Indonesian Journal of Multidisciplinary on Social and Technology
Homepage: https://journal.ilmudata.co.id/index.php/ijmst
Vol. 4 No. 2 (2026) pp: 1940-1951
P-ISSN: 2986-6790, e-ISSN: 2986-6782

Hazard Identification, Risk Assessment, and Determining Control (HIRADC) Analysis as an Occupational Health and Safety Risk Control Measure at Mychotech Lab

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Abstract
MYCL (Mycotech Lab) is a biomaterial company that develops sustainable leather alternatives using mushroom mycelium through a circular economy approach. One of its main products, Mylea, is a mycelium-based leather material developed for fashion and lifestyle applications. Although this production process provides environmental benefits compared with conventional leather and synthetic materials, it still involves occupational safety and health (OSH) risks. Workers may be exposed to biological hazards, chemical agents, high-temperature equipment, mechanical hazards, and ergonomic risks during production activities. This study aims to identify workplace hazards, assess risk levels, and determine appropriate control measures in the mycelium leather production process at MYCL. The research applied a qualitative approach through direct observation, interviews, and documentation of production activities, including growth medium preparation, sterilization, inoculation, incubation, harvesting, pressing, drying, and finishing. Hazard identification and risk assessment were conducted using the Hazard Identification, Risk Assessment, and Determining Control (HIRADC) method. The results showed that identified hazards ranged from medium to very high risk levels. The highest risks were found in the sterilization process due to exposure to high-temperature autoclave surfaces and pressurized steam, as well as in the pressing and forming process involving hydraulic equipment. Other risks included contamination, biological exposure, ergonomic issues, and heat exposure. Recommended control measures include improving personal protective equipment (PPE) compliance, strengthening safety procedures, conducting routine equipment maintenance, improving workplace sanitation, implementing ergonomic practices, and providing worker training. The findings provide an overview of occupational risks in mycelium-based manufacturing and support safer and more sustainable industrial operations.

Keywords: Occupational Safety and Health (OSH), HIRADC, Risk Assessment, Mycelium Leather, Hazard Identification

1. Introduction

MYCL (Mycotech Lab) is an innovative biomaterial company that bridges biology and industrial design through the utilization of mushroom mycelium as a sustainable raw material (MYCL; Wattanavichean et al., 2025; Ismail, 2026). By transforming agricultural waste into high-value products, MYCL supports a circular economy approach in which low-value residues are converted into functional and environmentally friendly materials (Geissdoerfer et al., 2017). Through this concept, the company develops bio-based alternatives that reduce dependence on conventional materials derived from animals or fossil resources (Ellen MacArthur Foundation, 2019).

One of MYCL's flagship innovations is Mylea, a mycelium-based leather alternative designed for fashion and lifestyle applications (MYCL). Unlike traditional animal leather, which requires extensive land and water resources, or synthetic leather made from petroleum-based materials, Mylea is cultivated in a controlled environment using fewer resources and without cruelty to animals (Hottle et al., 2017). In addition to its aesthetic and functional qualities, this material is compostable and suitable for products such as bags, footwear, wallets, and decorative panels (Jones et al., 2020). This shows the potential of mycelium technology not only as a sustainable material, but also as a commercially viable industrial product (Appels et al., 2019).

The production process of mycelium-based materials at MYCL involves several stages, including substrate preparation, inoculation, mycelium incubation, harvesting and finishing, and final product manufacturing (MYCL; Vandelook et al., 2021; Vanden Elsacker, 2021). Agricultural residues such as corn husks, wood chips, and other plantation wastes are prepared as growth media, then inoculated with fungal spores or cultures to initiate mycelium development (Attias et al., 2020). During incubation, the mycelium grows and binds the substrate into a dense composite structure, followed by harvesting and environmentally friendly finishing processes that avoid hazardous chemicals such as chromium-based treatments (Islam et al., 2017). Although this process is sustainable, it still involves various occupational safety and health risks related to biological exposure, manual handling, repetitive work, and process control (International Labour Organization [ILO], 2022).

Based on these conditions, this study aims to analyze the implementation of Occupational Safety and Health practices at MYCL through direct field observation at the production facility. The analysis focuses on the main stages of mycelium production, namely substrate preparation, inoculation, incubation, harvesting and finishing, and final product formation. To identify and evaluate workplace hazards systematically, this study applies to the Hazard Identification, Risk Assessment, and Determining Control (HIRADC) method (Ramli, 2010). The results are expected to provide a clearer understanding of potential risks in mycelium-based manufacturing and contribute to the improvement of safety management in sustainable biomaterial industries.

2. Research Methods

2.1 Research Approach

This study employs a qualitative research approach to analyze the implementation of Occupational Safety and Health practices at Mycotech Lab. Data were collected through direct field observation at the production facility and in-depth interviews. The observations focused on the mycelium production process, including substrate preparation, inoculation, incubation, harvesting, and finishing stages. The collected data were then described and analyzed to evaluate how OSH principles are implemented in daily operations, particularly in identifying potential hazards and existing control measures within the production environment.

2.2 Study Location and Object

This study was conducted at the MYCL Eco Factory in Lembang, West Java, Indonesia. The research project focuses on the mushroom-based production process carried out at the facility, starting from substrate preparation, inoculation, mycelium incubation, harvesting and finishing, to the final production of mushroom-based products. The location was selected because it provides direct access to observe the production activities and assess the implementation of Occupational Safety and Health practices in the actual working environment.

2.3 Data Collection

The data collected in this study include:

1. Primary Data

Primary data were collected through direct observation of activities in the Mycotech Lab laboratory (MYCL), interviews with workers or researchers involved in each stage of the process, and documentation of laboratory activities, particularly those related to the processing and development of mycelium-based materials (fungi).

2. Secondary Data

Secondary data were obtained from internal company documents, such as standard operating procedures (SOPs), laboratory safety manuals, and Material Safety Data Sheets (MSDS) of the chemicals used. In addition, the data were supported by previous reports and literature related to occupational health and safety (OHS) in mycelium-based biotechnology laboratories.

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 identifying potential hazards, assessing risk levels, and determining control measures to ensure workplace safety in the Mycotech Lab laboratory (MYCL). The application of this method to mycelium-based laboratory activities involves several stages, such as sterilization, fungal inoculation, incubation, and final material processing, each of which has different potential hazards and risks.

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 (MYCL).

In the context of a biotechnology laboratory at MYCL, hazard identification is particularly important because the activities involve biological agents, chemicals, laboratory equipment, and controlled environmental conditions that may expose workers to various risks. The identified hazards include:

1. Physical Hazard

Physical hazards are risks of injury caused by physical conditions in the laboratory, such as high temperatures from autoclaves, hot surfaces, slippery floors, and sharp tools.

2. Chemical Hazard

Chemical hazards are risks caused by exposure to chemicals such as ethanol, disinfectants, and other laboratory reagents, which may cause irritation, toxicity, or fire hazards.

3. Electrical Hazard

Electrical hazards are associated with laboratory equipment such as incubators, laminar airflow cabinets, and autoclaves, including damaged cables or unsafe installations that may cause electric shock or fire.

4. Mechanical Hazard

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Mechanical hazards arise from the use of tools or equipment, such as cutting tools or machinery, which may cause cuts or other physical injuries.

5. Biological Hazard

Biological hazards are risks caused by exposure to microorganisms, particularly fungi (mycelium), bacterial contamination, and airborne spores generated during inoculation and cultivation processes, which may lead to infections, allergic reactions, or respiratory disorders. Biological hazards in microbiology laboratories include exposure to microorganisms, airborne spores, and contamination risks, which may lead to infection or respiratory problems (WHO, 2020; CDC, 2020).

6. Sterilization Process Hazard

Hazards associated with sterilization processes, such as the use of autoclaves involving high pressure and temperature, which may cause burns, steam exposure, or equipment failure.

7. Contamination Hazard

Hazards related to cross-contamination from non-sterile tools, work surfaces, or improper handling of cultures, which may affect both worker safety and experimental outcomes.

8. Ergonomic Hazard

Ergonomic hazards are caused by repetitive movements, prolonged standing or sitting, and improper working posture during laboratory activities, which may result in fatigue or musculoskeletal disorders.

9. Environmental Hazard

Environmental hazards arise from laboratory conditions such as high humidity, controlled temperature rooms (incubation), inadequate ventilation, and improper waste handling, which may affect health and safety.

2. Risk Assessment

Risk management is a systematic process to identify, assess, and control potential hazards in the workplace to ensure occupational health and safety. In laboratory activities at Mycotech Lab, risk management is important due to the presence of biological agents, chemicals, and laboratory equipment that may pose risks.

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) in laboratory activities.
2	Unlikely	Could occur at some time, but the probability is low under normal laboratory conditions.
3	Possible	Might occur at some time, especially during certain laboratory processes such as handling cultures or chemicals.
4	Likely	Will probably occur in most circumstances, particularly during routine laboratory activities with frequent exposure.
5	Almost Certain	Expected to occur in most circumstances due to continuous exposure or lack of adequate control measures in the laboratory.

Table 2. Severity Parameter

Level	Severity Scale	Description
1	Insignificant	Requires only minor first aid, no lost work time in laboratory activities.
2	Minor	Minor injury requiring medical treatment, with lost work time less than 2 days.
3	Moderate	Moderate injury or temporary health effects (e.g., mild infection or irritation), limited work disruption.
4	Major	Serious injury, severe infection, or partial permanent disability, including significant laboratory damage.
5	Catastrophic	Fatality, total permanent disability, or major laboratory accident (e.g., explosion, widespread contamination).

The overall risk level was determined by combining the likelihood and severity values using a risk matrix, presented in Table 3. The matrix classifies risks into categories: Low, Medium, High, and Very High. Each identified hazard was assigned a likelihood and severity score, and the corresponding risk level was obtained from the matrix.

Table 3. Risk Matrix

SEVERITY	**5**	5 Medium	10 High	15 High	20 Very High	25 Very High

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	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 is carried out based on 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) (Ramli, 2010). Control measures are prioritized from the most effective to minimize the likelihood and impact of hazards in mycelium-based laboratory activities at Mycotech Lab (Ramli, 2010). PPE is used as an additional control to protect workers from direct exposure. The PPE includes laboratory coats, gloves, masks or respirators, safety goggles, and closed-toe footwear, especially in activities involving fungal handling, chemical usage, sterilization processes, and contamination risks [11,12].

4. Monitoring and Review

Monitoring and review are conducted periodically to evaluate the effectiveness of implemented control measures (Ramli, 2010). This aims to ensure compliance with laboratory safety procedures, identify existing or emerging hazards, and support continuous improvement in safety and operational efficiency at Mycotech Lab (Ramli, 2010).

2.5 Research Procedure

This study was conducted through systematic stages, including literature review, field observation, hazard identification, risk assessment using the HIRADC method, determination of control measures, data analysis, and conclusion drawing, as summarized in **Figure 1**.

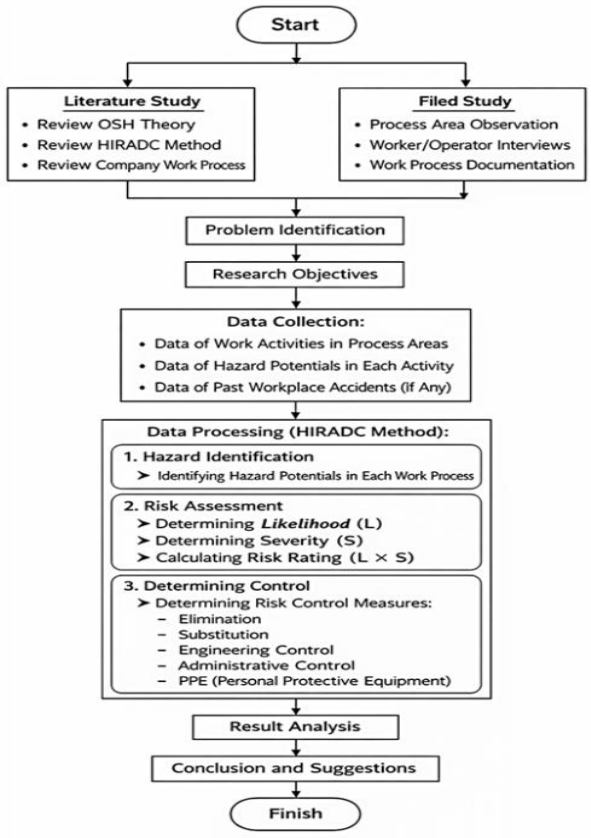

Figure 1. HIRADC Data Processing Flowchart

(Source: Ajeng. A & Sinta. D, 2024. (Jones et al., 2020))

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3. Results and Discussions

3.1 Process Description of Myselium

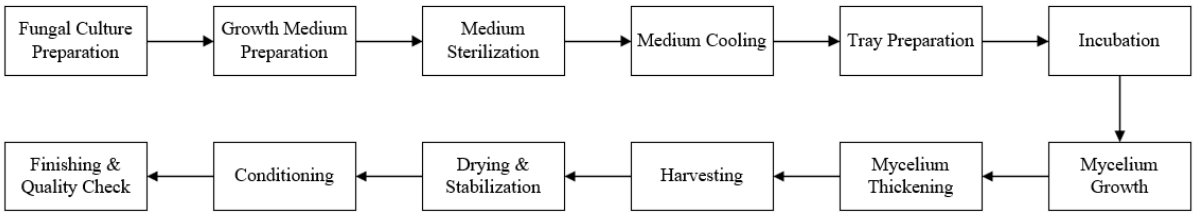

Figure 2. Block Flow Diagram of myselium production process

The production process begins with the preparation of growth media containing water, nutrients, and supporting materials for mycelium cultivation. The prepared media are then sterilized using an autoclave (Figure 2) to eliminate unwanted microorganisms that may cause contamination during cultivation. After sterilization, the media are cooled to an appropriate temperature before inoculation. The inoculation process is conducted under controlled and sterile conditions to ensure the successful introduction of fungal starter cultures into the growth medium.

Following inoculation, the culture media are transferred into cultivation trays and placed in an incubation area (Figure 3). During incubation, environmental conditions such as temperature, humidity, and cleanliness are carefully controlled to support mycelial growth and prevent contamination by other fungi or microorganisms. Over time, the mycelium colonizes the surface of the substrate and develops into a thick and continuous layer suitable for harvesting.

(a) **(b)**

(c) **(d)**

Figure 3. (a)Autoclave Used for Media Sterilization (b)Controlled Incubation Area for Mycelium Growth (c)Hydraulic Press Used for Material Forming (d)Drying and Conditioning Area

After sufficient growth is achieved, the mycelium layer is harvested and subjected to further processing. Depending on the product specifications, the harvested material may undergo pressing and forming processes using a hydraulic press (Figure 4) to improve its density and shape. This stage contributes to the development of the desired mechanical properties of the biomaterial.

The formed material is subsequently transferred to the drying and conditioning area (Figure 5) to reduce moisture content and stabilize the structure. Proper drying is essential to stop biological activity and enhance product durability. After conditioning, the material undergoes quality inspection to ensure that the thickness, texture, and overall appearance meet the required standards before being utilized as a sustainable biomaterial product.

Additional supporting processes were also observed during the site visit. Rotary drum equipment (Figure 6) is utilized for material treatment and processing activities, while heating equipment (Figure 7) is used in the preparation and treatment of cultivation materials. These supporting operations play an important role in maintaining material quality and process consistency throughout production. From an occupational health and

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safety perspective, potential hazards identified during these activities include exposure to hot surfaces, steam, moving mechanical parts, biological agents, and ergonomic risks associated with manual handling. Therefore, the implementation of standard operating procedures (SOPs), personal protective equipment (PPE), and routine equipment inspections is necessary to minimize workplace risks.

(e) **(f)**

Figure 4. (e)Rotary Drum Processing Equipment (f) Heating Equipment for Material Preparation

After harvesting, the mycelium material undergoes drying, conditioning, and quality inspection to ensure the desired physical properties and product consistency. These processes improve the stability and durability of the material while maintaining its quality standards. This stage results in mycelium leather sheets that are ready for further manufacturing into various sustainable products, such as furniture, interior materials, and other eco-friendly applications.

3.2 Hazard Identification and Risk Assesment

Hazard identification was conducted by observing work activities, workplace conditions, and production processes involved in mycelium leather manufacturing at Mycotech Lab, supported by relevant occupational health and safety literature [13]. The risk assessment was performed using a 5×5 risk matrix adapted from the AS/NZS 4360 Risk Management Standard. Risk levels were determined by multiplying the likelihood (L) and severity (S) scores of each identified hazard. The resulting risk values were then classified into Low, Medium, High, and Very High risk categories to facilitate prioritization of control measures. The assessment covered all production stages, including growth medium preparation, sterilization, inoculation, incubation, harvesting, pressing, drying, conditioning, and quality inspection. Potential hazards were identified based on their possible impacts on workers, which may vary according to exposure duration, work frequency, and existing control measures [14].

Risk assessment was subsequently performed to determine the level of risk associated with each identified hazard. Data were collected through direct observation and worker interviews, while risk levels were calculated using the likelihood (L) and severity (S) values to obtain the risk rating (R) (Jones et al., 2020). The identified hazards and corresponding risk levels are presented in Table 5.

Table 5. Risk Assessment Results

Work Activity	Potential Hazard	Potential Impact	L	S	R	Risk Level
Growth medium preparation	Manual lifting and handling of raw materials and media components	Back pain, muscle strain, and fatigue	4	2	8	Medium
Growth medium preparation	Exposure to organic materials and microbial contaminants	Allergic reactions, skin irritation, and respiratory discomfort	3	2	6	Medium
Growth medium preparation	Spilled materials and poor housekeeping	Slips, trips, and falls	4	2	8	Medium
Growth medium preparation	Contact with cleaning and sanitizing agents	Skin and eye irritation	3	2	6	Medium
Medium sterilization	Exposure to high-temperature autoclave surfaces	Burns and heat-related injuries	4	4	16	Very High
Medium sterilization	Exposure to pressurized steam during autoclave operation	Scalding and thermal burns	4	4	16	Very High

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Medium sterilization	Improper operation of sterilization equipment	Pinching injuries and equipment-related accidents	3	3	9	Medium
Medium sterilization	Heat accumulation in the work area	Heat stress and worker discomfort	3	2	6	Medium
Incubation process	Exposure to fungal cultures and spores	Allergic reactions and respiratory irritation	3	2	6	Medium
Incubation process	Cross-contamination from non-sterile equipment or surfaces	Product contamination and batch failure	4	3	12	High
Incubation process	Repetitive hand movement during inoculation	Wrist pain and muscle fatigue	3	2	6	Medium
Incubation process	Inadequate cleanliness of work area	Increased contamination risk	4	3	12	High
Incubation process	Growth of unwanted fungi and microorganisms	Product quality deterioration	4	3	12	High
Incubation process	Airborne contaminants entering incubation area	Contamination of mycelium cultures	4	3	12	High
Incubation process	Excess humidity and poor ventilation	Microbial proliferation and worker discomfort	3	2	6	Medium
Incubation process	Slippery floor due to condensation	Slips and falls	3	2	6	Medium
Harvesting process	Direct contact with mycelium and cultivation media	Skin irritation and allergic responses	3	2	6	Medium
Harvesting process	Contact with cutting tools during harvesting	Cuts and lacerations	3	3	9	Medium
Harvesting process	Repetitive harvesting movements	Muscle fatigue and musculoskeletal disorders	4	2	8	Medium
Harvesting process	Improper handling during harvesting	Product contamination	4	3	12	High
Pressing and forming process	Contact with hydraulic press components	Pinching injuries, crushed fingers, and bruises	4	4	16	Very High
Pressing and forming process	Manual positioning of material sheets	Back pain and muscle strain	3	2	6	Medium
Pressing and forming process	Sudden release of pressurized components	Impact injuries	3	4	12	High
Drying and stabilization	Exposure to hot surfaces and drying equipment	Burns and heat stress	4	3	12	High
Drying and stabilization	Elevated temperature in drying area	Dehydration and worker discomfort	3	2	6	Medium
Drying and stabilization	Electrical malfunction or overheating equipment	Fire and property damage	2	5	10	High
Conditioning process	Manual transport and handling of material sheets	Shoulder pain, back pain, and fatigue	3	2	6	Medium
Quality inspection	Prolonged standing during inspection activities	Leg fatigue and musculoskeletal discomfort	3	2	6	Medium
Quality inspection	Contact with cutting or trimming tools	Cuts and lacerations	3	3	9	Medium

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General laboratory activities	Exposure to cleaning and disinfecting agents	Skin irritation, eye irritation, and respiratory discomfort	3	2	6	Medium
General laboratory activities	Inadequate waste management practices	Reduced workplace hygiene and increased safety risks	3	2	6	Medium
Growth medium preparation	Manual handling and lifting of raw materials	Muscle strain, fatigue, and back pain	4	2	8	Medium
Growth medium preparation	Exposure to organic materials and microbial contaminants	Allergic reactions, skin irritation, or respiratory discomfort	3	2	6	Medium
Growth medium preparation	Poor housekeeping and material spills	Slips, trips, and falls	4	2	8	Medium
Medium sterilization	Exposure to high-temperature autoclave surfaces	Burns and heat-related injuries	4	4	16	Very High
Medium sterilization	Exposure to pressurized steam	Scalding and thermal burns	4	4	16	Very High

Based on the results presented in Table 5, several hazards were identified throughout the mycelium leather production process, with risk levels ranging from medium to very high. Appropriate control measures and continuous monitoring are recommended to ensure worker safety, product quality, and safe production activities

3.4 Determining Control Measures

Based on the hazard identification and risk assessment results, several hazards were identified throughout the mycelium leather production process. These hazards require appropriate control measures to reduce the likelihood and severity of workplace incidents. Table 6 presents the existing controls and recommended actions for each identified hazard.

Table 6. Determining Control Measures

Work Activity	Existing Control	Recommended Action	Existing Control	Recommended Action
Growth medium preparation	Workers manually handle materials and use basic lifting techniques	Provide manual handling training and use mechanical aids when possible	Workers manually handle materials and use basic lifting techniques	Provide manual handling training and use mechanical aids when possible
Growth medium preparation	Use of work clothing and routine cleaning	Provide gloves, masks, and improve hygiene practices	Use of work clothing and routine cleaning	Provide gloves, masks, and improve hygiene practices
Growth medium preparation	Regular cleaning of work areas	Implement housekeeping schedules and spill response procedures	Regular cleaning of work areas	Implement housekeeping schedules and spill response procedures
Growth medium preparation	Workers use cleaning agents according to instructions	Provide chemical-resistant gloves and safety goggles	Workers use cleaning agents according to instructions	Provide chemical-resistant gloves and safety goggles
Medium sterilization	Autoclave operated by trained personnel	Install warning signs and require heat-resistant gloves	Autoclave operated by trained personnel	Install warning signs and require heat-resistant gloves
Medium sterilization	Standard autoclave operating procedures are available	Implement routine inspection and mandatory PPE use	Standard autoclave operating procedures are available	Implement routine inspection and mandatory PPE use
Medium sterilization	Equipment operated by designated personnel	Conduct periodic operator training and equipment maintenance	Equipment operated by designated personnel	Conduct periodic operator training and equipment maintenance
Medium sterilization	Natural ventilation is available	Improve ventilation and provide adequate rest periods	Natural ventilation is available	Improve ventilation and provide adequate rest periods

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Inoculation process	Work conducted in a controlled area	Require masks and maintain workplace cleanliness	Work conducted in a controlled area	Require masks and maintain workplace cleanliness
Inoculation process	Sterilization procedures are implemented	Strengthen aseptic techniques and routine sanitation	Sterilization procedures are implemented	Strengthen aseptic techniques and routine sanitation
Inoculation process	Workers take short breaks when necessary	Improve workstation ergonomics and schedule task rotation	Workers take short breaks when necessary	Improve workstation ergonomics and schedule task rotation
Inoculation process	Regular cleaning activities are conducted	Establish stricter cleaning and monitoring procedures	Regular cleaning activities are conducted	Establish stricter cleaning and monitoring procedures
Incubation process	Incubation area is monitored regularly	Improve environmental monitoring and sanitation	Incubation area is monitored regularly	Improve environmental monitoring and sanitation
Incubation process	Incubation area is partially enclosed	Improve air filtration and access control	Incubation area is partially enclosed	Improve air filtration and access control
Incubation process	Ventilation is available in the work area	Improve humidity and ventilation control systems	Ventilation is available in the work area	Improve humidity and ventilation control systems
Incubation process	Floors are cleaned when necessary	Use anti-slip flooring and improve drainage	Floors are cleaned when necessary	Use anti-slip flooring and improve drainage
Harvesting process	Workers use basic protective clothing	Provide gloves and improve personal hygiene practices	Workers use basic protective clothing	Provide gloves and improve personal hygiene practices
Harvesting process	Workers handle tools carefully	Provide cut-resistant gloves and tool safety training	Workers handle tools carefully	Provide cut-resistant gloves and tool safety training
Harvesting process	Informal rest breaks are taken	Implement ergonomic work practices and task rotation	Informal rest breaks are taken	Implement ergonomic work practices and task rotation
Harvesting process	Workers follow handling procedures	Improve handling SOPs and supervision	Workers follow handling procedures	Improve handling SOPs and supervision
Pressing and forming process	Machine guards are installed	Install emergency stop systems and reinforce operator training	Machine guards are installed	Install emergency stop systems and reinforce operator training
Pressing and forming process	Materials handled manually	Provide ergonomic lifting techniques and handling aids	Materials handled manually	Provide ergonomic lifting techniques and handling aids
Pressing and forming process	Routine equipment checks are performed	Increase preventive maintenance and safety inspections	Routine equipment checks are performed	Increase preventive maintenance and safety inspections
Drying and stabilization	Workers are aware of hot surfaces	Require heat-resistant gloves and warning signage	Workers are aware of hot surfaces	Require heat-resistant gloves and warning signage
Drying and stabilization	Natural air circulation is available	Improve ventilation and provide drinking water stations	Natural air circulation is available	Improve ventilation and provide drinking water stations
Drying and stabilization	Equipment is inspected periodically	Conduct routine electrical inspections and install fire protection systems	Equipment is inspected periodically	Conduct routine electrical inspections and install fire protection systems
Conditioning process	Workers transport materials manually	Use carts or material handling equipment	Workers transport materials manually	Use carts or material handling equipment

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Conditioning process	Materials stored in designated areas	Improve environmental control and storage procedures	Materials stored in designated areas	Improve environmental control and storage procedures
Quality inspection process	Workers take occasional breaks	Provide anti-fatigue mats and scheduled rest periods	Workers take occasional breaks	Provide anti-fatigue mats and scheduled rest periods
Quality inspection process	Workers use tools according to procedures	Provide cut-resistant gloves and safety training	Workers use tools according to procedures	Provide cut-resistant gloves and safety training
Quality inspection process	Inspection follows standard procedures	Strengthen quality control procedures and supervision	Inspection follows standard procedures	Strengthen quality control procedures and supervision
General laboratory activities	Cleaning chemicals are used according to instructions	Provide PPE and chemical handling training	Cleaning chemicals are used according to instructions	Provide PPE and chemical handling training
General laboratory activities	Waste is collected in designated containers	Improve waste segregation and disposal procedures	Waste is collected in designated containers	Improve waste segregation and disposal procedures
Growth medium preparation	Workers manually handle materials and use basic lifting techniques	Provide manual handling training and use mechanical aids when possible	Workers manually handle materials and use basic lifting techniques	Provide manual handling training and use mechanical aids when possible
Growth medium preparation	Use of work clothing and routine cleaning	Provide gloves, mask, and improve hygiene practices	Use of work clothing and routine cleaning	Provide gloves, mask, and improve hygiene practices
Growth medium preparation	Regular cleaning of work areas	Implement housekeeping schedules and spill response procedures	Regular cleaning of work areas	Implement housekeeping schedules and spill response procedures
Growth medium preparation	Workers use cleaning agents according to instructions	Provide chemical-resistant gloves and safety goggles	Workers use cleaning agents according to instructions	Provide chemical-resistant gloves and safety goggles
Medium sterilization	Autoclave operated by trained personnel	Install warning signs and require heat-resistant gloves	Autoclave operated by trained personnel	Install warning signs and require heat-resistant gloves
Medium sterilization	Standard autoclave operating procedures are available	Implement routine inspection and mandatory PPE use	Standard autoclave operating procedures are available	Implement routine inspection and mandatory PPE use
Medium sterilization	Equipment operated by designated personnel	Conduct periodic operator training and equipment maintenance	Equipment operated by designated personnel	Conduct periodic operator training and equipment maintenance
Medium sterilization	Natural ventilation is available	Improve ventilation and provide adequate rest periods	Natural ventilation is available	Improve ventilation and provide adequate rest periods
Inoculation process	Work conducted in a controlled area	Require masks and maintain workplace cleanliness	Work conducted in a controlled area	Require masks and maintain workplace cleanliness
Inoculation process	Sterilization procedures are implemented	Strengthen aseptic techniques and routine sanitation	Sterilization procedures are implemented	Strengthen aseptic techniques and routine sanitation
Inoculation process	Workers take short breaks when necessary	Improve workstation ergonomics and schedule task rotation	Workers take short breaks when necessary	Improve workstation ergonomics and schedule task rotation

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Inoculation process	Regular cleaning activities are conducted	Establish stricter cleaning and monitoring procedures	Regular cleaning activities are conducted	Establish stricter cleaning and monitoring procedures
Incubation process	Incubation area is monitored regularly	Improve environmental monitoring and sanitation	Incubation area is monitored regularly	Improve environmental monitoring and sanitation
Incubation process	Incubation area is partially enclosed	Improve air filtration and access control	Incubation area is partially enclosed	Improve air filtration and access control
Incubation process	Ventilation is available in the work area	Improve humidity and ventilation control systems	Ventilation is available in the work area	Improve humidity and ventilation control systems
Incubation process	Floors are cleaned when necessary	Use anti-slip flooring, improve drainage	Floors are cleaned when necessary	Use anti-slip flooring, improve drainage

Based on the data processing and risk assessment conducted, it was identified that the potential hazards in the mycelium leather production process at Mycotech Lab range from medium to very high-risk levels. The highest risk levels were observed during the medium sterilization and pressing/forming processes. In the medium sterilization stage, workers are exposed to high-temperature autoclave surfaces and pressurized steam, which may result in severe burns and thermal injuries. Meanwhile, during the pressing and forming process, workers face the risk of pinching injuries, crushed fingers, and bruises due to contact with hydraulic press components.

High-risk hazards were also identified during incubation, harvesting, and drying activities. These hazards include cross-contamination from non-sterile equipment, growth of unwanted microorganisms, contamination of mycelium cultures, improper handling during harvesting, exposure to hot drying equipment, and electrical malfunctions that may lead to fire hazards. Medium-risk hazards were primarily associated with ergonomic issues, biological exposure, housekeeping conditions, and manual material handling activities throughout the production process.

Based on the results of the Hazard Identification, Risk Assessment, and Determining Control (HIRADC) analysis, several risk control measures were proposed according to the hierarchy of controls. These measures aim to reduce workplace accidents, prevent product contamination, and improve occupational safety and health performance within the mycelium leather production facility. The recommended control measures are summarized as follows:

1. **Medium Sterilization Process:** The very high risks associated with autoclave operation require strict operating procedures, routine equipment inspections, warning signage, and the mandatory use of heat-resistant gloves and other appropriate personal protective equipment. Operator training should also be conducted regularly to minimize the risk of thermal injuries.
2. **Incubation Process:** High contamination risks during incubation can be reduced through stricter sanitation procedures, improved workplace cleanliness, environmental monitoring, air filtration systems, and controlled access to cultivation areas. These measures are essential to maintain product quality and prevent culture contamination.
3. **Harvesting and Pressing/Forming Processes:** Workers are exposed to mechanical hazards, repetitive movements, and manual handling activities. Therefore, machine guarding systems, emergency stop devices, ergonomic work practices, task rotation, and proper handling procedures should be implemented to reduce injury risks and musculoskeletal disorders.
4. **Drying and Stabilization Process:** Exposure to hot surfaces, elevated temperatures, and electrical hazards can be controlled through routine equipment maintenance, adequate ventilation, electrical inspections, warning signs, and the use of heat-resistant personal protective equipment.

From the workplace environment perspective, maintaining good housekeeping practices, proper waste management, adequate ventilation, and continuous supervision are important to reduce occupational risks and support safe and sustainable mycelium leather production activities at Mycotech Lab.6G

4. Conclusion

Based on observations, interviews, and HIRADC analysis conducted at Mycotech Lab, various occupational hazards were identified throughout the mycelium leather production process. The identified hazards included physical, biological, chemical, ergonomic, contamination, mechanical, and environmental hazards associated with growth medium preparation, sterilization, incubation, harvesting, pressing and forming, drying, conditioning, quality inspection, and general laboratory activities. The risk assessment results showed that most identified hazards were classified as medium risk, while several hazards were categorized as high and very high risk. The highest risk levels were found in the medium sterilization process due to exposure to high-temperature autoclave surfaces and pressurized steam, as well as in the pressing and forming process involving hydraulic press

DOI: https://doi.org/10.69693/ijmst.v4i2.10163
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equipment. High-risk hazards were also identified during incubation, harvesting, and drying activities, particularly those related to contamination, product quality deterioration, and thermal hazards. Based on the hierarchy of controls, several risk control measures were recommended, including improving workplace sanitation, strengthening contamination control procedures, conducting routine equipment inspections and maintenance, enhancing worker training, implementing ergonomic work practices, and ensuring the proper use of personal protective equipment (PPE). The implementation of these measures is expected to reduce occupational risks, improve worker safety and health, and support the sustainable production of mycelium leather products at Mycotech Lab.

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DOI: https://doi.org/10.69693/ijmst.v4i2.10163
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