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Human Error Risk Analysis In Expiration Date Labeling Using SHERPA, HOR And Fuzzy Logic In Makassar Bread Msmes

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Abstract

Human error in the expiration date labeling process is one of the main causes of declining product quality and increasing food safety risks in Micro, Small, and Medium Enterprises (MSMEs). This study aims to identify potential human errors, determine risk priorities, and formulate mitigation strategies in the expiration date labeling process using an integration of the Systematic Human Error Reduction and Prediction Approach (SHERPA), House of Risk (HOR), and Fuzzy Logic methods. The study used a qualitative approach with a case study design in one of the bakery MSMEs in Makassar City. Data were obtained through observation, interviews, documentation, and assessments by 25 respondents consisting of operators and production supervisors. The results identified 35 potential human errors, with action errors as the most dominant type of error. HOR analysis showed that errors in setting expiration dates, not rechecking, and operator fatigue were priority risks. The integration of Fuzzy Logic resulted in a more objective risk assessment by considering uncertainty in respondents' assessments. This study shows that the integration of SHERPA, HOR and Fuzzy Logic is effective as a risk analysis approach to support the improvement of quality control, food safety, and mitigation decision making in the MSME-scale food industry.

Keywords: human error; SHERPA; House of Risk; Fuzzy Logic; food labeling; bakery SMEs.

INTRODUCTION

The food and beverage industry is a strategic sector that supports national economic growth and contributes significantly to food security. In Indonesia, this sector is dominated by Micro, Small, and Medium Enterprises (MSMEs), which play a crucial role in job creation,

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increasing added value, and strengthening the food industry supply chain. According to the Ministry of Industry of the Republic of Indonesia (2024), the food and beverage industry remains the largest contributor to the Gross Domestic Product (GDP) of the non-oil and gas processing industry, accounting for over 39%, while also demonstrating relatively stable growth compared to other manufacturing subsectors. This situation demonstrates that increasing the competitiveness of food MSMEs is not only an economic issue but is also closely related to aspects of food safety, consumer protection, and industrial sustainability.

Amidst increasing market competition and consumer demands for safe and high-quality products, quality control systems are increasingly becoming a determining factor in the success of the food industry. The Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO) emphasize that food safety is a key prerequisite for achieving a sustainable food system, as every stage of production has the potential to become a source of hazard if not systematically controlled (FAO & WHO, 2022). One aspect that has direct consequences for consumer safety is the accuracy of information on product labels, particularly the inclusion of expiration dates. This information serves as the basis for consumers in determining the suitability for consumption of a product and is a requirement stipulated in various international food safety regulations, including those of the Codex Alimentarius Commission (Codex Alimentarius Commission, 2023).

Errors in the labeling process, particularly in the inclusion of production and expiration dates, can have significant impacts. In addition to increasing the risk of unfit products circulating in the market, labeling errors can also lead to product recalls, economic losses, decreased consumer confidence, and even legal consequences for producers. Reports from various food regulatory agencies indicate that labeling errors remain a leading cause of corrective action against food products in various countries (Food Standards Australia New Zealand [FSANZ], 2023; US Food and Drug Administration [FDA], 2024). This phenomenon demonstrates that risk control in the labeling process is an increasingly important issue, especially for MSMEs, which generally have limited resources, technology, and quality control systems.

In practice, most food MSMEs in Indonesia still rely on semi-manual production processes with a high level of operator intervention, including at the printing and label inspection stages. These repetitive activities increase the likelihood of human error, such as incorrect date entry, inconsistencies in label information, and failure to detect errors before the product is marketed (Alfano & Rusindiyanto, 2021). From an ergonomic and human factors engineering perspective, repetitive work over long periods of time is known to increase the likelihood of errors due to operator fatigue, decreased concentration, and cognitive load. Therefore, identifying the sources of human error is a crucial step in improving the quality of the food production process.

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Various previous studies have utilized the Human Reliability Analysis (HRA) approach, particularly the Systematic Human Error Reduction and Prediction Approach (SHERPA), to structuredly identify potential human error in various manufacturing systems (Patradhiani et al., 2022). On the other hand, the House of Risk (HOR) method is widely used to prioritize risk agents based on their impact level and probability of occurrence in supply chain systems and production processes. However, most previous studies still apply risk assessment using conventional linguistic scales or deterministic weighting, thus failing to fully accommodate uncertainty, subjectivity of expert judgment, or variations in perceptions between evaluators. In fact, the characteristics of operational risks in food MSMEs are generally influenced by incomplete information and dynamic field conditions, so deterministic modeling has the potential to produce less representative mitigation priorities (Fradinata et al., 2022).

This research gap highlights the need to develop risk analysis methods capable of integrating detailed human error identification, prioritization of risk drivers, and uncertainty management into the decision-making process. Integrating SHERPA with the House of Risk, enhanced by a fuzzy logic approach, is expected to produce risk evaluations that are more objective, adaptive, and closer to actual operational conditions (Aliabadi et al., 2024). The fuzzy approach enables the transformation of linguistic assessments into quantitative values without ignoring the ambiguity inherent in human perception, thereby increasing accuracy in prioritizing mitigation actions.

Based on the description, this study aims to develop a human error risk analysis model in the food product labeling process by integrating the SHERPA method, House of Risk (HOR), and fuzzy logic. The integration of these three methods is expected to be able to identify the most critical types of errors, determine risk agents with the highest priority, and formulate more effective and targeted mitigation strategies. Theoretically, this study contributes to the development of the Human Reliability Analysis approach through the integration of the SHERPA–HOR method based on fuzzy logic in the context of the food industry. Practically, the results of this study are expected to be a basis for MSMEs and food industry managers in improving quality control systems, reducing the risk of labeling errors, strengthening food safety, and increasing consumer confidence in the products produced.

METHODS

This research employed a case study design with a mixed methods approach that integrates qualitative data collection techniques and quantitative analysis. This approach was chosen because it allows researchers to gain a comprehensive understanding of the causes of human error in the expiration date labeling process while systematically measuring risk levels.

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According to Creswell and Creswell (2023), a mixed methods approach provides the opportunity to combine the power of exploratory qualitative data with quantitative analysis, resulting in objective and structured measurements.

The research object was the expiration date labeling process at a Micro, Small, and Medium Enterprise (MSME) in the bakery industry in Makassar City, South Sulawesi. The research location was selected using purposive sampling, based on the consideration that the company still uses a semi-manual production system and has a documented history of labeling errors. The purposive technique was chosen because it allows researchers to obtain relevant information in accordance with the research objectives (Patton, 2015).

The research subjects consisted of labeling operators, production supervisors, and business owners directly involved in the product labeling process. The informant selection criteria included: (1) having at least one year of experience in the production process, (2) understanding product labeling procedures, and (3) being willing to provide complete information during the research. The informant selection was carried out purposively because they were considered to have adequate knowledge and experience regarding the operational activities that were the object of the research

The research data sources consisted of primary and secondary data. Primary data were obtained through direct observation of labeling activities, semi-structured interviews with operators and supervisors, and discussions with the business owner to identify potential human errors and their causal factors. Observations were conducted to obtain an actual picture of the work stages, operator interactions with equipment, and work environment conditions. Interviews were used to obtain information on operator experience, operational obstacles, and implemented quality control mechanisms. Secondary data were obtained from company documents in the form of standard operating procedures (SOPs), production records, reports of labeling errors from the past three months, and relevant scientific literature.

Data analysis was conducted through three integrated stages. The first stage was the identification of potential human errors using the Systematic Human Error Reduction and Prediction Approach (SHERPA) developed by Kirwan (1994). Prior to error identification, all labeling activities were analyzed using Hierarchical Task Analysis (HTA) to ensure a comprehensive decomposition of the operator's physical and cognitive activity elements (Hantara & Susanto, 2022). Next, each activity was evaluated based on the five SHERPA error categories: action error, checking error, retrieval error, selection error, and communication error. The analysis produced a list of potential errors, their consequences, causes, and initial control recommendations.

The second stage is a risk priority analysis using the House of Risk (HOR) method. At this stage, identified potential human errors are systematically mapped into risk events and their

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triggers, or risk agents (Natalia et al., 2021). Assessments are made based on the severity of the impact (severity), the probability of occurrence (occurrence), and the correlation between variables to obtain the Aggregate Risk Potential (ARP) value. This ARP value is used as a baseline for prioritizing the allocation of improvement resources to factors that contribute the greatest risk in the production system (Puji & Yul, 2021).

The third stage is the application of Fuzzy Logic to reduce subjectivity and interpretation bias in the HOR risk matrix. Expert assessments of impact and probability parameters are generally expressed in linguistic variables, which are prone to ambiguity. Therefore, a fuzzy approach is used to transform these linguistic variables into fuzzy numbers through a fuzzification process. Next, an inference process is performed using fuzzy rules (fuzzy inference system) and concluded with a defuzzification process to obtain the final quantitative risk value. This integration results in a more objective and adaptive mitigation action prioritization system that addresses the uncertainty of real conditions at the operational level (Ulfah et al., 2023).

To enhance the validity of the findings, the study employed source and method triangulation. Source triangulation was conducted by comparing information obtained from operators, supervisors, and business owners, while method triangulation was conducted through a combination of observation, interviews, and document analysis. Furthermore, risk identification results were reconfirmed with informants (member checking) to ensure the researcher's interpretations matched actual conditions in the field. The application of these various validation techniques is expected to enhance the credibility, consistency, and reliability of the research findings.

RESULT AND DISCUSSION

Human Error Identification Based on SHERPA

Identification of potential human errors was conducted using the Systematic Human Error Reduction and Prediction Approach (SHERPA) method for all stages of the expiration date labeling process in a bread MSME. Based on field observations, interviews with 25 respondents, and Hierarchical Task Analysis (HTA), 35 potential human errors were identified across ten stages of the production process, from machine preparation to handling production errors.

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Table 1. Results of Human Error Identification Using SHERPA

No	Process Stages	Error Type (Sherpa)	Error Description	Consequence
1	Preparing the Machine	Action Error	The machine is not turned on or set up correctly.	Production process is hampered, working time is wasted
		Selection Error	Wrong engine type or initial settings selected	Print results do not meet established standards
2	Preparing the Ink	Action Error	Forgot or didn't refill the empty ink	The date text or numbers do not appear at all.
		Selection Error	Not checking the quality and clarity of the ink	Blurry, faded or difficult for consumers to read print
3	Preparing the Packaging	Action Error	Wrong type of packaging or label	Information does not match the existing product type
4	Date settings	Action Error	Incorrect input of date, month, or year numbers	Products at risk of being consumed outside their shelf life
		Checking Error	Not rechecking the data entered	Errors go undetected and pass through to consumers
5	Format Settings	Selection Error	Wrong date format selected (DD/MM/YY vs MM/DD/YY)	Confusing consumers and causing confusion
6	Position setting	Action Error	Incorrect placement or position of the print	Labels are skewed, cut off, or illegible
7	Printing process	Action Error	Wrong button press or machine working sequence	The product is not labeled at all or the print is damaged.
		Checking Error	Not monitoring print results regularly	Errors that repeat continuously without being corrected

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No	Process Stages	Error Type (Sherpa)	Error Description	Consequence
8	Checking results	Checking Error	Not carefully looking at the print results	Errors passed to consumers
		Retrieval error	Forgot the standard expiration date of each product	Misjudging the suitability of a product that should be
		Action Error	Not taking sample for examination	There is no measurable and regular quality control
		Communication Error	Do not report if errors or damage are found	The problem is unknown to the leadership and keeps recurring
9	Recording	Action Error	Not recording inspection results or production data	There is no material for evaluation and improvement in the future.
		Checking Error	Wrongly writing or recording observation results	The stored data becomes invalid and incorrect.
10	Handling when problems occur	Action Error	Do not stop the machine when an error occurs	Defective products continue to be produced in large quantities
		Selection Error	Wrong choice of method or corrective action	The existing problem is not resolved properly
		Communication Error	Not coordinating with supervisors when there is a problem	Handling becomes slow and unfocused

Source: Primary data from observations, interviews, and researcher analysis using the (SHERPA) method, 2026

The identification results show that the Action Error category is the most dominant type of error compared to other categories. These errors occur at almost every stage of the process, such as incorrect machine settings, incorrect expiration date input, incorrect print position

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settings, and failure to stop the machine when deviations occur. The dominance of Action Errors indicates that labeling activities still rely heavily on operator skills, potentially increasing the incidence of human error.

In addition to action errors, the study also identified several checking errors with the potential for serious consequences, particularly during expiration date verification and printout inspection. Failure to perform rechecks allows errors to slip through until the product reaches consumers. This situation indicates that weaknesses in the quality control system are not solely caused by operator error, but also by suboptimal inspection mechanisms during the production process.

Other identified errors include Selection Errors, Retrieval Errors, and Communication Errors. Although their frequency is lower than Action Errors, these three categories still have a significant impact on product quality because they relate to the selection of work procedures, mastery of expiration date standards, and coordination between operators. These findings indicate that the causes of human error are not only individual factors but also influenced by work systems and communication within the organization.

Overall, the SHERPA identification results indicate that the labeling process has several critical points that require further control. Therefore, all identified potential errors were further analyzed using the House of Risk (HOR) method to prioritize risks requiring mitigation

Risk Priority Analysis Using House of Risk (HOR)

Once all potential human errors have been identified, the next step is to determine the risk priority level using the House of Risk (HOR) method. The assessment is based on three main parameters: Severity (S), Occurrence (O), and Detection (D). The risk value is calculated by multiplying these three parameters to determine the priority level of each error.

Table 2. Risk Assessment Results Using HOR

Ranking	Type of Error / Process Stage	Severity	Emergence	Detection	Risk Value	Category
1	Incorrect expiry date input (Date Settings)	5	4	2	40	Very high
2	Do not double check the entered data (Date Settings)	5	4	2	40	Very high

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Ranking	Type of Error / Process Stage	Severity	Emergence	Detection	Risk Value	Category
3	Incorrect date format (DD/MM/YY)	4	3	2	24	Tall
4	Not monitoring print results regularly (Printing)	4	3	2	24	Tall
5	Decreased focus & fatigue (General All Processes)	4	4	2	32	Tall
6	Not being careful when viewing the print results (Result Checking)	4	3	3	36	Tall
7	Forgot the product expiration date standard (Result Check)	3	3	2	18	Currently
8	Wrong choice of corrective action (Problem Handling)	3	2	3	18	Currently
9	Not coordinating when there is a problem (Problem Handling)	3	2	3	18	Currently
10	Wrongly writing/recording data (Recording)	2	2	4	16	Low

Source: Results of data processing using the House of Risk (HOR) method by researchers (2026).

The results of the analysis showed that the error was entering the wrong expiration date andFailure to double-check the date data resulted in the highest risk score, 40, categorizing it as very high risk. This score indicates that both errors have a significant impact on food safety and a relatively high probability of occurrence.

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Errors in the date setting stage are critical because they directly impact the information consumers receive. Even the slightest error in the expiration date can result in unfit products remaining on the market, potentially causing economic losses and a decline in consumer confidence.

Another interesting finding was the high risk of operator fatigue, with a risk score of 32. While not a direct technical error, fatigue contributes to an increased likelihood of various types of human error. This suggests that ergonomics and workload significantly influence the quality of the labeling process.

Conversely, errors at the recording stage received the lowest risk rating. Nevertheless, this risk still requires attention because inaccurate documentation can hinder the evaluation and continuous improvement process. The HOR analysis results indicate that this method is capable of systematically determining risk priorities. However, this approach still uses deterministic assessments and therefore cannot fully accommodate the uncertainty in respondents' perceptions. Therefore, further analysis was conducted using Fuzzy Logic.

Risk Analysis Using Fuzzy Logic

The application of Fuzzy Logic aims to reduce subjectivity in risk assessments derived from respondent perceptions. This approach transforms linguistic assessments into numerical values through a process of fuzzification, inference, and defuzzification, resulting in more representative risk levels.

Table 3. Risk Calculation Results Using Fuzzy Logic

No	Type of Error	HOR Risk Value	Fuzzy Risk Value	Final Risk Category
1	Wrong date input	40	0.92	Very high
2	Not double checking the data	40	0.91	Very high
3	Decreased focus / work fatigue	32	0.84	Very high
4	Wrong date format	24	0.75	Tall
5	Not monitoring the printing process	24	0.72	Tall
6	Not careful during final inspection	36	0.70	Tall
7	Forgot product standards	18	0.53	Currently
8	Wrong corrective action	18	0.48	Currently

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No	Type of Error	HOR Risk Value	Fuzzy Risk Value	Final Risk Category
9	Lack of coordination with supervisors	18	0.45	Currently
10	ta recording error	16	0.31	Low

Source: Results of data processing using Fuzzy Logic by researchers (2026)

The analysis results indicate a shift in priorities compared to the HOR results. One key finding is the increased risk of decreased focus and work fatigue, which achieved a fuzzy score of 0.84, falling into the Very High category. These results demonstrate that the fuzzy approach is able to capture uncertainty in respondents' assessments, resulting in more realistic risk priorities.

Furthermore, fuzzy logic provides a more detailed risk gradation than the HOR method. An error value close to 1.00 indicates that the risk requires immediate mitigation, while risks with a value below 0.50 can still be controlled through routine monitoring. Thus, the integration of HOR and Fuzzy Logic produces a risk prioritization system that is more adaptive to real-world conditions.

Risk Mitigation Strategy

Based on the analysis using the House of Risk (HOR) and Fuzzy Logic methods, mitigation strategies are developed based on the identified risk priority levels. This approach aims to focus corrective actions on the risk causes with the highest impact and probability, thereby making control implementation more effective and efficient. Mitigation priorities are grouped into three categories: very high risk, high risk, and medium to low risk.

1. Very High Risk Mitigation (Fuzzy Value > 0.80).

This category includes errors such as entering incorrect expiration dates, failing to double-check data, and decreased concentration due to work fatigue. These three risks are a top priority because they directly impact food safety, product quality, and compliance with labeling regulations.

Proposed mitigation strategies include:

- The implementation of a double-checking system requires that all date data entered by an operator be re-verified by a supervisor or second operator before the printing process begins. This procedure is expected to minimize input errors that could potentially result in products not meeting food safety standards.

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- Providing visual work instructions in the labeling area that include machine setup procedures, examples of correct date formats, and inspection steps. Visual media is expected to reduce errors due to operator negligence and inconsistency.
- Managing work schedules and rest periods through job rotation and providing regular rest periods can reduce physical and mental fatigue. Given that fatigue is a dominant factor in human error, workload management is a crucial aspect of improving operator reliability.
- Improvements to the work environment, such as increased lighting, temperature control in production rooms, and ergonomic work positions. A comfortable work environment is expected to increase operator concentration during the labeling process

2. High Risk Mitigation (Fuzzy Value 0.60–0.80)

High-risk groups include incorrect date format selection, inadequate monitoring of print results, and inaccuracy during the final inspection stage. These risks have the potential to degrade the quality of information on product labels and increase the likelihood of defective products making it to the distribution stage.

Recommended mitigation strategies include:

- Standardize date formats by establishing one standard format, for example DD/MM/YYYY, across all products to avoid differences in interpretation between operators.
- Increase the frequency of inspections during the production process by periodically checking printed samples, for example every 15–20 minutes, so that deviations can be detected early before they affect the entire product.
- Operator competency training, particularly on label inspection procedures, printing error identification techniques, and the implementation of standard operating procedures (SOPs), is expected to strengthen the consistency of quality control implementation.

3. Medium and Low Risk Mitigation (Fuzzy Value < 0.60)

This category includes errors in remembering expiration dates, lack of coordination between operators, and errors in recording production data. Although the risk is relatively low, controls are still necessary to support the overall effectiveness of the quality management system. Proposed mitigation strategies include:

- Providing information media regarding the expiration date of each product, such as information boards or reference cards in the work area, so that operators do not only rely on memory in determining the shelf life of the product.

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- Strengthening operational communication systems by establishing clear reporting procedures for deviations during the labeling process. A good communication system will expedite decision-making and prevent repeated errors.
- Implementing a standardized recording system, using inspection forms or checksheets with a standard format, is expected to improve documentation accuracy, facilitate traceability, and support ongoing quality control performance evaluation.

Overall, the proposed mitigation strategy demonstrates that reducing human error in the labeling process relies not only on increasing operator accuracy but also requires improvements in work systems, work environments, operational procedures, and quality control mechanisms. The risk-prioritization approach generated through the integration of SHERPA, HOR, and Fuzzy Logic allows companies to focus resources on the most critical risks, thereby enhancing the effectiveness of corrective action implementation.

DISCUSSION

The research results show that the expiration date labeling process in bakery MSMEs still has a high potential for human error. Based on the SHERPA analysis, 35 potential errors were identified across all stages of the process, from machine preparation to recording production results. The dominance of action errors indicates that most errors are caused by operator actions during work activities. This finding indicates that the labeling process still relies heavily on individual skills and is not fully supported by a control system capable of preventing operational errors.

These results align with the Human Reliability Analysis concept proposed by Kirwan (1994), which states that repetitive work activities have a higher probability of human error if they are not supported by clear work procedures and adequate verification mechanisms. Furthermore, Reason (1990) explains throughThe Swiss Cheese Model suggests that accidents or system failures generally occur due to a combination of active operator errors and latent system weaknesses, such as inadequate supervision, suboptimal procedures, or an unsupportive work environment. This study found these conditions in date setting errors, insufficient rechecks, and poor communication between operators.

Analysis using the House of Risk (HOR) indicates that errors in the expiration date setting stage are the highest priority risks. Incorrect date entry and failure to double-check received the highest risk scores due to their high severity and relatively high probability of occurrence. These findings indicate that the verification process is a critical point in the food product labeling system. Inaccurate expiration date information can result in products no longer fit for consumption remaining on the market, increasing the risk to consumer safety and resulting in legal

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consequences and economic losses for businesses. This condition aligns with the provisions ofThe Codex Alimentarius Commission (2020) emphasizes that information on food labels must be accurate, clear, and reliable because it is part of the food safety assurance system.

This study also shows that the factorsWork fatigue is one of the main causes of the increased risk of human error. Although this factor is not directly a technical error, the results of HOR and Fuzzy Logic analysis indicate that decreased operator concentration significantly contributes to the increased chance of error at various stages of the process. This finding supports Dhillon's (2007) opinion that physical and mental fatigue influence decreased operator alertness, decision-making speed, and accuracy in completing repetitive tasks. Thus, controlling human error depends not only on improving worker competence but also requires workload management, organizing rest periods, and improving work environment conditions.

The application of Fuzzy Logic provides a different perspective compared to deterministic risk assessment using HOR. The results show that some risks experienced a change in priority level after considering uncertainty in respondents' assessments. For example, the risk related to decreased operator focus received a fuzzy value of 0.84 and fell into the category ofvery high, even though the previous HOR value did not place it as the highest risk. This indicates that the fuzzy approach is able to accommodate variations in respondents' perceptions of the severity, frequency, and detectability of a risk. These findings support Zimmermann's (2010) theory that Fuzzy Logic is more appropriate for use in decision-making processes involving linguistic data and uncertainty than conventional deterministic approaches.

The integration of the SHERPA, HOR, and Fuzzy Logic methods is the main contribution of this research. SHERPA functions to systematically identify sources of human error in each work activity, HOR determines risk priorities based on the relationship between risk events and their causes, while Fuzzy Logic improves assessment accuracy by accommodating the uncertainty arising from respondents' assessments. The integration of these three methods produces a more comprehensive analytical framework than using each method separately. This approach allows organizations not only to identify the types of errors that occur but also to understand the level of risk priority and determine more targeted mitigation strategies.

Based on the results of the analysis, the mitigation strategy is focused on strengthening the labeling process control system through the implementation ofdouble-checking, standardizing date formats, increasing the frequency of inspections during the production process, developing visual work instructions, and improving the ergonomics of the work environment. These strategies not only aim to reduce operator errors but also strengthen the quality control system to minimize the risk of non-compliant products being released. This approach aligns with the principle of risk-based thinking in quality management and food safety systems, which emphasizes that control

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measures should be prioritized on risks with the greatest impact.

Theoretically, this research contributes to the development of risk analysis methods in the MSME-scale food industry through the application of the SHERPA, HOR and Fuzzy Logic integrative model. The model shows that human error analysis is not sufficient to only identify the type of error, but also needs to consider risk priorities and the level of uncertainty in the assessment process. Practically, the research results can be used as a basis for developing quality control policies in the food product labeling process, especially for MSMEs that still use semi-manual systems and have limited resources.

However, this study has several limitations. First, the study was conducted on only one bread-processing MSME, so the risk characteristics obtained cannot be generalized to the entire food industry. Second, the number of respondents, 25 people, is still limited to the operational conditions of the company being studied. Third, the risk assessment still relies on expert judgment, so even though it has been accommodated using Fuzzy Logic, the element of subjectivity cannot be completely eliminated. Therefore, further research is recommended to involve more research subjects, compare several types of food industries, and integrate the SHERPA, HOR and Fuzzy Logic method with technology.Internet of Things (IoT), machine vision, or Artificial Intelligence to improve fault detection capabilities automatically and in real-time.

CONCLUSION

This study successfully identified and analyzed the potential for human error in the process of labeling the expiration date of bread products by integrating the method.Systematic Human Error Reduction and Prediction Approach (SHERPA), House of Risk (HOR), and Fuzzy Logic. The SHERPA analysis identified 35 potential human errors across ten stages of the labeling process, with action errors being the most dominant error category. These findings indicate that the labeling process is still heavily influenced by human factors, especially in repetitive activities that require high accuracy.

Analysis using the HOR method showed that errors in the expiration date setting stage, particularly incorrect date input and failure to double-check, were the highest-priority risks. Furthermore, work fatigue was identified as a significant factor increasing the likelihood of human error. The application of Fuzzy Logic improved risk assessment results by accommodating uncertainty in respondents' judgments, resulting in more representative risk priorities than deterministic approaches.

Based on the analysis results, this study produces mitigation recommendations that prioritize the implementation of a double-checking system, standardization of labeling formats, increasing the frequency of inspections, developing visual work instructions, improving ergonomic

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conditions of the work environment, and strengthening communication and documentation systems. Overall, the integration of SHERPA, HOR, and Fuzzy Logic has been proven to provide a comprehensive approach in identifying, prioritizing, and controlling the risk of human error in the food product labeling process, thus potentially improving product quality, food safety, and the effectiveness of the quality control system in MSMEs.

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