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Research Article

OCCUPATIONAL ACCIDENT RISK ANALYSIS IN IMAGAWAYAKI PRODUCTION USING THE HIRARC METHOD

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Abstract
Company Z is a frozen food processing industry located in Japan that produces imagawayaki cakes, traditional Japanese cakes that have a round shape and are filled with various fillings. In the production process, workers often come into direct contact with various large-capacity machines, raw materials, and work equipment that have potential hazards from a physical, mechanical, and ergonomic perspective. Some potential hazards often found in the production environment in this food industry include slippery floors due to water or oil spills, hot molds and baking machines, hot room temperatures, and the use of sharp tools. This study aims to identify all hazards in each stage of the production process, then map them into risk levels so that appropriate controls can be provided for existing risks. This study uses a descriptive quantitative approach that applies the Hazard Identification, Risk Assessment, and Risk Control (HIRARC) method as an analytical tool to identify potential hazards and assess the risk of work accidents in the food processing industry sector. Thus, the risk percentage results obtained are at extreme risk of 0%, high risk of 66%, medium risk of 27%, and low risk of 7%. There are also 50 risk control suggestions based on the risk control hierarchy, namely 2 elimination, 7 substitution, 12 engineering controls, 15 administrative controls, and 14 use of personal protective equipment.

Keywords: Occupational Accidents, Risk Assessment, Risk Control

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INTRODUCTION

The food production industry has developed rapidly due to increasing public demand for ready-to-eat food products, including bakery and traditional cake products. This growth encourages companies to apply large-scale production systems supported by modern machines and automated equipment. However, the use of advanced production technology may also increase the possibility of occupational hazards, especially for workers who interact directly with machines, raw materials, hot equipment, and production tools. In the production of Imagawayaki, workers may be exposed to several potential hazards, such as slippery floors caused by oil or water spills, hot molds and baking machines, sharp tools, hot room temperatures, and narrow working spaces. These hazards may cause occupational accident risks, including slipping, burns, cuts, scratches, dehydration, heat stroke, and musculoskeletal disorders. Imagawayaki refers to a traditional Japanese round-shaped cake filled with various fillings, such as red bean paste or custard cream.

This study aims to identify potential hazards in each stage of the Imagawayaki cake production process, assess the level of occupational accident risk, and determine appropriate risk control recommendations using the Hazard Identification, Risk Assessment, and Risk Control method. Hazard Identification, Risk Assessment, and Risk Control, abbreviated as HIRARC, is a systematic occupational safety and health method used to identify hazards, assess risk levels based on likelihood and consequences, and determine control measures to minimize workplace accident risks. The main variables investigated in this study include production activities, types of hazards, accident risks, working conditions, likelihood, consequences, risk levels, and risk control measures.

The significance of this study lies in the need to improve occupational safety and health management in the food processing industry, particularly in production activities that involve direct contact with machines, hot surfaces, sharp objects, and manual handling tasks. The production process of Imagawayaki has a high potential for physical, mechanical, and ergonomic hazards because workers perform repetitive activities, handle materials manually, work near hot baking machines, and operate in areas where floors may become slippery. Without systematic hazard identification and risk control, these conditions may increase the possibility of occupational accidents and reduce worker safety, productivity, and operational efficiency. Therefore, this study is important as an effort to provide practical recommendations for preventing accidents and creating a safer production environment.

Previous studies have shown that the food production sector contains various occupational hazards that require proper risk management. Marlina and Rizal (2017) stated that the application of modern technology in food and beverage manufacturing is important to support production continuity and meet consumer demand, but it may also create occupational safety risks if not properly controlled. Prayoga, Zuki, Lukman, et al. (2023) found that bakery production activities involve several hazards, including slippery floors caused by scattered butter, noise from operating machines, sharp equipment, and heat from baking machines that may cause worker fatigue. These findings are relevant to the present study because Imagawayaki production also involves similar hazards, especially slippery floors, hot equipment, and sharp tools. In addition, Windi Ningsih, Assyifa, and Pramudita (2025) emphasized that risk management is needed to prevent risks from disrupting industrial activities.

The HIRARC method has been widely used in previous occupational safety studies. Mardiah (2022) explained that risk management is a systematic and logical process used to identify, monitor, determine solutions, and report risks in work activities. Amalia, Mufti, and Alfiza (2025) stated that HIRARC consists of hazard identification, risk assessment, and risk control stages, which are useful for minimizing occupational accident risks. Yutaro and Roosmini (2024) further explained that HIRARC plays an important role in determining risk ratings by combining the likelihood of an incident and the severity of its consequences. Several studies have applied HIRARC in food-related industries. Prayoga, Zuki, and Hidayat (2023) identified 30 risks in a bakery production business, consisting of low, medium, and high-risk categories, and proposed risk controls based on substitution, engineering control, administrative control, and personal protective equipment. Wenur, Kawatu, and Joseph (2025) identified ergonomic, physical, biological, and mechanical hazards in coconut production, while Irwanda BR (2022) found physical, chemical, and ergonomic hazards in tofu production.

Although previous studies have applied HIRARC in bakery, coconut, and tofu production industries, limited research has specifically analyzed occupational accident risks in the production of Imagawayaki, a traditional Japanese cake produced using large-capacity machines and hot baking molds. This condition shows a research gap in the application of HIRARC to Imagawayaki cake production activities. The novelty of this study is the specific focus on identifying and assessing occupational accident risks in each production stage of the Imagawayaki industry and formulating risk control recommendations based on the hierarchy of controls. This study assumes that production activities in the Imagawayaki industry contain various hazards with different risk levels and that the application of the HIRARC method can provide a systematic basis for determining appropriate risk control measures.

This study used a descriptive quantitative approach by applying the HIRARC method. Data were collected through observation, questionnaires, and company document review related to occupational accident data. The assessment was conducted by identifying hazards in each production activity, determining the likelihood and consequences of each risk, calculating the risk score, and classifying the risks into low, medium, high, or extreme categories. Risk control recommendations were then formulated based on the hierarchy of controls, including elimination, substitution, engineering control, administrative control, and the use of personal protective equipment. Personal protective equipment, abbreviated as PPE, refers to protective equipment used by workers to reduce exposure to workplace hazards. Through this approach, the study is expected to support the implementation of occupational safety and health in the Imagawayaki production industry and contribute to a safer, more efficient, and more productive working environment.

RESEARCH METHOD

Research Design

This study used a descriptive quantitative research design by applying the Hazard Identification, Risk Assessment, and Risk Control (HIRARC) method. This approach was selected because it provides a systematic framework for identifying potential hazards, assessing the level of occupational accident risks based on likelihood and consequences, and formulating appropriate risk control measures. The study was conducted to describe and measure occupational accident risks in the production section of an Imagawayaki cake industry. The risk assessment was carried out using the AS/NZS 4360 Risk Management standard, in which each identified hazard was assessed by considering the probability of occurrence and the severity of its consequences. The research was conducted from February 1, 2025, to July 30, 2025. The study took place in the production section of Company Z, a frozen food processing industry located in Japan that produces Imagawayaki cakes. The production area was selected because workers in this section are directly involved with production machines, raw materials, hot molds, sharp tools, and other work equipment that may generate physical, mechanical, and ergonomic hazards.

Research Target/Subject

The target of this study was the work process in the production section of the Imagawayaki cake industry. The research subjects consisted of the main production activities and workers who were directly involved in or understood the production process. The total number of respondents was three people, consisting of two key persons and one supporting respondent. The respondents were selected using a purposive sampling technique, because they were considered to have adequate knowledge and experience regarding the production process, potential hazards, and occupational accident risks in the workplace.

Research Procedure

The research procedure was carried out through several sequential stages. First, preliminary observation was conducted to understand the workflow and identify production activities in the Imagawayaki cake production section. Second, each production activity was analyzed to identify potential hazards, including hazards caused by slippery floors, improper manual handling, sharp tools, hot molds, hot room temperature, thin shoe soles, and narrow working spaces. Third, the risks arising from each hazard were identified, such as slipping, musculoskeletal disorders, cuts, scratches, burns, dehydration, heat stroke, and collisions. Fourth, each risk was assessed based on likelihood and consequences. Fifth, the risk score was determined and classified into risk categories, namely low risk, medium risk, high risk, and extreme risk. Finally, risk control recommendations were formulated based on the hierarchy of controls, including elimination, substitution, engineering control, administrative control, and the use of personal protective equipment.

Instruments, and Data Collection Techniques

The data used in this study consisted of primary and secondary data. Primary data were collected through workplace observation and questionnaires given to respondents who had knowledge of the production process. Observation was used to identify work activities, hazard sources, unsafe conditions, and possible accident risks in each production stage. Questionnaires were used to support the assessment of likelihood and consequences for each identified risk. Secondary data were obtained through company document review, particularly documents related to occupational accident records and production activities. The main research instrument was the HIRARC worksheet, which contained columns for activity description, hazard identification, risk identification, working condition, likelihood score, consequence score, risk level, and risk control recommendation.

Data Analysis Technique

Data were analyzed using the HIRARC method by identifying hazards in each production activity, assessing risks based on likelihood and consequence scores, and determining risk levels using the risk matrix. The risks were classified into four categories: low, medium, high, and extreme risk. The percentage of each category was then calculated to describe the distribution of occupational accident risks. Based on the assessment results, risk control recommendations were developed according to the hierarchy of controls, including elimination, substitution, engineering control, administrative control, and personal protective equipment. The assessment criteria used in this study are presented in Tables 1–4 (Adiatmaja, Ushada, and Purwadi, 2025).

Table 1. Risk determination conditions

No.	Condition	Definition
1	Normal (N)	Daily work performed according to procedures
2	Abnormal (A)	Work performed outside procedures
3	Emergency (E)	Conditions that are difficult to control

Table 1 presents the risk determination conditions used as the basis for hazard identification and risk assessment in the study, adapted from Adiatmaja, Ushada, and Purwadi (2025). The framework classifies operational conditions into three categories: Normal (N), Abnormal (A), and Emergency (E). Normal (N) refers to routine daily activities performed in accordance with established operational procedures and standard work practices, representing conditions with predictable and controlled risks. Abnormal (A) describes situations in which work is conducted outside standard operating procedures due to unexpected operational changes, equipment malfunctions, or non-routine activities, thereby increasing the potential for hazards. Emergency (E) represents critical situations that are difficult to control and require immediate response measures to prevent severe consequences for personnel, equipment, and the environment. This classification provides a systematic foundation for evaluating risk under different operational scenarios, enabling more accurate hazard identification, prioritization of risk mitigation strategies, and the development of effective safety management practices (UNSW Health and Safety, 2008).

Table 2. Likelihood criteria

Level	Description	Explanation
1	Rare	Occurs less than once in 10 years
2	Unlikely	Occurs once in 10 years
3	Possible	Occurs once every 5 years to once per month
4	Likely	Occurs more than once per year to once per month
5	Almost certain	Occurs more than once per month

Table 2 presents the likelihood criteria adapted from the UNSW Health and Safety (2008) risk assessment framework, which categorizes the probability of an event occurring into five distinct levels. The scale ranges from Level 1 (Rare), indicating events expected to occur less than once in ten years, to Level 5 (Almost Certain), representing events that are anticipated to occur more than once per month. Intermediate categories include Unlikely (Level 2), referring to events occurring approximately once in ten years; Possible (Level 3), describing events that may occur between once every five years and once per month; and Likely (Level 4), indicating events expected to occur more than once per year up to once per month. This standardized likelihood classification provides a consistent framework for estimating the frequency of potential risks and serves as a critical component of qualitative risk assessment by supporting objective evaluation, prioritization, and decision-making in health and safety management (UNSW Health and Safety, 2008).

Table 3. Consequences criteria

Level	Description	Explanation
1	Insignificant	Does not cause loss or injury to humans and does not result in lost workdays
2	Minor	Causes minor injury and minor loss, but the worker can still work on the same day
3	Moderate	Causes serious injury requiring hospital treatment, without permanent disability; causes moderate financial loss and fewer than 3 lost workdays
4	Major	Causes severe injury and permanent disability, major financial loss, and 3 or more lost workdays
5	Catastrophic	Causes death, severe financial loss, may stop business operations, and results in permanent loss of workdays

Table 3 presents the consequence criteria adapted from UNSW Health and Safety (2008), which classify the severity of potential incidents into five progressive levels based on their impact on human safety, financial loss, and operational continuity. Level 1 (Insignificant) represents incidents that cause no injuries, financial losses, or lost workdays. Level 2 (Minor) includes events resulting in minor injuries and limited financial losses, allowing affected workers to continue their duties on the same day. Level 3 (Moderate) refers to incidents requiring hospital treatment without causing permanent disability, accompanied by moderate financial losses and fewer than three lost workdays. Level 4 (Major) encompasses severe injuries leading to permanent disability, substantial financial losses, and three or more lost workdays. The highest category, Level 5 (Catastrophic), describes incidents resulting in fatalities, extreme financial losses, disruption or cessation of business operations, and permanent loss of work capacity. This consequence classification provides a standardized framework for evaluating the severity of occupational risks and supports organizations in prioritizing risk mitigation strategies and allocating safety resources effectively(UNSW Health and Safety, 2008).

Table 4. Risk matrix

Likelihood	Consequences				
	1	**2**	**3**	**4**	**5**
1	**L**	**L**	**M**	**H**	**H**
2	**L**	**L**	**M**	**H**	
3	**L**	**M**	**H**		
4	**M**	**H**	**H**		
5	**H**	**H**			

L = Low Risk; M = Medium Risk; H = High Risk; E = Extreme Risk

Table 4 presents the risk matrix adapted from the UNSW Health and Safety (2008) framework, which is used to evaluate and classify risks based on the interaction between the likelihood of an event occurring and the severity of its consequences. The matrix consists of five levels of likelihood and five levels of consequence, producing four categories of risk: Low (L), Medium (M), High (H), and Extreme (E). Risks with low likelihood and minor consequences are categorized as Low Risk, indicating that routine monitoring and standard control measures are generally sufficient. As either the likelihood or the severity of consequences increases, the risk level progresses to Medium and High Risk, requiring additional mitigation strategies and closer management. Scenarios characterized by both a high probability of occurrence and severe consequences are classified as Extreme Risk, demanding immediate intervention, comprehensive risk controls, and continuous monitoring to minimize potential adverse outcomes. This matrix provides a systematic framework for prioritizing hazards, supporting evidence-based decision-making, and ensuring that resources are allocated efficiently to manage the most critical risks.

RESULTS AND DISCUSSION

The findings of this study show that the production section of the Imagawayaki cake industry contains various occupational hazards that may lead to work accidents and health problems. Six main activities consisting of thirteen activity descriptions were identified in the production section, resulting in fifteen occupational accident risks. The main hazards found in the production process included slippery floors, improper manual handling, sharp tools, thin shoe soles, hot molds and baking machines, hot room temperature, and narrow working spaces.

Table 5. Hazard identification, risk assessment, and risk control in the production section

Activity Description	Hazard	Risk	Condition	L	C	Risk Level	Risk Control
Taking, lifting, and inserting ingredients into the mixer machine	Slippery floor due to oil spills	Slipping	N	5	1	High	Replace slippery flooring with anti-slip flooring; provide oil spill containers; establish cleaning schedules and warning signs; use anti-slip safety shoes
Lifting dough in buckets onto a trolley or material handling device	Improper lifting method	Musculoskeletal disorders	N	5	1	High	Install wheel locks on the trolley; place empty buckets under the mixer; provide safe lifting training and job rotation
Taking cake fillings from plastic packaging	Slippery floor	Slipping	N	4	1	Medium	Replace slippery flooring with anti-slip

and placing them into containers							flooring; provide spill containers; establish cleaning schedules and warning signs; use anti-slip safety shoes
Cutting filling packaging using a knife	Sharp knife	Cuts	N	1	1	Low	Replace ordinary knives with safety knives; provide knife guards; provide safe cutting training and warning signs; use cut-resistant gloves, apron, and safety shoes
Carrying and inserting cake fillings into the baking machine	Slippery floor	Slipping	N	4	1	Medium	Replace slippery flooring with anti-slip flooring; provide spill containers; establish cleaning schedules and warning signs; use anti-slip safety shoes
Carrying and inserting cake fillings into the baking machine	Thin shoe soles	Slipping	N	5	1	High	Replace worn-out shoes with anti-slip safety shoes; conduct routine shoe inspections; use comfortable and properly fitted safety

							shoes
Carrying cake fillings manually	Improper lifting method	Musculoskeletal disorders	N	5	2	High	Use a trolley or assistive device; replace containers with ergonomic handles; provide safe lifting training and job rotation; use anti-slip gloves
Taking initial products before filling	Hot mold	Burns	N	3	2	Medium	Install guards around the picking area; use assistive tools; provide heat warning signs and safe work training; use heat-resistant gloves
Arranging products from the baking machine to the conveyor	Hot room temperature	Dehydration and heat stroke	N	4	1	Medium	Install exhaust fans for air circulation; provide job rotation, drinking water, and heat stroke awareness; use neck fans
Manually taking products that are not clamped during machine trouble	Hot product molds in the machine	Burns	N	4	2	High	Install guards around the picking area; use assistive tools; provide heat warning signs and safe work training; use heat-resistant gloves
Passing under the conveyor to	Narrow workspace and low	Collision or bumping	N	5	2	High	Install protective padding

stop or repair a troubled machine	conveyor position						under the conveyor; provide safe movement training and warning signs; use safety shoes
Turning over used molds	Hot molds	Burns	N	4	2	High	Install guards around the machine area; provide heat warning signs and safe mold-handling training; use heat-resistant gloves
Cleaning product clamps on the baking machine	Sharp ends of product clamps	Scratches	N	4	2	High	Use assistive tools such as long-handled brushes or air sprays; provide adequate lighting; provide safe cleaning training and sharp hazard warning signs; use scratch-resistant gloves
Carrying washed machine tools back to the machine	Slippery floor	Slipping	N	5	1	High	Replace slippery flooring with anti-slip flooring; establish cleaning schedules and warning signs; use anti-slip safety shoes
Cleaning molds using an air jet	Hot air from air jet and	Dehydration and heat stroke	N	5	1	High	Install exhaust fans; provide job

machine	enclosed room		rotation, drinking water, and heat stroke awareness; use neck fans

N = Normal condition; L = Likelihood; C = Consequence.

Table 5 presents the results of the Hazard Identification, Risk Assessment, and Risk Control (HIRARC) analysis conducted in the production section, identifying 15 routine work activities with varying levels of occupational risk. The assessment revealed that High-risk hazards were the most prevalent, particularly those associated with slippery floors, improper manual handling techniques, hot equipment, and restricted workspaces. Slipping hazards frequently occurred during ingredient handling, filling transportation, and equipment cleaning due to oil spills and wet floors, while musculoskeletal disorders were primarily linked to improper lifting practices during manual material handling. Thermal hazards, including burns from hot molds and product handling, were also identified as significant risks during baking and maintenance operations. In contrast, Medium-risk hazards were related to dehydration, heat stress, and minor slipping incidents, whereas Low-risk activities were limited to cutting packaging materials with knives. To mitigate these risks, the proposed control measures emphasize engineering controls, administrative controls, and personal protective equipment (PPE), including the installation of anti-slip flooring, machine guards, exhaust ventilation systems, ergonomic material-handling devices, routine housekeeping schedules, worker training, job rotation, warning signage, and the mandatory use of appropriate PPE such as anti-slip safety shoes, heat-resistant gloves, cut-resistant gloves, and protective aprons. These findings indicate that implementing comprehensive risk control strategies is essential for reducing workplace accidents, improving employee safety, and promoting a safer production environment.

Table 6. Distribution of risk levels in the production section

Risk Level	Number of Risks	Percentage
Extreme Risk	0	0%
High Risk	10	66.67%
Medium Risk	4	26.67%
Low Risk	1	6.67%
Total	**15**	**100%**

These hazards resulted in several risks, such as slipping, musculoskeletal disorders, cuts, scratches, burns, dehydration, heat stroke, and collisions. Based on the HIRARC assessment, most risks were categorized as high risk, with a percentage of 66.67%, followed by medium risk at 26.67%, low risk at 6.67%, and extreme risk at 0%. These results indicate that although no risk reached the extreme category, most work activities in the production section still require immediate and appropriate control measures.

The dominance of high-risk categories indicates that workers in the Imagawayaki production section are frequently exposed to hazards during routine work activities. Slippery floors caused by oil or water spills were one of the most frequent hazards identified in several production stages. This condition increases the possibility of slipping, especially when workers carry materials, move between production areas, or work near machines. This finding is consistent with Murniyati (2012) in Fitriani et al. (2021), who stated that many minor injury incidents, including slipping, occur due to slippery work floors. Similar findings were also reported by Raudahtusshofie (2025), who explained that slips, trips, and falls may be influenced by environmental factors such as wet or oily floor surfaces. Therefore, slippery floors in the production area should not be considered a minor condition, because repeated exposure may increase the probability of accidents.

Ergonomic hazards were also found in activities involving the lifting and carrying of dough or cake fillings. Improper lifting methods were associated with the risk of musculoskeletal disorders. Although the consequence level of some ergonomic risks was not categorized as severe, the likelihood score was high because the activities were performed repeatedly during the production process. This finding supports Sjarifah and Rosanti (2019) in Aprianto et al. (2021), who stated that inappropriate work posture performed continuously and repeatedly may contribute to musculoskeletal disorders among workers. In this study, ergonomic risks were mainly related to manual handling, including lifting buckets of dough and carrying cake fillings into the baking machine. These findings suggest that the production process requires ergonomic improvements, such as using assistive devices, improving container design, and providing training on safe lifting techniques.

Mechanical hazards were identified from the use of sharp objects, such as knives and sharp ends of product clamps on the baking machine. These hazards may cause cuts or scratches during the preparation of fillings and cleaning of machine components. The risk of cuts from knives was categorized as low risk because the likelihood and consequence scores were both low. However, scratches from sharp machine parts were categorized as high risk due to more frequent exposure during cleaning activities. This finding is in line with Latief et al. (2018) in Zumala (2023), who stated that the use of sharp objects can result in injuries such as scratches, punctures, and cuts, especially when workers do not use or store tools properly. The difference in risk levels between knife use and machine clamp cleaning may be explained by differences in exposure frequency, work position, and the level of control available during the activity.

Heat-related hazards were also important findings in this study. Hot molds, baking machines, and hot room temperatures created risks of burns, dehydration, and heat stroke. Several activities, such as taking products from the baking machine, handling hot molds, and cleaning molds using a hot air jet, were categorized as high risk. This is consistent with Supit and Alpiah (2023), who stated that burns may occur due to exposure to heat, radiation, electricity, friction, or chemical substances. Bahlia and Rizaldy (2025) also explained that burns can occur when the body comes into contact with objects that generate heat, either directly or indirectly. In addition, Maharani, Raihanah, and Mubien (2024) stated that heat stroke is a serious medical condition that may occur when body temperature increases significantly, often due to working in high-temperature environments. These findings indicate that heat exposure in the Imagawayaki production process needs to be controlled not only to prevent burns but also to reduce heat stress among workers.

The risk of collision or being hit was found in activities carried out in narrow workspaces, especially when workers passed under a low conveyor to stop or repair a troubled machine. This risk was categorized as high because the likelihood of occurrence was high, even though the consequence score was relatively low. This finding supports Manurung et al.

(2025), who stated that narrow workspaces may increase the risk of occupational accidents and reduce work productivity. In the context of this study, the limited workspace may encourage unsafe movements, particularly when workers are in a hurry or when machines experience operational problems. Therefore, improving workplace layout and installing protective padding or warning signs are important control measures.

The results of this study are consistent with previous HIRARC studies in food production and processing industries. Prayoga, Zuki, and Hidayat (2023) found low, medium, and high-risk categories in bakery production and recommended controls through substitution, engineering control, administrative control, and personal protective equipment. Wenur, Kawatu, and Joseph (2025) also identified ergonomic, physical, biological, and mechanical hazards in the production section of a coconut processing industry. Similarly, Irwanda BR (2022) found physical, chemical, and ergonomic hazards in tofu production. Compared with these previous studies, the present study confirms that food production activities generally involve repeated exposure to physical, mechanical, and ergonomic hazards. However, this study provides a specific contribution by applying HIRARC to the Imagawayaki cake production process, which involves unique production characteristics such as hot molds, baking machines, cake filling handling, and cleaning using a hot air jet.

Table 7. Summary of risk control recommendations based on the hierarchy of controls

Hierarchy of Controls	Number of Recommendations	Examples of Control Measures
Elimination	2	Using assistive tools to reduce direct contact with sharp or hazardous machine parts
Substitution	7	Replacing slippery floors with anti-slip floors; replacing ordinary knives with safety knives; replacing worn-out shoes
Engineering Control	12	Installing spill containers, machine guards, exhaust fans, protective padding, and adequate lighting
Administrative Control	15	Providing safety training, warning signs, cleaning schedules, routine inspections, job rotation, and heat stroke awareness
Personal Protective Equipment	14	Using anti-slip safety shoes, cut-resistant gloves, heat-resistant gloves, scratch-resistant gloves, aprons, and neck fans
Total	**50**	—

The risk control recommendations in this study were developed based on the hierarchy of controls. A total of 50 risk control measures were proposed, consisting of 2 elimination controls, 7 substitution controls, 12 engineering controls, 15 administrative controls, and 14 personal protective equipment controls. The large number of administrative controls and PPE recommendations indicates that many risks can be reduced through work procedures, training, warning signs, cleaning schedules, job rotation, and the use of protective equipment. However, reliance only on administrative controls and PPE may not be sufficient because these controls depend heavily on worker compliance. Therefore, engineering controls and substitution measures, such as installing anti-slip flooring, providing spill containers, improving ventilation, using assistive devices, and installing machine guards, should be prioritized where possible because they can reduce hazards at the source or minimize direct exposure.

The findings imply that occupational safety and health management in the Imagawayaki production industry should focus on routine hazard monitoring, workplace layout improvement, heat exposure control, ergonomic work design, and consistent implementation of safe work procedures. The HIRARC method can help companies identify priority risks and determine control measures according to the risk level. In practical terms, the company should prioritize high-risk activities, especially those related to slippery floors, hot equipment, manual handling, sharp machine parts, and narrow workspaces. These controls are expected to reduce accident potential and support a safer and more productive working environment.

This study has several limitations. The assessment was limited to the production section of Company Z and involved only three respondents, consisting of two key persons and one supporting respondent. Therefore, the findings may not fully represent all workers or other departments in the company. In addition, this study did not conduct direct environmental measurements, such as heat intensity, noise level, humidity, or lighting level, which may provide more objective evidence for evaluating physical hazards. The risk assessment was based on observation, questionnaires, document review, and the HIRARC matrix; therefore, the results may still be influenced by respondents' perceptions and the conditions observed during the research period.

Future studies are recommended to involve a larger number of respondents and include direct measurement of workplace environmental factors, especially temperature, humidity, noise, and lighting. Further research may also compare risk levels before and after the implementation of control measures to evaluate the effectiveness of the recommended controls. In addition, future studies could apply ergonomic assessment tools to examine manual handling and work posture risks in more detail. These improvements would provide stronger evidence for developing occupational safety and health interventions in food production industries.

CONCLUSION

This study found that the production section of the Imagawayaki cake industry contains several occupational hazards that may lead to work accidents and health problems. The identified hazards were mainly related to slippery floors, improper manual handling, sharp tools, worn-out shoe soles, hot molds and baking machines, hot room temperature, and narrow working spaces. These hazards generated risks such as slipping, musculoskeletal disorders, cuts, scratches, burns, dehydration, heat stroke, and collisions. Based on the HIRARC assessment, the risk levels consisted of 0% extreme risk, 66.67% high risk, 26.67% medium risk, and 6.67% low risk. These findings indicate that most risks in the production section were categorized as high risk and therefore require appropriate and immediate control measures.

The application of the HIRARC method was able to systematically identify hazards, assess risk levels, and determine risk control recommendations in each stage of the production process. A total of 50 risk control recommendations were proposed based on the hierarchy of controls, consisting of 2 elimination controls, 7 substitution controls, 12 engineering controls, 15 administrative controls, and 14 personal protective equipment controls. The recommended controls include the use of anti-slip flooring, assistive devices, machine guards, exhaust fans, warning signs, cleaning schedules, job rotation, safety training, and appropriate personal protective equipment.

DECLARATION OF AI AND AI ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this work the author(s) used ChatGPT to assist in improving grammar, language quality, and overall readability of the text. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

AUTHOR CONTRIBUTIONS

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.
Author 2: Conceptualization; Data curation; In-vestigation.
Author 3: Data curation; Investigation.
Author 4: Formal analysis; Methodology; Writing - original draft.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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