure | 6 |
| | Storage product So | E31 | Cold storage temperature is unstable | 1 |
| Deliver | Delivery product | E32 | Means of transportation used in dirty conditions | 8 |
| | | E33 | The shipping process has the potential to be contaminated with feces and dirt. | 6 |
| | | E34 | Temperature in container less than optimal | 6 |
| Return | Return product So from customer | E35 | The size grade does not match the customer's UR | 1 |

Source: Data processing results (2026).

Table 5. Results of the Occurrence Assessment Questionnaire

| Code | Risk Agent | Occurrence |
|---|---|---|
| A1 | Supplier's inability to provide raw materials in sufficient quantity | 2 |
| A2 | There is a sudden additional order from a customer | 1 |
| A3 | Limited vehicle availability at the time of delivery | 2 |
| A4 | Delay delivery from supplier | 4 |
| A5 | Party supplier not enough thorough | 2 |
| A6 | Water sources are not clean or distribution pipes rusty | 1 |

| Code | Risk Agent | Occurrence |
|---|---|---|
| A7 | Supervision of the use of PPE by workers is less strict | 6 |
| A8 | Lack of worker awareness of the importance of sanitation before entering the production area | 2 |
| A9 | Product operational standards are not implemented and staff training is lacking. | 4 |
| A10 | Officers were less careful in checking the completeness of workers' vaccination documents | 2 |
| A11 | Gaps in ventilation, doors, or drainage that allow animals to enter production areas | 4 |
| A12 | There are no physical barriers or perimeter security systems preventing animals from entering the production area. | 1 |
| A13 | There are no regular checks on the cleanliness of equipment and machines. | 4 |
| A14 | Monitoring the use of equipment so that it is not used for other purposes is less strict | 3 |
| A15 | non-food grade stationery in production areas is not controlled. | 8 |
| A16 | Inaccuracy of measurement results due to the use of chlorine indicator paper that is damaged or has decreased in quality | 1 |
| A17 | Lack of attention worker to quality of water used moment washing | 4 |
| A18 | Officer insufficient receiving meticulous / well-trained | 1 |
| A19 | Lack of ice or cooler on the work table | 5 |
| A20 | Knife too sharp / blunt | 2 |
| A21 | Worker technique not enough skilled | 2 |
| A22 | Engine speed and vibration are not appropriate | 3 |
| A23 | High workload which causes supervision to be not optimal | 1 |
| A24 | Grading officers are in a hurry because of high production targets. | 1 |
| A25 | The salt/phosphate measuring instrument is not properly calibrated. | 1 |
| A26 | The surface of the label paper is wet and the ink/marker cannot stick perfectly. | 2 |
| A27 | The thermometer on the boiler is damaged or inaccurate error, so the temperature/pressure reading does not match the actual condition of the machine. | 1 |
| A28 | Setting the glazing process parameters no precision | 1 |
| A29 | The workers are unfocused and not thorough | 4 |
| A30 | Improper packaging perfect | 2 |
| A31 | SOP for handling fallen shrimp is not consistently implemented by workers | 7 |
| A32 | Temperature checks in cold storage are inconsistent | 3 |
| A33 | Inconsistency in the implementation of sanitation of transport vehicles | 1 |
| A34 | This means of transportation has been used for goods whose halal status is not clear. | 6 |
| A35 | Lack of caution of the driver in operating the vehicle during the delivery process | 1 |
| A36 | Weather factors | 2 |
| A37 | Temperature checks in containers are inconsistent | 1 |
| A38 | Mismatch information customer requests with order data | 1 |

Source: Data processing results (2026).

Isolating dominant causative drivers relied on applying the Pareto principle. Frequently termed the 80/20 rule, this concept dictates that a critical 20 percent of underlying factors typically drives 80 percent of observed operational disruptions, meaning targeted interventions addressing this minor fraction yield maximum structural recovery (Adelia & Widiasih, 2023). Within this investigation, applying the Pareto rule focused directly on the calculated Aggregate Risk Potential metrics derived for each individual causative driver. Risk agents were then selected as priorities if their cumulative contribution reached 80% of the total ARP. This approach ensured that the most significant risk agents those contributing the largest potential risk to the halal food supply chain were prioritized for mitigation.

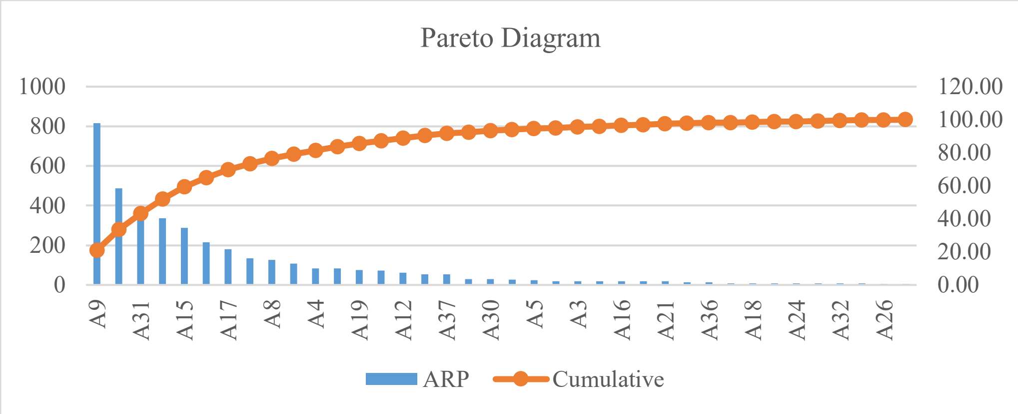


Figure 2 Pareto Diagram

Source: Data processing results (2026).

Table 6. Priority Risk Agent

| Rank | Code | Risk Agent | ARP | Percentage | Cumulative |
|---|---|---|---|---|---|
| 1 | A9 | Product operational standards are not implemented and staff training is lacking. | 816 | 21.07 | 21.07 |
| 2 | A7 | Supervision of the use of PPE by workers is less strict | 486 | 12.55 | 33.62 |
| 3 | A31 | SOP for handling fallen shrimp is not consistently implemented by workers | 378 | 9.76 | 43.38 |
| 4 | A11 | Gaps in ventilation, doors, or drainage that allow animals to enter production areas | 336 | 8.68 | 52.05 |
| 5 | A15 | non-food grade stationery in production areas is not controlled. | 288 | 7.44 | 59.49 |
| 6 | A13 | There are no regular checks on the cleanliness of equipment and machines. | 216 | 5.58 | 65.07 |
| 7 | A17 | Lack of attention worker to quality of water used moment washing | 180 | 4.65 | 69.71 |
| 8 | A14 | Monitoring the use of equipment so that it is not used for other purposes is less strict | 135 | 3.49 | 73.20 |
| 9 | A8 | Lack of worker awareness of the importance of sanitation before entering the production area | 126 | 3.25 | 76.45 |
| 10 | A34 | This means of transportation has been used for goods whose halal status is not clear. | 108 | 2.79 | 79.24 |

Source: Data processing results (2026).

The selection of ten risk agents was based on a three-tier criterion: (1) cumulative ARP ≥79% as a practical approximation of the 80% Pareto benchmark, (2) a marginal contribution drop of >0.5 percentage points indicating diminishing returns beyond the 10th agent, and (3) high controllability scores to ensure actionable mitigation in the second phase of the House of Risk framework. The top ten agents achieved 79.24% cumulative risk coverage operationally equivalent to 80% given the <1% tolerance commonly accepted in supply chain risk studies. Since the 11th agent added only 1.36% marginal coverage with significantly lower controllability, its inclusion was deemed inefficient. Thus, the ten-agent selection optimizes the trade-off between risk coverage, resource efficiency, and practical feasibility, focusing corrective efforts on the most impactful drivers affecting both operational flow and religious compliance.

Initiating the second phase of the House of Risk framework involves formulating targeted action plans for the primary causative drivers that registered top-tier Aggregate Risk Potential scores during initial evaluations. Developing these corrective actions required close consultation with enterprise management to guarantee operational feasibility and contextual relevance.

Table 7. Mitigation Strategy Designs

| Rank | Code | Risk Agent | Code | Preventive Action |
|---|---|---|---|---|
| 1 | A9 | Product operational standards are not implemented and staff training is lacking. | PA1 | Do training worker related good halal manufacturing |
| | | | PA2 | SOP audit & training refresher training |
| 2 | A7 | Supervision of the use of PPE by workers is less strict | PA3 | Increase supervision of employees and implement SOPs correctly |
| | | | PA4 | Implementation system no PPE no work |
| 3 | A31 | SOP for handling fallen shrimp is not consistently implemented by workers | PA5 | Conducting socialization and re-training regarding SOP for handling fallen products |
| 4 | A11 | Gaps in ventilation, doors, or drainage that allow animals to enter production areas | PA6 | Installation insect screen / wire mesh on ventilation and ducts air |
| | | | PA7 | Close all cracks or gap use sealant ( silicone / epoxy ) |
| 5 | A15 | The use of non-food grade stationery in production areas is not controlled. | PA8 | Non-food grade stationery with food grade |
| 6 | A13 | There are no regular checks on the cleanliness of equipment and machines. | PA9 | Conduct regular cleanliness checks on machines and the work environment. |
| | | | PA10 | Create a checklist for equipment and machine cleanliness inspections |
| 7 | A17 | Lack of attention worker to quality of water used moment washing | PA11 | Monitoring the quality of washing water shrimp in a way periodically |
| 8 | A14 | Monitoring the use of equipment so that it is not used for other purposes is less strict | PA12 | Imposing strict sanctions against misuse of equipment |
| | | | PA13 | Provide several knives and tools that can be used interchangeably |
| 9 | A8 | Deficient worker awareness regarding required hygiene and sanitation protocols prior to entering manufacturing zones. | PA14 | Institute mandatory instructional sessions and daily pre-shift briefings emphasizing sanitation protocols prior to entering manufacturing zones. |
| 10 | A34 | Deploying transport vehicles that previously handled cargo with unverified or ambiguous religious compliance status. | PA15 | Verify the compliance and structural suitability of transport vehicles prior to dispatch. |
| | | | PA16 | Establish product delivery transportation standards (sanitation, covering, and vehicle traceability) |

Source: Data processing results (2026).

The next stage after formulating mitigation strategies is to determine their correlation with risk agents, compute the Total Effectiveness of Action (TEk), and derive the Effectiveness to Difficulty ratio (ETDk). The ETDk is then applied to rank the proposed actions, where a larger ETD value reflects a stronger case for early implementation.

| *Code* | | *Preventive Action* | | | | | | | | | | | | | | | | ARP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | PA1 | PA2 | PA3 | PA4 | PA5 | PA6 | PA7 | PA8 | PA9 | PA10 | PA11 | PA12 | PA13 | PA14 | PA15 | PA16 | |
| *Risk Agent* | A9 | 9 | 9 | | | | | | | | | | | | | | | 816 |
| | A7 | | | 9 | 3 | | | | | | | | | | | | | 486 |
| | A31 | | | | | 9 | | | | | | | | | | | | 378 |
| | A11 | | | | | | 9 | 9 | | | | | | | | | | 336 |
| | A15 | | | | | | | | 9 | | | | | | | | | 288 |
| | A13 | | | | | | | | | 3 | 9 | | | | | | | 216 |
| | A17 | | | 9 | | | | | | | | 9 | | | | | | 180 |
| | A14 | | | 9 | | | | | | | | | 3 | 1 | | | | 135 |
| | A8 | 9 | | 9 | | | | | | | | | | | 9 | | | 126 |
| | A34 | | | | | | | | | | | | | | | 3 | 9 | 108 |
| TEk | | 8478 | 7344 | 8343 | 1458 | 3402 | 3024 | 3024 | 2592 | 648 | 1944 | 1620 | 405 | 135 | 1134 | 324 | 972 | |
| Dk | | 4 | 4 | 4 | 5 | 4 | 3 | 3 | 3 | 3 | 4 | 3 | 4 | 4 | 4 | 4 | 3 | |
| ETDk | | 2119,50 | 1836 | 2085,75 | 291,60 | 850,50 | 1008 | 1008 | 864 | 216 | 486 | 540 | 101,25 | 33,75 | 283,50 | 81 | 324 | |

Figure 3. Results of House of Risk (HOR) Phase 2
Source: Data processing results (2026).

Determining priority hierarchies for proposed interventions during the second phase of the House of Risk methodology required computing Total Effectiveness of Action metrics, evaluating Degree of Difficulty ratings, and deriving Effectiveness to Difficulty ratios. Calculating Total Effectiveness involved multiplying each driver's Aggregate Risk Potential by its correlation score relative to the proposed action, summing these products across each intervention option. A representative calculation for Total Effectiveness of Action appears below:

$$TE_k = \sum ARP_j E_{jk} \quad (1)$$

$$TE_{PA1} = (ARP_9 \times 9) + (ARP_8 \times 9)$$
$$= (816 \times 9) + (126 \times 9)$$
$$= 8478$$

Assigning Degree of Difficulty ratings relied on survey responses from the High-Risk Production Manager, using a 3 to 5 rating scale where 3 denotes minimal implementation effort, 4 represents moderate complexity, and 5 indicates extreme execution difficulty. Computing Effectiveness to Difficulty ratios involved dividing Total Effectiveness values by their corresponding difficulty scores, with elevated ratio values reflecting superior operational yield and implementation efficiency. A representative calculation for this ratio metric appears below:

$$ETD_k = TE_k / D_k \quad (2)$$

$$ETD_{PA1} = 8478/4$$
$$= 2119{,}50$$

PA1 obtained the top priority because it has very high effectiveness by addressing two priority risk agents (A9 with ARP 816 and A8 with ARP 126) through strong correlation (9), a moderate level of difficulty (Dk=4), and provides long-term benefits through sustainable improvement of worker capacity, which serves as the foundation for the success of other mitigation strategies.

### Probability Impact Matrix

Establishing baseline risk intensity prior to executing interventions requires mapping the primary causative drivers derived from initial House of Risk evaluations using the Probability Impact Matrix framework. This is done by assigning occurrence values as the probability measure and the average severity of related risk events as the impact measure.

Table 8. Priority Risk Agent Mapping Matrix Before Mitigation

| *Probability Rating (Occurrence )* | *Impact Rating ( Severity )* | | | | |
|---|---|---|---|---|---|
| | *1 – Very Low* | *2 – Low* | *3 – Moderate* | *4 – High* | *5 – Very High* |
| *5 – Very High* | | | | | |
| *4 – High* | | A15 | A31 | | |
| *3 – Moderate* | | | A34 | | A7 |
| *2 – Low* | | | A13, A17, A14 | A9, A11 | |
| *1 – Very Low* | | | | A8 | |

Source: Data processing results (2026).

Based on the mapping before mitigation, risk agents A9, A7, A31, and A11 are in the High category (red zone), indicating they have high probability and impact levels and require priority handling. Risk agents A15, A13, A17, A14, A8, and A34 are in the Moderate category (yellow zone), still requiring attention in risk control.

Risk mapping after mitigation is carried out to estimate the risk level if the mitigation strategies proposed in HOR Phase 2 are implemented by the company. The preparation of the Probability Impact Matrix at this stage aims to evaluate the potential changes in risk levels after the proposed preventive actions are applied to priority risk agents. Unlike mapping before mitigation, at this stage evaluation is focused on risk agents in the Very High and High categories (red zone) in the PIM before mitigation because they are risks with the highest priority level requiring mitigation actions.

Table 9. Post-Mitigation Probability and Impact Values

| **Code** | **Risk Agent** | **Probability** | **Impact** | **Code** | **Preventive Action** |
|---|---|---|---|---|---|
| A9 | Product operational standards are not implemented and staff training is lacking. | 2 | 5 | PA1 | Do training worker related to good halal manufacturing |
| | | | | PA2 | SOP audit & training refresher training |
| A7 | Supervision of the use of PPE by workers is less strict | 2 | 3 | PA3 | Increase supervision of employees and implement SOPs correctly |
| | | | | PA4 | Implementation system no PPE no work |
| A31 | SOP for handling fallen shrimp is not consistently implemented by workers | 4 | 5 | PA5 | Conducting socialization and re-training regarding SOP for handling fallen products |
| A11 | Gaps in ventilation, doors, or drainage that allow animals to enter production areas | 3 | 4 | PA6 | Installation of insect screens / wire mesh on ventilation and ducts air |
| | | | | PA7 | Close all cracks or gap using sealant (silicone/epoxy) |

Source: Data processing results (2026).

Table 10. Priority Risk Agent Mapping Matrix After Mitigation

| *Probability Rating (Occurrence)* | *Impact Rating (Severity)* | | | | |
|---|---|---|---|---|---|
| | *1 – Very Low* | *2 – Low* | *3 – Moderate* | *4 – High* | *5 – Very High* |
| *5 – Very High* | | | | | |
| *4 – High* | | | | | |
| *3 – Moderate* | | | | | |
| *2 – Low* | | A11 | A31 | | |
| *1 – Very Low* | | A7 | A9 | | |

Source: Data processing results (2026).

Based on the mapping after mitigation, A7 is estimated to decrease to Very Low category, A9 and A11 to Low category, and A31 to Moderate category. These results indicate that if the mitigation strategies are implemented by the company, all risk agents previously in the red zone are estimated to decrease in risk level, with no risk agents remaining in the High or Very High categories.

**Discussion**

Integrating House of Risk and Probability Impact Matrix analytical frameworks isolated 10 primary causative drivers across the halal distribution network at CV. XYZ, led by driver A9 (non-compliance with operational standards and insufficient staff training) recording a peak Aggregate Risk Potential score of 816. This outcome confirms workforce operational competency as the single largest contributor to halal vulnerability, corroborating prior findings within bakery manufacturing(Lestari et al., 2021) and poultry processing environments (Widyaningsih & Nugroho, 2024).

However, this study reveals context-specific characteristics of frozen seafood processing. Unlike Lestari et al., (2021), where the dominant risk was workers lacking expertise (A20), this study identified A9 as the highest risk agent, indicating a more systemic organizational failure rather than merely individual competence. Unique risks specific to seafood processing were also identified, including A31 (inconsistent handling of fallen shrimp), A11 (gaps allowing animal entry), A17 (poor water quality monitoring), and A15 (use of non-food-grade stationery), reflecting the critical role of physical contamination control in seafood halal integrity.

In HOR Phase 2, 16 preventive actions were formulated, with the top three being: worker training on good halal manufacturing (ETD=2119.50), enhanced supervision with correct SOP implementation (ETD=2085.75), and SOP auditing with refresher training (ETD=1836). The prioritization of training strategies confirms previous findings (Widyaningsih & Nugroho, 2024; Lestari et al., 2021), while providing new evidence on specific training content tailored to seafood processing, including handling of fallen shrimp, water quality monitoring, and equipment sanitation.

PIM analysis showed that four risk agents initially in the High category decreased after proposed mitigation: A7 to Very Low, A9 and A11 to Low, and A31 to Moderate. This demonstrates the potential effectiveness of the proposed strategies, consistent with Lestari et al., (2021). Notably, risks related to worker compliance (A7) showed more pronounced reduction compared to those requiring systemic operational changes (A31), suggesting behavioral risks are relatively easier to address.

The integration of HOR and PIM methods proved valuable in this research. HOR effectively identified risk agents and ranked them based on quantitative risk values, while PIM provided a visual tool for understanding the relative importance of risks and tracking improvements after mitigation. This combination enabled a more comprehensive risk analysis than either method alone could provide.

## 5. Conclusion

Structuring the analytical workflow through joint implementation of the House of Risk methodology and the SCOR reference model mapped a total of 35 distinct risk occurrences driven by 38 underlying causative factors throughout the halal supply network of CV. XYZ. Ten priority agents were selected via ARP and Pareto analysis, led by A9 (Product operational standards are not implemented and staff training is lacking). Sixteen mitigation strategies were subsequently designed based on ETD values. Evaluation using the Probability Impact Matrix (PIM) showed that these strategies could significantly reduce the four initially high-risk agents (A9, A7, A31, and A11). A7 moved to Very Low, A9 and A11 moved to Low, and A31 moved to Moderate, with none remaining in the red zone. This demonstrates that the proposed mitigations, if consistently implemented, are expected to effectively lower overall risk levels and better safeguard product quality and halal integrity.

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