

Product Halal Risk Mitigation in Broiler Meat Supply Chain: A Case Study of Colombo Market Yogyakarta

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Abstract—The increase in halal food consumption in Indonesia aligns with the growing Muslim population. The Quran also mandates the consumption of halal and tayyib food. A significant portion of the population sources their food from traditional market. According BPS 2020 data shows there are 5,949 markets in Java and 33 markets in Yogyakarta. The Yogyakarta Health Office found that 56% of the 25 markets observed did not meet the requirements standard, including issues such as pork contamination. As food sales increase, attention must given to production, distribution and storage to prevent halal contamination. Study showed discrepancies in the broiler supply chain. This study focuses on the broiler meat supply chain at Colombo Market, Yogyakarta, uncovering risks such as cross-contamination and inadequate halal supervision. Key findings include the absence of halal Standard Operating Procedures (SOPs) and certification. To address these risks, the study recommends developing comprehensive halal SOPs, obtaining necessary certifications, and improving supervision and control throughout the supply chain.

Keywords—Supply Chain, Halal, Broiler Chicken, Market.

I. INTRODUCTION

The increasing trend of people's lifestyle in consuming halal food in line with the increasing number of Muslims in Indonesia makes the opportunity for halal food high. The Quran always emphasizes to Muslims to consume only halal food which must be free from everything that is not halal [1]. Halal is defined as something that is in accordance with Islamic law or sharia, while Tayyib is defined as something that is good and clean [2]. Most people obtain these foods from traditional markets.

The number of markets in Java based on BPS in 2020 is 5,949, while in Yogyakarta alone there are 33 markets [3]. The Yogyakarta health office stated that of the 25 markets observed, 56% did not meet the requirements. In addition, the discovery of processed meat in Yogyakarta is still contaminated with pork. The high increase in food sales movement makes it important to develop not only in terms of production, but in terms of packing, distribution, storage, and reaching consumers [4]. The risk of various halal issues to the last consumer is a concern because the slightest contamination means that the food is said to be non-halal. An analysis is needed to prevent higher contamination.

A market research using the supply chain in the form of surveys and interviews shows the low value of producers and knowledge of safe, healthy, intact and halal status, but traders still want to make their products safe to reach consumers properly [5]. In the research of [6] shows the problem of integration in the long chicken supply chain process, namely the mismatch of the original conditions and regulations. So an analysis of the risks regarding the halalness of broiler meat is needed.

Based on the results of interviews and direct observation, it is known that problems regarding the halal supply chain in broiler chicken also occur in Colombo Market, Sleman, Yogyakarta. In the distribution chain that starts from the company providing food and vitamins for livestock to consumers, there are generally risks of cross-contamination to food safety that can affect the halalness of the product. Therefore, it is necessary to have strict supervision and control or risk mitigation to ensure the halalness of broiler products that reach consumers.

II. LITERATURE REVIEW

A. Reference Matrix for This Research

Various risks in the broiler meat supply chain have been identified in several studies. A study highlighted risks associated with cramped production houses, excessive stock capacity, staff negligence, and poor condition of delivery vehicles [7]. To address these risks, recommendations included worker training, adding refrigeration machines, expanding the production site, and leasing production equipment. In addition, another study identified risks such as product mishandling, machine damage, and weight loss due to long-distance delivery [8]. To mitigate these risks, recommendations include implementing rewards and punishments,

conducting regular machine maintenance, ensuring good coordination, and ongoing maintenance. It is also important to maintain chicken meat storage facilities to ensure product quality [9]. Problems in the slaughter process where the chicken neck tendons are not completely cut are recommended to add employees and improve standard operating procedures (SOPs) [10]. One study identified weather conditions as a risk factor, and suggested measures to prevent chicken accumulation during the production process [11]. On the issue of uneven chicken size and insufficient deposits, which can be mitigated by using basket lids [12]. Finally, highlighting the lack of discipline among workers can be improved through additional training [13].

The study considers several key variables in the broiler meat supply chain. First, broiler meat procurement is used to gauge supply chain activities at Colombo Market Yogyakarta. Second, maintaining production equipment is crucial to prevent cross-contamination that could affect the product's halal status. Third, the slaughtering and production processes are vital, as they directly impact the halal status of the final product. Fourth, the conveyance used for distribution must meet standards to preserve product quality and halal integrity. Fifth, proper storage is essential to prevent contamination. Lastly, selecting appropriate packaging materials is important to maintain both the quality and halal status of the meat.

B. Supply Chain Risk Management (SCRM).

Supply Chain Risk Management (SCRM) is a systematic process in identifying and analyzing events related to risks in supply chain activities [7]. Halal supply chain risk management is a concept or method in the supply chain flow from upstream to downstream that also pays attention to halal conditions along the product supply chain. In supply chain risk management, there must be obstacles that can hinder the process, both obstacles caused by natural factors or those caused by company factors.

Risks or disturbances that occur in SCM can be reduced if an industry implements supply chain risk management (SCRM) in accordance with applicable regulations. SCRM rules consist of 3 steps, namely Risk Identification, Risk Assessment and Risk Mitigation [8]. Risk identification is an identification effort made by the company to find out the potential risks that occur, Risk Evaluation is an assessment of potential risks, and Risk Mitigation is an effort to control risks [9].

C. Supply Chain Operation Reference (SCOR)

One approach that can be used to describe the supply chain flow in an industry is the Supply Chain Operations Reference (SCOR) [10]. SCOR is a supply chain diagnostic tool that provides cross-industry standards for supply chain management developed and managed by one of the professional organizations, the Global Supply Chain Council (SCC) [10]. SCOR aims to facilitate the industry to communicate, compare, and develop new supply chain practices and improve the failure of existing supply chain activities.

D. House of Risk

House of Risk (HOR) is the result of the development of a combination of two previously known methods, namely the House of Quality (HOQ) method and Failure Modes and Effects Analysis (FMEA) to develop a framework for proactively managing supply chain risks [10]. House of Risk is the most recent method in analyzing supply chain risks [11]. The approach of this method is focused on reducing the probability of occurrence of risk sources (risk agents) by implementing preventive measures. The emergence of a risk event is often triggered by a risk source (risk agent), so that by reducing a risk source (risk agent) it is expected to reduce the potential for the emergence of an existing risk event (risk event). There are two stages in the House of Risk (HOR) method, namely HOR phase 1 and HOR phase 2. HOR phase 1, is a stage to prioritize risk agents by identifying risk events and identifying risk agents and determining the severity of the risk event, the occurrence of the risk agent, and the correlation between the risk event and the risk agent, which is then calculated to determine the Aggregate Risk Potential (ARP) value using formula (1), which will be used as a reference in HOR phase 2 processing [10].

$$ARP_j = O_j \sum S_i R_{ij} \quad (1)$$

ARP_j is the Aggregate Risk Potential, O_j is the measurement of the chance value of the risk agent, S_i is the measurement of the risk impact level, R_{ij} is the measurement of the correlation value, and E_i is the identification of risk events.

In HOR phase 2, the most appropriate mitigation strategy is developed to reduce the possible impact caused by the risk source agent [10]. The steps in HOR phase 2 begin with designing mitigation strategies, finding the correlation value between mitigation strategies and existing risk agents, calculating the Total Effectiveness (TE_k) and Degree of Difficulty (D_k) values using formula (2), and the last step is to calculate the Effectiveness To Difficulty (ETD_k) ratio using formula (3), to determine the priority ranking of the required mitigation strategies or recommendations.

$$TE_k = \sum_j ARP_j E_{jk} \quad (2)$$

TE_k (2) is the total effectiveness, ARP_j is the Aggregate Risk Potential, and E_{jk} is the identification of risk events.

$$ETD_k = TE_k / D_k \quad (3)$$

ETD_k (3) is the Effectiveness to difficulty of ratio, TE_k is the total effectiveness, and D_k is the Degree of Difficulty.

E. Pareto Chart

A Pareto diagram is a bar chart that shows problems in order of their occurrence. Each problem is represented by one bar chart. The most prevalent problem will be the highest bar chart, while the least prevalent problem will be represented by the lowest bar chart (Heriyana, 2008). Pareto diagrams are used to identify the most critical risks.

F. Conceptual Framework

This is conceptual framework use in this paper.

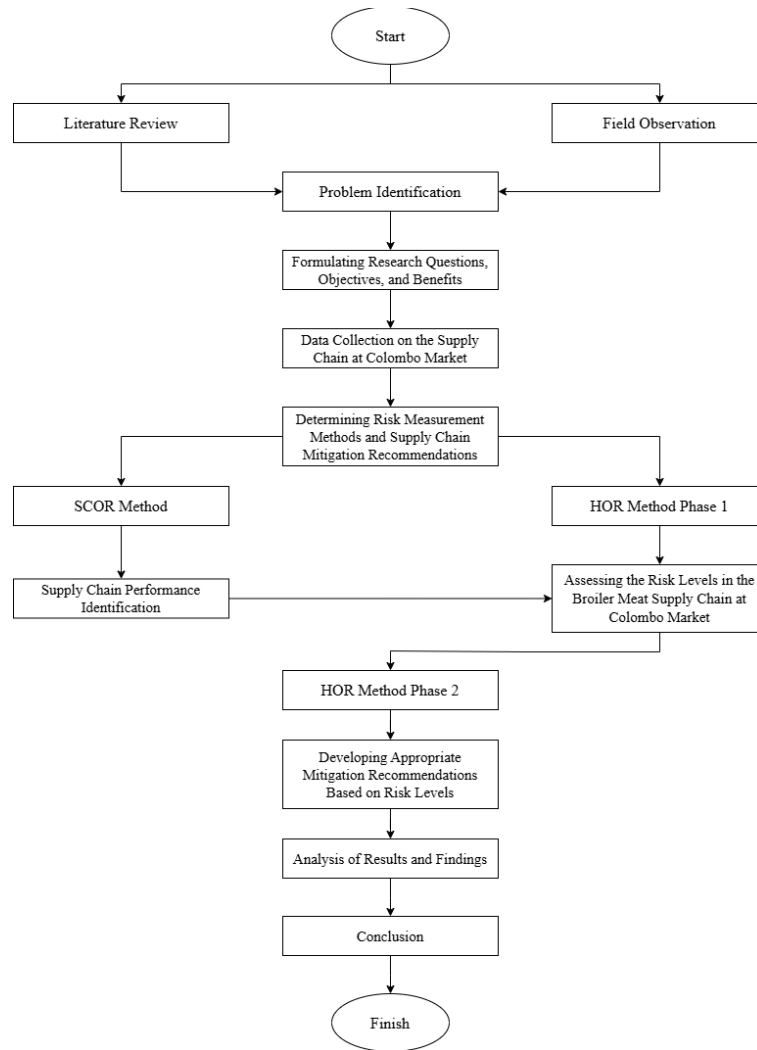


Fig. 1. Research Flowchart

The flowchart in Figure 1 outlines a structured research process focused on risk assessment and mitigation in the broiler meat supply chain at Colombo Market. The process begins with two parallel activities: a literature review and field observation, which are essential for gathering foundational information. Following these initial steps, the research moves to problem identification, leading to the formulation of specific research questions, objectives, and benefits. Once the framework is established, data collection on the supply chain at Colombo Market is conducted to provide the necessary empirical evidence. The research then diverges into two main methodological paths. The first path employs the SCOR method to identify and evaluate supply chain performance. Concurrently, the second path uses the HOR method, which is divided into two phases: Phase 1 focuses on assessing risk levels within the supply chain, while Phase 2 involves developing mitigation strategies based on the identified risks. These two methodological approaches converge in the analysis of results and findings, ultimately leading to the study's conclusion.

III. METHODOLOGY

A. Object of Research

The research object that will be used in this study is the chicken meat supply chain at Colombo Market located in Yogyakarta. This research is conducted by measuring the risks that may occur in the supply chain at Colombo Market in order to formulate mitigation suggestions that are in accordance with the level of risk in the chicken meat supply chain at Colombo Market. The variables used in this study are production equipment maintenance, slaughtering and production processes, shipping conveyance, storage, packaging materials, and raw materials, namely broiler chicken meat. This research uses the SCOR approach and the HOR method to formulate appropriate mitigation suggestions according to the level of risk that has been measured.

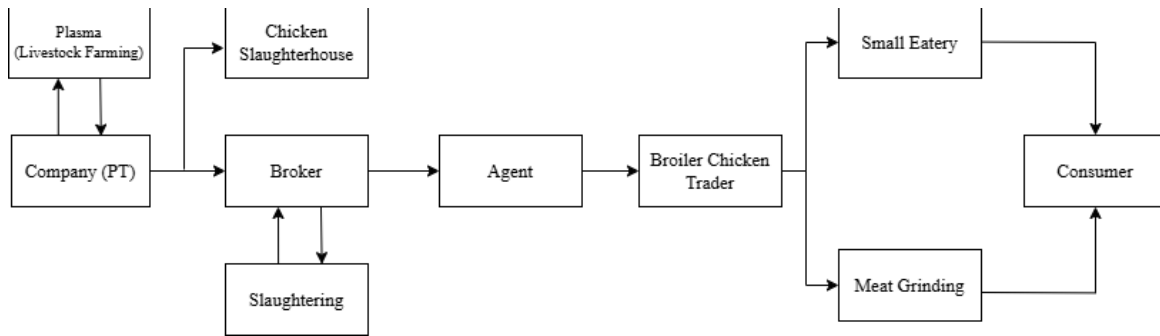


Fig. 2. Flow Chart of the Research Object

Figure 2 illustrates the flow of broiler meat supply chain in Colombo Market Yogyakarta. This flowchart presents a comprehensive overview of the broiler supply chain, tracing the journey from the early stages of farming to final consumption by end users. The process starts with the plasma (farm) phase, where broilers are raised under the care of small farmers. These farmers usually operate under contracts or agreements with larger companies, often referred to as PT (Perseroan Terbatas) in Indonesia. These companies provide essential support to the farmers, including providing feed, animal care and technical guidance to ensure that the chickens are raised under optimal conditions. The partnership between the plasma farmers and the companies plays an important role in maintaining the quality and consistency of the broilers produced.

Once the chickens reach the appropriate size and weight, they are ready for sale. At this point, brokers come into play to facilitate the transaction between the farmer and the next stage in the supply chain. Brokers are important intermediaries that connect farmers with potential buyers, ensuring that chickens are sold at a fair price and distributed to where they are most needed. After this transaction, the chickens are transported to the slaughterhouse, where they undergo the necessary slaughter process. These abattoirs operate according to strict industry standards, which often include compliance with halal requirements to meet the demands of specific consumer markets. Once the chickens are slaughtered and processed, they enter the distribution stage, which is managed by agents. These agents are responsible for ensuring that the processed chicken gets into the hands of buyers, including wholesalers, retailers and food service providers. The role of agents is crucial in maintaining product flow in the supply chain, as they help bridge the gap between production and final consumption.

The next key player in the supply chain is the broiler trader. These traders specialize in buying broilers in bulk from agents and then selling them to various end users. Traders play an important role in determining the availability of broilers in the market, as they distribute them to various outlets, including small restaurants and other food service establishments. Small restaurants, as one of the main end-users in this chain, purchase chicken from traders and prepare it for their customers, thus contributing to the local food economy. In some cases, chicken meat undergoes further processing, such as meat grinding, to create specific products such as ground chicken or chicken-based sausages. This additional processing allows the meat to be used in a wider range of culinary applications, catering to diverse consumer preferences. Ultimately, the supply chain culminates in consumers, who purchase chicken directly from retail outlets or enjoy it as a dish prepared by restaurants.

This entire process highlights the complex and multi-faceted nature of the broiler supply chain. Each stage, from farm to final consumption, involves various stakeholders who must coordinate effectively to ensure the smooth flow of the product. The complexity of the supply chain underscores the importance of each participant, from the smallholder farmers who initiate the process, to traders and agents who facilitate distribution, and finally to consumers who complete the chain by purchasing and consuming the product. This detailed flowchart serves as a valuable tool for understanding the various dynamics at play in the broiler industry, emphasizing the need for efficiency, quality control, and effective communication at all stages of the supply chain.

B. Data Collection Method

The method used is based on literature studies and interviews with expert respondents, namely stall owners as well as slaughterhouse owners who have been in contact with PT and partners for a long time. Furthermore, the analysis is carried out using the SCOR method to determine risk events and risk agents in each chain. Furthermore, the calculation of Aggregate Risk Potential (ARP) is carried out. After prioritizing risks, HOR phase 2 is continued, namely Pareto analysis.

C. Validity

The validity test in this study was used to determine the validity of the questionnaire used using the face validity test. The face validity test is used by validating the questionnaires used in the study by validating them through supply chain lecturers and halal product supervisors.

IV. RESULTS

Colombo Market is one of the traditional markets in Yogyakarta, located in Depok, Sleman, within the Yogyakarta Special Region. Managed by Condongcatur Village, the market underwent building revitalization and land expansion in 2018, which included the addition of parking lots, prayer rooms, and bathrooms. Colombo Market offers a variety of food items, divided into two distinct areas. Inside the market, kitchen ingredients are available, while the outside northern section is designated for selling chicken, beef, and fish. Additionally, there are several meat mills adjacent to the meat-selling area. Based on observation data on the field, found some source of the risk in the broiler chicken supply chain.

Table I. Sources of Risk in the Broiler Chicken Supply Chain

Code	Risk Source
A1	Inaccurate market opportunity planning
A2	Incorrect storage techniques for broiler chicken
A3	Unsanitary transportation conditions
A4	Transportation of chicken from the slaughterhouse to the market
A5	Cutting process of chicken into smaller parts
A6	Unsanitary display of meat products at the market
A7	Use of dull or non-sterile cutting tools
A8	Meat grinding process
A9	Cleanliness of grinding equipment
A10	Production maintenance management errors
A11	Inadequate equipment during the cutting process
A12	Absence of cutting standards (SOP)
A13	Very distant delivery areas
A14	Errors in chicken storage techniques
A15	Inadequate facilities for chicken delivery
A16	Inefficient distribution
A17	Lack of halal certification
A18	Absence of halal SOPs

Table I outlines various risk factors that can impact the safety and quality of broiler chicken throughout its supply chain. Each risk source is represented by a specific code from A1 to A18. These codes include inaccuracies in market opportunity planning (A1), improper storage techniques (A2), unsanitary transportation conditions (A3), and issues related to the transportation, cutting, and handling of chicken (A4 - A11). It also addresses concerns such as inadequate delivery facilities (A15), inefficient distribution (A16), and the lack of halal certification and SOPs (A17 - A18). Correspondents with 16-30 years of experience in chicken slaughtering were consulted. Based on the analysis and processing results using HOR 1, detailed insights and answers regarding the market's operations and risk management are provided.

Table II. HOR 1 Analysis

Code	ARP	Percentage	%Cummulative	Rank
A18	3630	38.60%	38.60%	1
A17	3267	34.74%	73.35%	2
A12	752	8.00%	81.35%	3
A15	285	3.03%	84.38%	4
A3	270	2.87%	87.25%	5
A10	212	2.25%	89.50%	6
A6	180	1.91%	91.42%	7
A4	175	1.86%	93.28%	8
A7	156	1.66%	94.94%	9
A5	125	1.33%	96.27%	10
A16	96	1.02%	97.29%	11
A2	88	0.94%	98.22%	12
A13	80	0.85%	99.07%	13
A14	43	0.46%	99.53%	14
A1	26	0.28%	99.81%	15
A11	10	0.11%	99.91%	16
A8	4	0.04%	99.96%	18
A9	4	0.04%	100.00%	17
Total	9403	100%		

Table II outlines the prioritized risk assessment based on ARP (Annualized Risk Probability) and the corresponding ranking. The top priority risk, A18, has an ARP of 3630 and accounts for 38.60% of the total risk, followed by A17 with an ARP of 3267 and 34.74% of the risk, leading to a cumulative percentage of 73.35%. A12 ranked third with an ARP of 752, representing 8.00% of the risk, bringing the cumulative total to 81.35%. A15, with an ARP of 285 and 3.03% of risk, and A3, with an ARP of 270 and 2.87% of risk, follow in the rankings, making the cumulative percentages 84.38% and 87.25% respectively. Continuing the list, A10 (ARP 212, 2.25%) and A6 (ARP 180, 1.91%) pushed the cumulative totals to 89.50% and 91.42%. A4 ranked eighth with an ARP of 175 and 1.86% of risk, followed by A7 with an ARP of 156 and 1.66%, leading to cumulative percentages of 93.28% and 94.94%. Finally, A5 comes in tenth with an ARP of 125, accounting for 1.33% of the total risk, bringing its cumulative percentage to 96.27%. The table continues with the remaining risks, eventually totaling 9403 ARPs. It also driven on the pareto chart graph below.

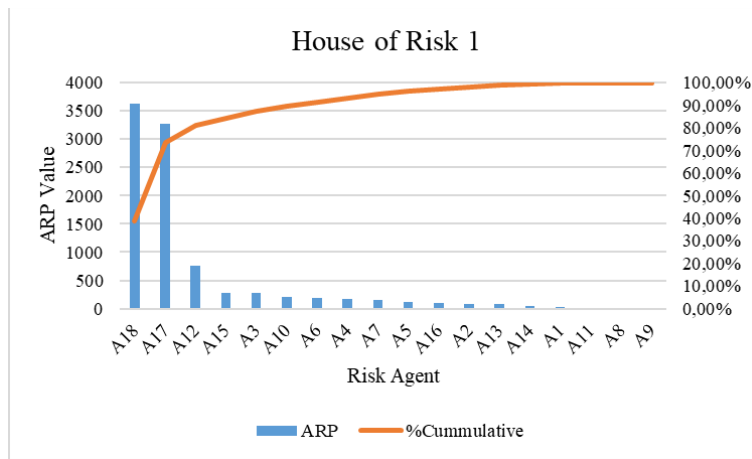


Fig. 3. HOR 1 Pareto Diagram

Based on the processing results in HOR 1, three main risks were identified: A18, where there is no halal SOP; A17, where there is no halal certificate; and A12, where there is no cutting SOP. Various mitigations can be implemented to address these risks. For A18, which lacks a halal SOP, the mitigations include developing a halal SOP according to halal standards, consulting with halal experts, training employees on the importance of halal standards, and conducting internal audits. For A17, which lacks a halal certificate, the mitigation involves preparing the required documents for halal certification and submitting them. For A12, which lacks a slaughtering SOP, the mitigations include conducting an external audit, implementing hygiene and sanitation standards, conducting monitoring and supervision, and documenting the process to facilitate audits. Following these mitigations, the HOR 2 process will be carried out to determine which risks should be prioritized.

Table III. HOR Method Mitigation Strategies

Code	Mitigation
PA1	Developing SOPs in compliance with halal standards
PA2	Consulting with halal experts
PA3	Training employees on the importance of halal standards
PA4	Conducting internal audits
PA5	Preparing the necessary documents for halal certification and submitting them
PA6	Conducting external audits
PA7	Implementing hygiene and sanitation standards
PA8	Conducting monitoring (supervision)
PA9	Documenting processes to facilitate audits

Table III outlines various mitigation measures necessary to ensure compliance with halal standards. These measures include developing and implementing Standard Operating Procedures (SOPs) that comply with halal standards, consulting with halal experts, training employees on the importance of halal standards, and conducting both internal and external audits. Additionally, it involves preparing and submitting the required documents for halal certification, implementing hygiene and sanitation standards, performing ongoing supervision, and documenting processes to facilitate audits.

Table IV. HOR 2 Analysis

Code	ETD	Percentage	%Cumulative	Rank
PA1	22947	31.45%	31.45%	1
PA8	14235	19.51%	50.96%	2
PA5	12865.8	17.63%	68.59%	3
PA7	8355.5	11.45%	80.04%	4
PA2	7649	10.48%	90.52%	5
PA3	3921.75	5.37%	95.90%	6
PA4	1089	1.49%	97.39%	7
PA9	1089	1.49%	98.88%	8
PA6	816.75	1.12%	100.00%	9
Total	72968.8	100%		

Table IV presents a breakdown of the various codes (Codes) along with their ETD (Expected Time Delay), percentage, and cumulative percentage. Code PA1 has the highest ETD of 22947, accounting for 31.45% of the total, and a cumulative percentage of 31.45%. PA8 follows with an ETD of 14235, making up 19.51% of the total, resulting in a cumulative percentage of 50.96%. PA5, with an ETD of 12865.8, represents 17.63% of the total, bringing its cumulative percentage to 68.59%. PA7's ETD of 8355.5 accounts for 11.45%, bringing its cumulative percentage to 80.04%. PA2 has an ETD of 7649, accounting for 10.48% of the total,

and a cumulative percentage of 90.52%. PA3, with an ETD of 3921.75, represented 5.37%, resulting in a cumulative percentage of 95.90%. Both PA4 and PA9 have an ETD of 1089, representing 1.49% of the total, resulting in a cumulative percentage of 97.39% and 98.88%, respectively. Finally, PA6 had the smallest ETD of 816.75, accounting for 1.12%, and making its cumulative percentage 100.00%. The total ETD reached 72968.8. It also driven in picture below.

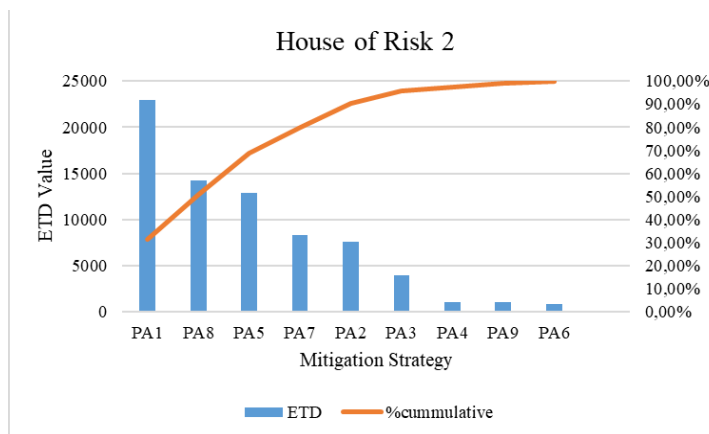


Fig. 4. HOR 2 Pareto Diagram

The pareto diagram in figure 4 illustrates the Expected Time Delay (ETD), percentage, and cumulative percentage for various codes in the phase 2 HOR analysis. PA1 has the highest ETD, close to 25,000, making a significant contribution to the total percentage. PA8 and PA5 follow, with ETDs of approximately 14,000 and 13,000, respectively. The cumulative percentage line graph shows a steep initial increase, driven by PA1, PA8, and PA5, highlighting their substantial impact on the overall ETD. As ETD values decrease for subsequent codes like PA7, PA2, and PA3, the cumulative percentage line flattens, approaching 100%. Codes PA4, PA9, and PA6 have much lower ETDs, with PA6 being the lowest and contributing minimally to the cumulative percentage. Based on this analysis, to address the top 80% of the ETD impact, priority should be given to the following four steps: first, compile halal SOPs in accordance with halal standards; second, conduct monitoring (supervision); third, prepare and file the necessary documents for halal certification; and lastly, implement hygiene and sanitation standards. Traders also complained about the difficulty of obtaining halal certification for the sale of broiler chickens in Colombo market. This can be a concern for the government that ease of regulation can be the answer. In addition, cooperating with young students to help can also be used as a first step for halal certification in this market.

To effectively address the 80% of the impact related to ETD (Estimated Time of Departure) in the context of halal certification, it is crucial to prioritize a series of strategic steps. First, developing comprehensive Standard Operating Procedures (SOPs) aligned with halal standards is essential. These SOPs should encompass all aspects of broiler production, handling, and sales, ensuring that every step in the process adheres to halal criteria. This approach will establish a clear operational framework and help maintain consistency in halal practices. Once SOPs are established, the next step involves thorough monitoring and supervision. This entails regularly inspecting operations to ensure adherence to the SOPs. Effective oversight is vital for identifying any deviations from halal standards and implementing corrective measures promptly. Regular audits and facility inspections are necessary to ensure ongoing compliance and address any emerging issues.

The third critical step is preparing and submitting the required documentation for halal certification. This process involves organizing and presenting all necessary documents, including application forms and evidence of compliance with halal standards. Proper documentation is key to a smooth certification process and demonstrates to certifying bodies that all requirements have been met. Implementing rigorous hygiene and sanitation standards is the final step in this process. Maintaining high levels of hygiene and proper handling practices is crucial for preserving the halal status of the product. This includes regular cleaning of facilities, adherence to proper food handling procedures, and preventing contamination throughout the production and distribution stages.

Additionally, it is important to address the specific challenges faced by traders in obtaining halal certification, particularly in markets such as Colombo. Traders have reported difficulties with the certification process, highlighting the need for a more efficient and accessible regulatory framework. The government can play a significant role in easing these regulatory barriers to facilitate smoother certification for traders. Furthermore, involving students in the halal certification process can provide valuable support. Students can assist with tasks such as research, documentation, and the implementation of standards. Their involvement can offer new perspectives and contribute to a more efficient certification process. By focusing on these strategic measures and addressing regulatory challenges, the halal certification process can be enhanced, ultimately alleviating difficulties for traders and ensuring adherence to halal standards in the market.

V. CONCLUSION

The conclusion of this study indicates that the majority of halal contamination in Colombo market is due to the lack of operational and halal standards. The highest risks identified are the absence of halal certification, improper handling of halal soup, and issues with cutting processes. To mitigate these risks, priorities should include developing halal Standard Operating Procedures (SOPs), conducting regular monitoring, ensuring proper documentation for slaughter, and implementing hygiene and sanitation standards. Additionally, it is important to note that halal issues are influenced by government regulations, highlighting the need for further research in this area.

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