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Identification And Control Of Occupational Hazards In Traditional Yellow Tofu Production Using The HIRADC Method

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Abstract

Traditional yellow tofu production involves various manual activities that may expose workers to occupational hazards if safety aspects are not properly managed. This study aims to identify occupational hazards and determine appropriate control measures in traditional yellow tofu production using the Hazard Identification, Risk Assessment, and Determining Control (HIRADC) method. The research was conducted at FMY Tofu Factory in Bandung, Indonesia, through direct observation, worker interviews, and documentation of production activities. Hazard identification was carried out at each production stage, including washing, soaking, grinding, boiling, filtering, coagulation, molding, re-boiling, and cutting. The identified hazards were classified into physical, ergonomic, mechanical, electrical, chemical, biological, and environmental hazards. Risk assessment was performed using likelihood and severity parameters to determine risk levels. The results identified 27 potential hazards with risk levels ranging from low to very high. Very high risks were mainly found in the grinding, boiling, and cutting stages due to exposure to rotating machinery, damaged electrical equipment, high temperatures, and sharp cutting tools. High risks were associated with slippery floors, repetitive manual handling, and awkward working postures. Recommended control measures include installing machine guards, improving ventilation and drainage systems, implementing ergonomic workstations, conducting routine electrical inspections, and providing appropriate personal protective equipment such as heat-resistant and cut-resistant gloves. The implementation of HIRADC provides a systematic approach to improving occupational safety and health conditions and reducing workplace accidents in traditional yellow tofu production.

Keywords: HIRADC, Occupational Safety And Health, Hazard, Yellow Tofu.

1. Introduction

Tofu is one of the soybean-based food products widely consumed in many countries, including Indonesia (Yosifani et al., 2021; Ratnaningsih et al., 2025). The production process of tofu involves several stages such as washing, soaking, grinding, boiling, pulp separation, coagulation, molding, and cutting (Alawi & Rahdiana, 2025). One of the popular varieties in Indonesia is yellow tofu, which has a distinctive color and flavor preferred by consumers (Yosifani et al., 2021). Along with the increasing demand for plant-based protein sources, the production of yellow tofu continues to grow, particularly in small-scale and traditional food industries (Farhan & Purnomo, 2025).

Despite the increasing production activities, the tofu manufacturing process also presents several occupational safety and health challenges (Herdhiansyah et al., 2022; Nurwidiana & Ela, 2025). Many stages of tofu production involve manual work, mechanical equipment, and exposure to high temperatures during the boiling process (Zhang et al., 2018; Afriza & Dewi, 2024). These conditions may expose workers to potential hazards such as slipping on wet floors, burns from hot steam, injuries from production tools, and ergonomic risks caused by repetitive work activities (Alawi & Rahdiana, 2025). Without proper hazard identification and safety management, these conditions may increase the risk of workplace accidents (Shaumarda & Suyono, 2025).

One of the approaches commonly used in occupational safety management is the Hazard Identification, Risk Assessment, and Determining Control (HIRADC) method (Shaumarda & Suyono, 2025; Henny et al., 2025). This method provides a systematic framework for identifying potential hazards, evaluating risks, and determining appropriate control measures in work activities (Rahardja, 2023; Afriza & Dewi, 2024). The application of HIRADC allows hazards in industrial processes to be identified more systematically, enabling the development of effective preventive measures to improve workplace safety (Shaumarda & Suyono, 2025).

Traditional food processing industries are often characterized by labor-intensive activities and limited implementation of occupational safety standards, which can increase workplace hazards for workers. In tofu production, workers are exposed to various risks such as burns, slips, repetitive movements, and injuries caused by machinery and manual tools used during the production process. According to Zhang et al. (2018), tofu processing involves several stages including grinding, heating, filtering, coagulation, and cutting, all of which require proper safety management to minimize occupational accidents and improve production efficiency. Therefore, hazard identification and risk assessment are essential to support safer working conditions and sustainable productivity in traditional tofu industries (Zhang et al., 2018). Another study also highlighted that occupational hazards in small-scale manufacturing industries are commonly associated with unsafe working conditions, inadequate machine protection, and poor ergonomic practices. According to Tarwaka (2017), repetitive work activities, awkward body posture, manual material handling, and exposure to unsafe physical environments significantly contribute to musculoskeletal disorders and workplace accidents among industrial workers. Therefore, ergonomic improvements and proper occupational safety management are necessary to reduce occupational risks and improve worker well-being in traditional tofu production industries (Tarwaka, 2017).

Based on these considerations, this study aims to identify potential occupational hazards in the traditional yellow tofu production process using the HIRADC method (Afriza & Dewi, 2024). The identification focuses on each stage of the production process, including washing, soaking, grinding, boiling, pulp separation, coagulation, molding, and cutting (Alawi & Rahdiana, 2025). The results of this study are expected to provide useful information for improving occupational safety practices and minimizing potential workplace accidents in traditional tofu production (Shaumarda & Suyono, 2025).

2. Research Methodology

2.1 Research Approach

This study used a descriptive observational approach to identify potential occupational hazards in the yellow tofu production process. Data were obtained through direct observation of work activities and interviews with workers involved in the production process. This approach was used to describe working conditions and identify potential hazards that may arise during production activities.

2.2 Study Location And Object

The study was conducted at Tofu Factory FMY located in Bandung, West Java, Indonesia. The object of this study was the yellow tofu production process, which consists of several stages including washing, soaking, grinding, boiling, pulp separation, coagulation, molding, and cutting.

2.3 Data Collection

The data collected in this study include:

1. Primary Data

Primary data were collected through direct observation of the yellow tofu production process, interviews with workers involved in each stage, and documentation of work activities.

2. Secondary Data

Secondary data were obtained from company records, standard operating procedures (SOPs), safety manuals, and previous reports related to occupational safety and health in the tofu production industry.

2.4 Risk Analysis Method

Risk analysis in this study was conducted using the HIRADC (Hazard Identification, Risk Assessment, and Determining Controls) method, which provides a systematic approach to identify hazards, evaluate risks, and implement control measures to ensure workplace safety (Shaumarda & Suyono, 2025). The application of this method in the production process of yellow tofu involves several sequential steps.

1. Hazard Identification

Hazard identification is a systematic process used to recognize and evaluate potential sources of danger in the workplace that may cause injury, illness, or other adverse effects on workers. It is an essential part of occupational health and safety management, as it provides the basis for risk assessment and the implementation of appropriate control measures. In the context of a tofu factory, hazard identification is particularly important because the production process involves various activities, equipment, materials, and environmental (Masri et al., 2022) conditions that may expose to:

a) **Physical Hazard**
   Physical hazards are risks of injury caused by physical conditions in the workplace, such as heat, noise, slippery floors, and sharp objects.
b) **Chemical Hazard**
   Chemical hazards are risks caused by exposure to chemicals, fumes, vapors, or other harmful substances that may affect health.
c) **Electrical Hazard**

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Electrical hazards are risks related to damaged cables, electrical equipment, or unsafe installations that may cause electric shock, burns, or fire.

d) Mechanical Hazard
Mechanical hazards are risks arising from machines, tools, or moving parts that can cause cuts, pinching, crushing, or other injuries.

e) Psychological Hazard
Psychological hazards are risks related to mental or emotional stress, such as work pressure, fatigue, or excessive workload, which can reduce concentration and increase accidents.

f) Biological Hazard
Biological hazards are risks caused by exposure to microorganisms, organic waste, or contaminated materials that may lead to infection or other health problems.

g) Ergonomic Hazard
Ergonomic hazards are risks caused by poor working posture, repetitive movements, manual lifting, or excessive physical effort that may result in muscle pain and fatigue.

h) Environmental Hazard
Environmental hazards are risks caused by unsafe workplace conditions, such as poor ventilation, waste buildup, inadequate drainage, and dirty work areas.

2. Risk Assessment

Risk assessment was performed to evaluate the level of risk associated with each identified hazard in the yellow tofu production process. The assessment used a quantitative approach based on the parameters of likelihood and severity, as shown in **Table 1 and Table 2**.

Table 1. Likelihood Parameter

Level	Likelihood Scale	Description
1	Rare	Highly unlikely to occur, may only happen in exceptional circumstances (e.g., once in 10 years).
2	Unlikely	Could occur at some time, but the probability is low.
3	Possible	Might occur at some time, exposure to the hazard is periodic.
4	Likely	Will probably occur in most circumstances frequent exposure recorded.
5	Almost certain	Expected to occur in most circumstances, high probability of occurrence due to lack of adequate controls.

Table 2. Severity Parameter

Level	Severity Scale	Description
1	Insignificant	Requires only minor first aid, no lost work time.
2	Minor	Minor injury requiring medical treatment, lost work time < 2 days.
3	Moderate	Moderate injury or temporary disability, lost work time < 2 days.
4	Major	Partial permanent disability, severe occupational disease, significant material loss.
5	Catastrophic	Fatality, total permanent disability, massive environmental damage.

The overall risk level was determined by combining the likelihood and severity values using a risk matrix, presented in **Table 4**. The matrix classifies risks into categories: Low, Medium, High, and Very High (Afriza & Dewi, 2024). Each identified hazard was assigned a likelihood and severity score, and the corresponding risk level was obtained from the matrix (Masri et al., 2022).

Table 3. Risk Matrix

SEVERITY	**5**	5 Medium	10 High	15 High	20 Very High	25 Very High
	4	4 Low	8 Medium	12 High	16 High	20 Very High
	3	3 Low	6 Medium	9 Medium	12 High	15 High
	2	2 Low	4 Low	6 Medium	8 Medium	10 High
	1	1 Low	2 Low	3 Low	4 Low	5 Medium
		1	**2**	**3**	**4**	**5**

LIKELIHOOD

3. Risk Controls
Risk control was established according to the assessed risk level by referring to the hierarchy of controls, namely elimination, substitution, engineering controls, administrative controls, and the use of personal protective equipment (PPE) (Masri et al., 2022). The selection of control measures was prioritized from the most effective to the least effective in order to minimize the probability and impact of identified hazards in the workplace.

4. Monitoring and Review
Monitoring and review were conducted through regular inspections and audits to evaluate the effectiveness of the implemented control measures. This process was intended to ensure compliance with safety procedures, identify remaining or emerging hazards, and support continuous improvement in the safety and efficiency of the yellow tofu production process (Antarani et al., 2019).

2.5 Research Procedure
The study was carried out through systematic stages, including literature review, field observation, problem identification, objective setting, data collection and processing, analysis, and conclusion formulation, as summarized in **Figure 1**.

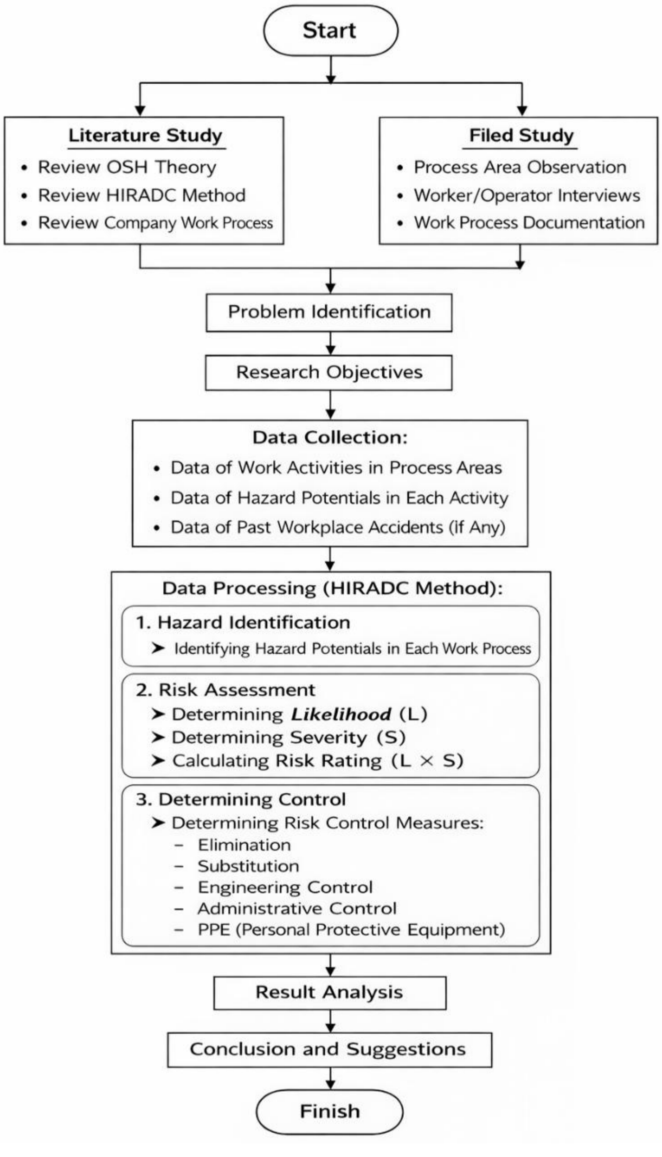

Figure 1. HIRADC Data Processing Flowchart
(Source: Ajeng. A & Sinta. D, 2024. (Afriza & Dewi, 2024))

3. Results And Discussion

3.1 Process Description Of Yellow Tofu Production

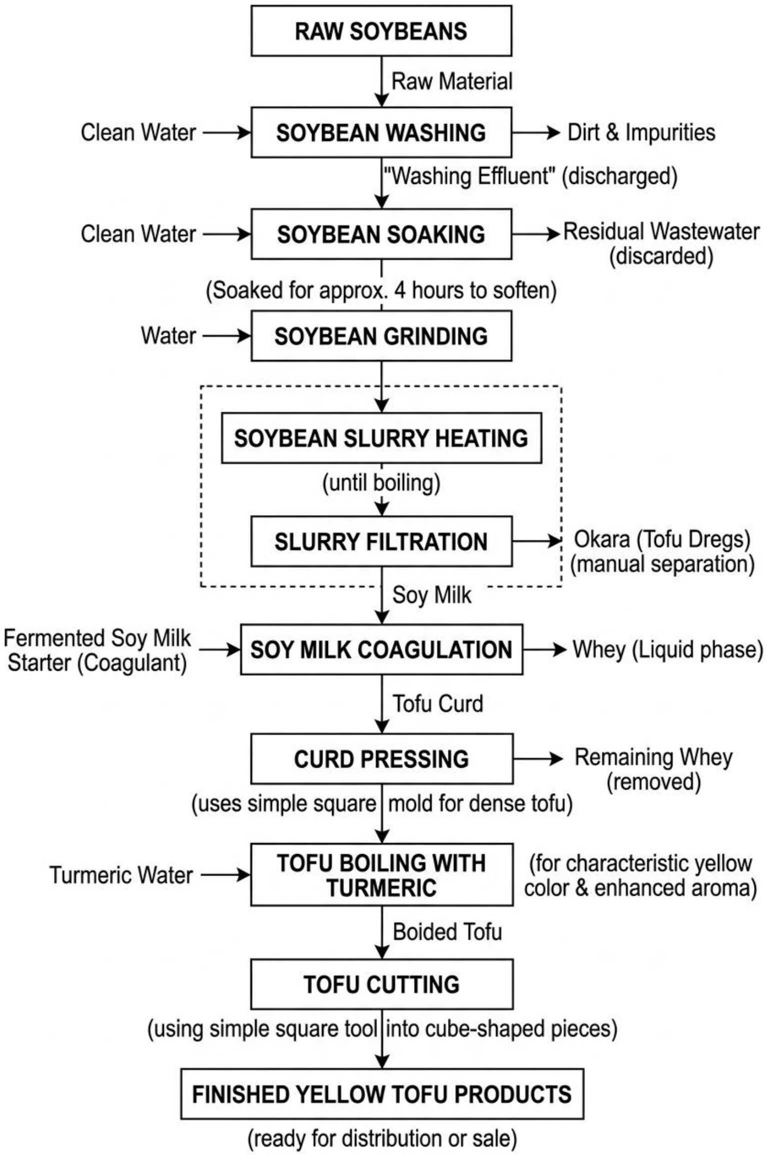

Figure 2. Block Flow Diagram Of Yellow Tofu Production

(Source: Antarani, et al., 2019 (Antarani et al., 2019))

The traditional yellow tofu production process begins with dry soybeans as the main raw material. The first stage involves washing the soybeans with clean water to remove dirt, dust, and other impurities attached to the soybean surface. The wastewater generated from this stage is discharged as washing effluent. After the washing process, the clean soybeans are transferred into a soaking container and soaked in clean water for approximately 4 hours. This stage aims to soften the soybeans and facilitate the subsequent grinding process. At the end of soaking, part of the remaining soaking water is discarded as residual wastewater. The soaked soybeans are then processed using a grinding machine with the addition of water to produce soybean slurry. The slurry is subsequently heated until boiling, resulting in cooked soybean slurry. The cooked soybean slurry is then filtered manually to separate tofu dregs (okara) from the liquid phase. This process produces soy milk, which is used in the next stage of production.

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Figure 3. Soybean Grinding

Figure 4. Soybean Slurry Heating

Figure 5. Slurry Filtration

Figure 6. Soy Milk Coagulation

The soy milk is then transferred into a coagulation container and mixed with tofu starter water as a coagulant to induce soybean protein coagulation. In this process, the coagulant used is fermented soy milk, which functions as a starter to promote curd formation. This stage results in the formation of tofu curd and residual liquid known as whey. The formed curd is then placed into a simple tofu press mold. At this stage, pressing is carried out to remove whey and produce denser molded tofu.

Figure 7. Curd Pressing

Figure 8. Tofu Boiling With Tumeric

Furthermore, the molded tofu is boiled again using turmeric water. This stage aims to produce the characteristic yellow color of the tofu and to enhance its aroma and product attractiveness. Finally, the tofu is cut using a simple square-shaped cutting tool, allowing the product to be directly formed into cube-shaped pieces. This stage results in finished yellow tofu products that are ready for distribution or sale.

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3.2 Identified Hazards

The identified hazards were classified based on observed work activities and workplace conditions in the traditional yellow tofu production process, as well as potential hazards identified from relevant literature (Alawi & Rahdiana, 2025). The potential impacts may vary depending on the frequency of exposure, duration of work, and effectiveness of existing control measures (Afriza & Dewi, 2024).

Table 4. Potential Hazards In The Yellow Tofu Production

Work Activity	Hazard Category	Potential Hazard	Potential Impact
Washing soybeans	Physical hazard	Wet and slippery floor due to spilled water	Slipping, falling, bruises, sprains, or head injury
Washing soybeans	Ergonomic hazard	Repetitive bending and prolonged standing posture	Back pain, muscle fatigue, and musculoskeletal disorders
Washing soybeans	Environmental hazard	Poor drainage causing puddles in the work area	Unhygienic workplace, increased slip risk, and reduced work safety
Soaking soybeans	Ergonomic hazard	Manual lifting and carrying of soaked soybeans	Muscle strain, shoulder pain, and lower back injury
Soaking soybeans	Biological hazard	Stagnant soaking water and organic residues	Microbial growth, unpleasant odor, and potential skin irritation
Soaking soybeans	Physical hazard	Tripping over the soaking container placed in the work area	Falling, bruises, sprains, or head injury
Grinding soybeans	Physical hazard	Water spills around the grinding area	Slipping and falling accidents
Grinding soybeans	Physical hazard	Noise generated by the grinding machine	Hearing discomfort and potential hearing impairment due to prolonged exposure
Grinding soybeans	Mechanical hazard	Contact with rotating grinder components	Finger injury, cuts, crushed hands, or severe mechanical injury
Grinding soybeans	Electrical hazard	Damaged cables or wet electrical equipment	Electric shock, burns, or electrocution
Boiling soybean slurry	Physical hazard	Direct exposure to high temperatures from the traditional furnace and boiling soybean slurry	Burns, heat stress, fatigue, and dehydration
Boiling soybean slurry	Physical hazard	Splash of boiling soybean slurry during stirring or transfer	Skin burns, scald injuries, and eye irritation
Boiling soybean slurry	Chemical hazard	Exposure to wood smoke from traditional firewood combustion	Eye irritation, coughing, respiratory discomfort, and breathing difficulties
Boiling soybean slurry	Environmental hazard	Smoke accumulation and poor air circulation in the production area	Reduced air quality, impaired visibility, discomfort, and increased risk of work accidents
Filtering soybean slurry	Ergonomic hazard	Repetitive manual handling of hot slurry and okara	Hand fatigue, muscle strain, and musculoskeletal complaints
Filtering soybean slurry	Physical hazard	Direct contact with hot slurry during filtering	Burns to hands and arms
Filtering soybean slurry	Biological hazard	Accumulation of wet okara residues	Microbial contamination, foul odor, and reduced workplace hygiene
Coagulation process	Physical hazard	Spill of hot soy milk during transfer and mixing	Slips, skin burns, and foot injury
Coagulation process	Chemical hazard	Exposure to acidic fermented soy milk used as coagulant	Skin irritation or eye irritation if splashed
Coagulation process	Ergonomic hazard	Repetitive stirring and awkward upper-body movement	Shoulder pain, wrist strain, and muscle fatigue

Pressing and molding	Ergonomic hazard	Manual pressing with excessive force	Hand pain, muscle strain, and fatigue
Pressing and molding	Mechanical hazard	Hands trapped between pressing components	Pinching injury, bruises, or crushed fingers
Re-boiling with turmeric mater	Physical hazard	Exposure to hot water and hot tofu surfaces	Burns and scald injuries
Re-boiling with turmeric mater	Environmental hazard	Wet floor from splashing water and spilled liquid	Slipping, falling, and possible head injury
Cutting tofu	Mechanical hazard	Contact with sharp cutting tool	Cuts, lacerations, and bleeding
Cutting tofu	Mechanical hazard	Improper hand placement during cutting	Deep cuts to fingers or hands
Cutting tofu	Ergonomic hazard	Repetitive hand movement and prolonged standing	Wrist pain, hand fatigue, and musculoskeletal disorders

Overall, the identified hazards vary in nature and potential impact across the traditional yellow tofu production process. These hazards require further evaluation to determine their risk levels, which will guide the implementation of appropriate control measures in the next stage of the assessment.

3.3 Risk Assessment Results

The hazards identified in the previous section were categorized based on their type. In this section, the focus is on assessing the risk levels of each process, considering the likelihood and severity of the hazards. Risk assessment in the yellow tofu factory was conducted through interviews with workers and direct observation of activities and work procedures in each production process. Likelihood (L) and severity (S) values were used to calculate the risk level (R) for each process (Afriza & Dewi, 2024). Table 5 presents the identified hazards and their corresponding risk levels observed during the field review.

Table 5. Risk Assessment Results

Work Activity	Potential Hazard	Potential Impact	L	S	R	Risk Level
Washing soybeans	Wet and slippery floor due to spilled water	Slipping, falling, bruises, sprains, or head injury	5	2	10	High
Washing soybeans	Repetitive bending and prolonged standing posture	Back pain, muscle fatigue, and musculoskeletal disorders	4	2	8	Medium
Washing soybeans	Poor drainage causing puddles in the work area	Unhygienic workplace, increased slip risk, and reduced work safety	3	1	3	Low
Soaking soybeans	Manual lifting and carrying of soaked soybeans	Muscle strain, shoulder pain, and lower back injury	4	3	12	High
Soaking soybeans	Stagnant soaking water and organic residues	Microbial growth, unpleasant odor, and potential skin irritation	3	2	6	Medium
Soaking soybeans	Tripping over the soaking container placed in the work area	Falling, bruises or sprains	3	2	6	Medium
Grinding soybeans	Water spills around the grinding area	Slipping and falling accidents	5	2	10	High
Grinding soybeans	Noise generated by the grinding machine	Hearing discomfort and potential hearing impairment due to prolonged exposure	5	1	5	Medium
Grinding soybeans	Contact with rotating grinder components	Finger injury, cuts, crushed hands, or severe mechanical injury	5	4	20	Very high
Grinding soybeans	Damaged cables or wet electrical equipment	Electric shock, burns, or electrocution	4	5	20	Very high
Boiling soybean slurry	Direct exposure to high temperatures from the traditional furnace and boiling soybean slurry	Burns, heat stress, fatigue, and dehydration	5	4	20	Very high

Boiling soybean slurry	Splash of boiling soybean slurry during stirring or transfer	Skin burns, scald injuries, and eye irritation	4	3	12	High
Boiling soybean slurry	Exposure to wood smoke from traditional firewood combustion	Eye irritation, coughing, respiratory discomfort, and breathing difficulties	5	2	10	High
Boiling soybean slurry	Smoke accumulation and poor air circulation in the production area	Reduced air quality, impaired visibility, discomfort, and increased risk of work accidents	5	2	10	High
Filtering soybean slurry	Repetitive manual handling of hot slurry and okara	Hand fatigue, muscle strain, and musculoskeletal complaints	4	2	8	Medium
Filtering soybean slurry	Direct contact with hot slurry during filtering	Burns to hands and arms	3	3	9	Medium
Filtering soybean slurry	Accumulation of wet okara residues	Microbial contamination, foul odor, and reduced workplace hygiene	3	2	6	Medium
Coagulation process	Spill of hot soy milk during transfer and mixing	Slips, skin burns, and foot injury	3	2	6	Medium
Coagulation process	Exposure to acidic fermented soy milk used as coagulant	Skin irritation or eye irritation if splashed	4	2	8	Medium
Coagulation process	Repetitive stirring and awkward upper-body movement	Shoulder pain, wrist strain, and muscle fatigue	4	2	8	Medium
Pressing and molding	Manual pressing with excessive force	Hand pain, muscle strain, and fatigue	4	2	8	Medium
Pressing and molding	Hands trapped between pressing components	Pinching injury, bruises, or crushed fingers	3	4	12	High
Re-boiling with turmeric mater	Exposure to hot water and hot tofu surfaces	Burns and scald injuries	4	3	12	High
Re-boiling with turmeric mater	Wet floor from splashing water and spilled liquid	Slipping, falling, and possible head injury	4	3	12	High
Cutting tofu	Contact with sharp cutting tool	Cuts, lacerations, and bleeding	5	4	20	Very high
Cutting tofu	Improper hand placement during cutting	Deep cuts to fingers or hands	5	4	20	Very high
Cutting tofu	Repetitive hand movement and prolonged standing	Wrist pain, hand fatigue, and musculoskeletal disorders	4	2	8	Medium

Based on the results presented in **Table 4**, several hazards were identified across the production processes, with risk levels ranging from low to very high. These findings are derived from interviews with workers at the factory and supported by relevant literature (Alawi & Rahdiana, 2025). Appropriate control measures and continuous monitoring are recommended to ensure worker safety and health in the yellow tofu factory.

3.4 Risk Control Measures

Based on the hazard identification and risk assessment results, several hazards were still found, ranging from low to very high risk. These hazards need to be controlled and monitored to reduce the likelihood and severity of occurrence. The following presents the risk control measures at the yellow tofu factory, including existing controls and recommended actions for each hazard.

Table 6. Risk Control Measures

Work Activity	Potential Hazard	Potential Impact	Existing Control	Recommended Action
Washing soybeans	Wet and slippery floor due to spilled water	Slipping, falling, bruises, sprains, or head injury	Workers manually clean the work area	Provide non-slip flooring and improve the drainage system
Washing soybeans	Repetitive bending and prolonged standing posture	Back pain, muscle fatigue, and musculoskeletal disorders	Workers take informal rest breaks	Provide ergonomic workstations and scheduled rest breaks
Washing soybeans	Poor drainage causing puddles in the work area	Unhygienic workplace, increased slip risk, and reduced work safety	Periodic cleaning of the work area	Improve drainage systems and maintain workplace cleanliness
Soaking soybeans	Manual lifting and carrying of soaked soybeans	Muscle strain, shoulder pain, and lower back injury	Manual lifting by workers	Use lifting aids or apply proper lifting techniques
Soaking soybeans	Stagnant soaking water and organic residues	Microbial growth, unpleasant odor, and potential skin irritation	Periodic replacement of soaking water	Regular cleaning of soaking containers and maintaining sanitation
Soaking soybeans	Tripping over the soaking container placed in the work area	Falling, bruises, sprains, or head injury	Containers placed in the work area	Arrange the workplace layout to ensure safe walking paths
Grinding soybeans	Water spills around the grinding area	Slipping and falling accidents	Manual floor cleaning	Install anti-slip mats and clean spills immediately
Grinding soybeans	Noise generated by the grinding machine	Hearing discomfort and potential hearing impairment due to prolonged exposure	Workers operate machines without hearing protection	Provide earplugs or earmuffs
Grinding soybeans	Contact with rotating grinder components	Finger injury, cuts, crushed hands, or severe mechanical injury	Machines operated by experienced workers	Install machine guards
Grinding soybeans	Damaged cables or wet electrical equipment	Electric shock, burns, or electrocution	Basic inspection by workers	Conduct routine inspection of electrical installations and cable insulation
Boiling soybean slurry	Direct exposure to high temperatures from the traditional furnace and boiling soybean slurry	Burns, heat stress, fatigue, and dehydration	Workers maintain distance from the furnace	Use heat-resistant gloves and improve ventilation
Boiling soybean slurry	Splash of boiling soybean slurry during stirring or transfer	Skin burns, scald injuries, and eye irritation	Stirring using long-handled tools	Use face shields and protective clothing
Boiling soybean slurry	Exposure to wood smoke from traditional firewood combustion	Eye irritation, coughing, respiratory discomfort, and breathing difficulties	Semi-open working area	Install ventilation systems or exhaust fans
Boiling soybean slurry	Smoke accumulation and poor air circulation in the production area	Reduced air quality, impaired visibility, discomfort, and	Natural ventilation	Install better ventilation systems

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		increased risk of work accidents		
Filtering soybean slurry	Repetitive manual handling of hot slurry and okara	Hand fatigue, muscle strain, and musculoskeletal complaints	Workers take turns performing tasks	Provide filtering tools or mechanical assistance
Filtering soybean slurry	Direct contact with hot slurry during filtering	Burns to hands and arms	Use of filtering cloth	Use heat-resistant gloves
Filtering soybean slurry	Accumulation of wet okara residues	Microbial contamination, foul odor, and reduced workplace hygiene	Manual waste disposal	Clean the work area regularly and manage waste properly
Coagulation process	Spill of hot soy milk during transfer and mixing	Slips, skin burns, and foot injury	Use of large containers	Use stable containers and anti-slip flooring
Coagulation process	Exposure to acidic fermented soy milk used as coagulant	Skin irritation or eye irritation if splashed	Manual handling by workers	Use gloves and eye protection
Coagulation process	Repetitive stirring and awkward upper-body movement	Shoulder pain, wrist strain, and muscle fatigue	Workers rest when tired	Use ergonomic stirring tools
Pressing and molding	Manual pressing with excessive force	Hand pain, muscle strain, and fatigue	Manual pressing process	Use mechanical pressing equipment
Pressing and molding	Hands trapped between pressing components	Pinching injury, bruises, or crushed fingers	Operated by trained workers	Install safety guards and implement safe work and procedures
Re-boiling with turmeric mater	Exposure to hot water and hot tofu surfaces	Burns and scald injuries	Workers handle hot materials cautiously	Provide heat-resistant gloves and ensure safe handling procedures
Re-boiling with turmeric mater	Wet floor from splashing water and spilled liquid	Slipping, falling, and possible head injury	Occasional floor cleaning	Use anti-slip mats and implement routine floor cleaning during operation
Cutting tofu	Contact with sharp cutting tool	Cuts, lacerations, and bleeding	Workers use standard knives for cutting	Provide cut-resistant gloves and proper knife handling training
Cutting tofu	Improper hand placement during cutting	Deep cuts to fingers or hands	Workers rely on personal experience	Provide training on safe cutting techniques and proper hand positioning
Cutting tofu	Repetitive hand movement and prolonged standing	Wrist pain, hand fatigue, and musculoskeletal disorders	Workers take short breaks when necessary	Introduce ergonomic workstations and scheduled rest breaks

Based on the data processing and risk assessment conducted, it is identified that the potential hazards in the traditional yellow tofu production area at FMY Factory range from low to very high-risk levels. Very High risks are identified in the grinding, boiling, and cutting stages, involving fatal electrical shocks, severe mechanical injuries from rotating components, and deep lacerations from sharp tools without adequate protection. High risks

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are primarily associated with ergonomic issues such as repetitive manual handling and awkward postures during the soaking and filtering stages, as well as physical hazards like slippery floors and noise. Meanwhile, Medium and Low risks are found in biological hazards from stagnant water and environmental factors like poor drainage in the washing area.

Based on the results of the Hazard Identification, Risk Assessment, and Determining Control (HIRADC) analysis, a set of improvement recommendations has been formulated, focusing on hazard sources from low to very high-risk levels. These proposed improvements refer to occupational safety principles and hierarchy of controls—elimination, substitution, engineering controls, administrative controls, and personal protective equipment (PPE) with the aim of minimizing accident potential and enhancing worker safety and comfort in the yellow tofu production environment. In an effort to improve occupational safety and health in the yellow tofu industry, the following improvement measures have been developed based on the identified hazards:

1. **Grinding and Boiling Stages:** On the grinding area, there are very high risks of electrocution and mechanical entrapment, while the boiling stage poses severe risks of burns and heat stress. To address these, the factory must implement engineering controls such as installing machine guards on grinders and grounding systems for electrical installations. For the boiling stage, installing exhaust fans to improve air circulation and mandatory use of heat-resistant gloves and face shields are highly recommended.
2. **Filtering and Coagulation Stages**: The primary risks in these stages involve ergonomic strain from repetitive stirring and potential chemical exposure from acidic coagulants. Improvements include providing ergonomic stirring tools to reduce muscle fatigue and the use of rubber gloves and eye protection to prevent skin and eye irritation from splashes.
3. **Cutting and Molding Stages:** In the cutting stage, the risk of deep lacerations is critical due to the lack of hand protection. It is essential to provide cut-resistant gloves and implement standardized safe cutting procedures. For the molding stage, using mechanical pressing assistance is recommended to reduce excessive physical force and prevent musculoskeletal disorders.

From the perspective of the working environment, wet and slippery floors across the production area significantly increase the risk of slips and falls. Therefore, installing anti-slip flooring or mats and improving the drainage system to prevent water puddles must be prioritized.

3.5. Comparative Analysis Of Occupational Health And Safety Conditions At FMY Tofu Factory And Modern Tofu Factory In Tangerang

The following discussion is based on the visit to FMY traditional tofu factory in Bandung and compared with the study by Viatina, Tejamaya, and Widanarko (2024), which examined two traditional tofu factories and one more modern silken tofu factory in Tangerang City. The comparison focuses on ergonomics, manual handling, musculoskeletal disorders (MSDs), and the most hazardous process points (Viatina et al., 2024).

Table 7. Comparison Of OHS Conditions At The Traditional FMY Tofu Factory And A Modern Tofu Factory In Tangerang.

OSH aspect	FMY (Bandung)	Modern factory (Tangerang City)	Comparison meaning
Production character	The process is still largely manual, so workers are directly involved in grinding, filtering, pressing, and material transfer.	The process is more modern and controlled; in the comparison study, the silken tofu factory used a more structured workflow and some tasks were supported by more advanced systems.	Modernization reduces exposure to heavy manual work that is common in traditional factories.
Main risks	The main risks come from non-ergonomic postures, repetitive movements, load handling, slippery floors, hot steam, and contact with hot equipment.	Risks still exist, but they are concentrated at specific process points, especially during material transfer and high-temperature handling.	In the modern factory, risks do not disappear, but they become more specific and easier to control.
MSD complaints	Based on the traditional factory characteristics, complaints involving the back, shoulders, neck, and legs are more likely because manual work is dominant.	In the Tangerang study, 12-month MSD prevalence was lower than in traditional factories; for example, lower back 81.3%, right shoulder 62.5%, and upper back 56.3% in the silken tofu factory.	Process modernization is associated with lower MSD complaints, although complaints still remain.

High-risk work points	High-risk points are usually grinding, filtering, pressing, and material transport.	The comparison study showed very high MSD risk for grinding and filtering in traditional factories, while the most critical point in the modern factory was transferring tofu crates from cold water to hot water tanks.	Hazards in the modern factory shift from many manual tasks to a few critical process points.
OSH implication	FMY needs ergonomic improvements, better workplace arrangement, reduced manual handling, and control of slippery/hot areas.	The modern factory still requires control of hot-process points, physical load, and material transfer.	Better OSH is achieved not by eliminating all risks, but by reducing exposure at the most demanding process points.

In summary, the FMY traditional tofu factory shows greater OSH risk in ergonomics and manual handling than the modern tofu factory in Tangerang City. However, the modern factory still has critical hazard points that must be controlled, which means process modernization should be accompanied by proper OSH supervision.

4. Conclusion

Based on the HIRADC analysis conducted at Tofu Factory FMY, it is concluded that the traditional yellow tofu production process involves 27 identified hazards across eight operational stages, with risk levels ranging from low to very high. These findings were derived from a comprehensive identification process that integrated direct field observations and worker interviews with relevant literature to capture all potential risks inherent in the production environment. The assessment highlights critical safety concerns in the grinding, boiling, and cutting stages, which are categorized as Very High risk due to the potential for fatal electrical shocks, severe mechanical injuries from unguarded machinery, and deep lacerations from manual cutting tools used without personal protective equipment (PPE) To mitigate these risks, the study recommends a structured implementation of the hierarchy of controls, prioritizing engineering and administrative measures alongside personal protective equipment. Key recommendations include installing machine guards and grounding systems for electrical safety, improving ventilation and drainage to address environmental hazards, and enforcing the mandatory use of heat-resistant and cut-resistant gloves. By integrating empirical data from the factory with established safety literature, this study provides a robust framework for reducing the likelihood and severity of occupational injuries, ensuring a safer and more sustainable production environment for traditional yellow tofu manufacturing.

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