People's Democratic Republic of Algeria
Ministry of Higher Education and Scientific Research
August 20, 1955 University - Skikda
Department of Agronomic Sciences

In order to obtain the Master's Degree in agronomic sciences

Specialization: plant improvement

Project aimed at obtaining an emerging enterprise diploma in accordance with ministerial decision 1275 : Design of an innovative mushroom cultivation system

Presented by:

- **ANNANE Rayane.**
- **BOUDEBZA Chaima.**
- **MEZIANE Amir.**

Defended before the jury :

- **President: BENDIB Riad.** **UNIV SKIKDA**
- **Supervisor: Laib Djamel Eddine .** **UNIV SKIKDA**
- **Co-supervisor: Laib Imen.** **UNIV SKIKDA**
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- **BMC Expert: CHAOUITE Meriem.** **UNIV SKIKDA**
- **Representative of economic partnership: NARSICE Muhammed.**

Academic year : 2023/2024

Summary

1. Introduction

In an era where sustainable agriculture and food security are paramount, our project, the Design of an Innovative Mushroom Cultivation System, stands at the forefront of agricultural innovation. This cutting-edge system integrates advanced automation, environmental stewardship, and economic efficiency to revolutionize mushroom farming. By leveraging state-of-the-art technology, our mycoculture machine automates critical processes, optimizes resource use, and reduces operational costs, all while promoting sustainable practices through the use of renewable energy and organic substrates. This project not only aims to enhance the productivity and profitability of mushroom cultivation but also seeks to contribute to global sustainability efforts, making it a transformative solution for the agricultural industry.

Mushroom cultivation, though ancient, has often been limited by labor-intensive practices and inconsistent yields. Our project addresses these issues head-on by implementing sophisticated sensors and control systems to maintain optimal growing conditions, ensuring consistent, high-quality yields. Additionally, the integration of smart resource management systems reduces waste and enhances productivity, promoting a circular economy through the recycling of agricultural waste into valuable cultivation media. The incorporation of renewable energy solutions further reduces the carbon footprint, aligning with global efforts to combat climate change.

Economically, the mycoculture machine is designed to be scalable and cost-effective, making advanced mushroom farming techniques accessible to both small-scale farmers and large agricultural enterprises. This scalability ensures that the benefits of our innovative system can be realized across diverse farming operations, fostering economic growth and food security. Ultimately, our project aspires to set a new standard in mushroom cultivation, demonstrating that agricultural innovation can drive both environmental sustainability and economic viability.

2. Project submission

2.1. Project implementation team:

2.1.1. Supervision team :

- Supervisor:	- Mr. LAIB Djamel Eddine
- Co-supervisor:	- Dr. LAIB Imen

2.1.2. Team work:

Name	First name	Specialization
ANNANE	Rayane	Master 2 in Plant improvement
BOUDEBZA	Chaima	Master 2 in Plant improvement
MEZIANE	Amir	Master 2 in Plant improvement

2.1. Sector: Agronomy (Mycoculture).

2.2. Project location: August 20, 1955 university, Skikda.

2.3. Project idea:

The project aims to design, develop, and manufacture **an innovative mycoculture machine** capable of creating optimal environmental conditions for mushroom cultivation, utilizing vermicompost treated with *Pistia stratiotes* water lettuce as a growth substrate.

The machine will enable precise control of parameters such as temperature, humidity, ventilation, and light to promote mushroom growth in a controlled environment.

2.4. Origin of the project idea:

The idea for this project may stem from several sources of inspiration :

2.4.1. Growing demand for mushroom:

The idea may arise from recognizing the increasing demand for mushroom in food and medicine, motivating the search for more efficient cultivation methods.

2.4.2. Limitations of traditional methods:

Traditional mushroom cultivation methods may have limitations in terms of efficiency and control over conditions, prompting the search for more advanced solutions.

2.4.3. Awareness of the importance of mushroom:

Increased awareness of the nutritional and medicinal importance of mushroom could stimulate interest in more sophisticated cultivation methods.

2.4.4. Technological innovation:

Interest in creating a mycoculture machine may be driven by a desire to bring technological innovation to the mushroom cultivation sector.

2.4.5. Accessibility:

The objective could be to make mushroom cultivation more accessible by developing an affordable solution while maintaining optimal conditions.

2.4.6. Environmental sustainability:

A commitment to environmental sustainability could be a motivation, seeking to minimize the ecological impact of mushroom cultivation.

2.4.7. Market opportunity:

Recognizing a market opportunity for an improved mycoculture solution could be a determining factor in the development of this machine.

2.4.8. Type of activity:

Manufacturing of an economically viable, controlled environment mycoculture machine plus production of a new mushroom cultivation substrate based on Pistia stratiotes water lettuce.

3. Proposed values:

3.1. Automated control system:

- integration of sensors to measure temperature and humidity.

- use of an automated control system to adjust these conditions in real-time. This optimizes growth while minimizing energy consumption.

3.2. Organic waste recycling:

A system for recycling organic waste is used in parallel to minimize waste and reduce the need for external inputs.

3.3. Renewable energy:

Integration of renewable energy sources such as a solar energy storage system to power part of the energy required for the machine's operation.

3.4. Controlled ventilation:

The machine is equipped with an efficient ventilation system that ensures adequate air exchange while conserving energy (low-energy consumption fans).

3.5. Water-efficient system: use of water-efficient systems such as a humidifier connected to a humidity controller immersed in a box containing distilled water.

4.Objectives:

4.1. Automation: implement automated control systems to monitor and adjust parameters such as temperature, humidity, lighting and ventilation in real-time. This optimizes growth conditions without requiring constant monitoring.

4.2. Rational use of resources: design the machine to minimize resource losses such as water, nutrients and growth substrates.

4.3. Adaptability and modularity: design the machine in a modular fashion to allow for easy upgrades and adaptation to technological advancements. This also facilitates adjusting production capacity according to needs.

4.4. Waste reduction: integration of cultivation practices that minimize waste production. Where possible, implement vermicomposting systems for crop residues.

5.project schedule:

5.1. Production of vermicompost based on *pistia stratiotes* water lettuce:

5.1.1. Water lettuce cultivation:

5.1.1.1. Filling basins with water:

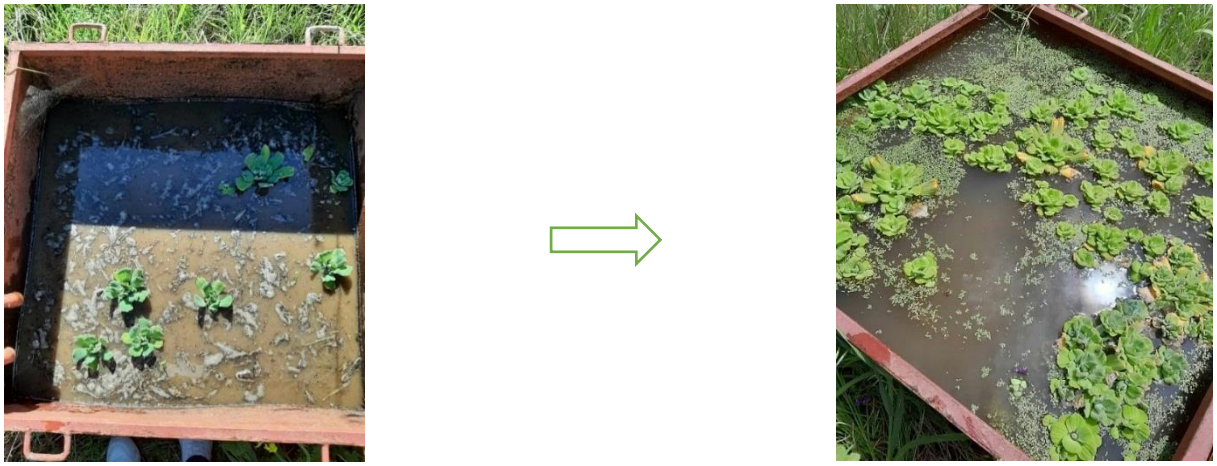
Initially, basins are filled with water. During hot periods, it is crucial to maintain constant monitoring of the basins to detect any significant evaporation and add water to prevent drying out. This practice also promotes oxygen renewal. It is necessary to maintain a water depth of at least 20 cm at all times.

5.1.1.2. Addition of nutrient substrate:

The nutrient solution used for optimal growth and multiplication of water lettuce is cow dung slurry prepared by adding 5 kg of cow dung to a 20 l bucket of water. This solution is then added to the basin.

5.1.1.3. Addition of water lettuce plants:

water lettuce plants are subsequently added to the basin.



Adding water lettuce plants + 5 kg of cow dung to a 20 l.

water lettuce propagation.

Figure 1. Water lettuce cultivation.

5.1.2. Preparation of vermicompost treated with *pistia stratiotes* water lettuce:

The steps for preparing vermicompost of *pistia stratiotes* (water lettuce) are presented in figure 2.

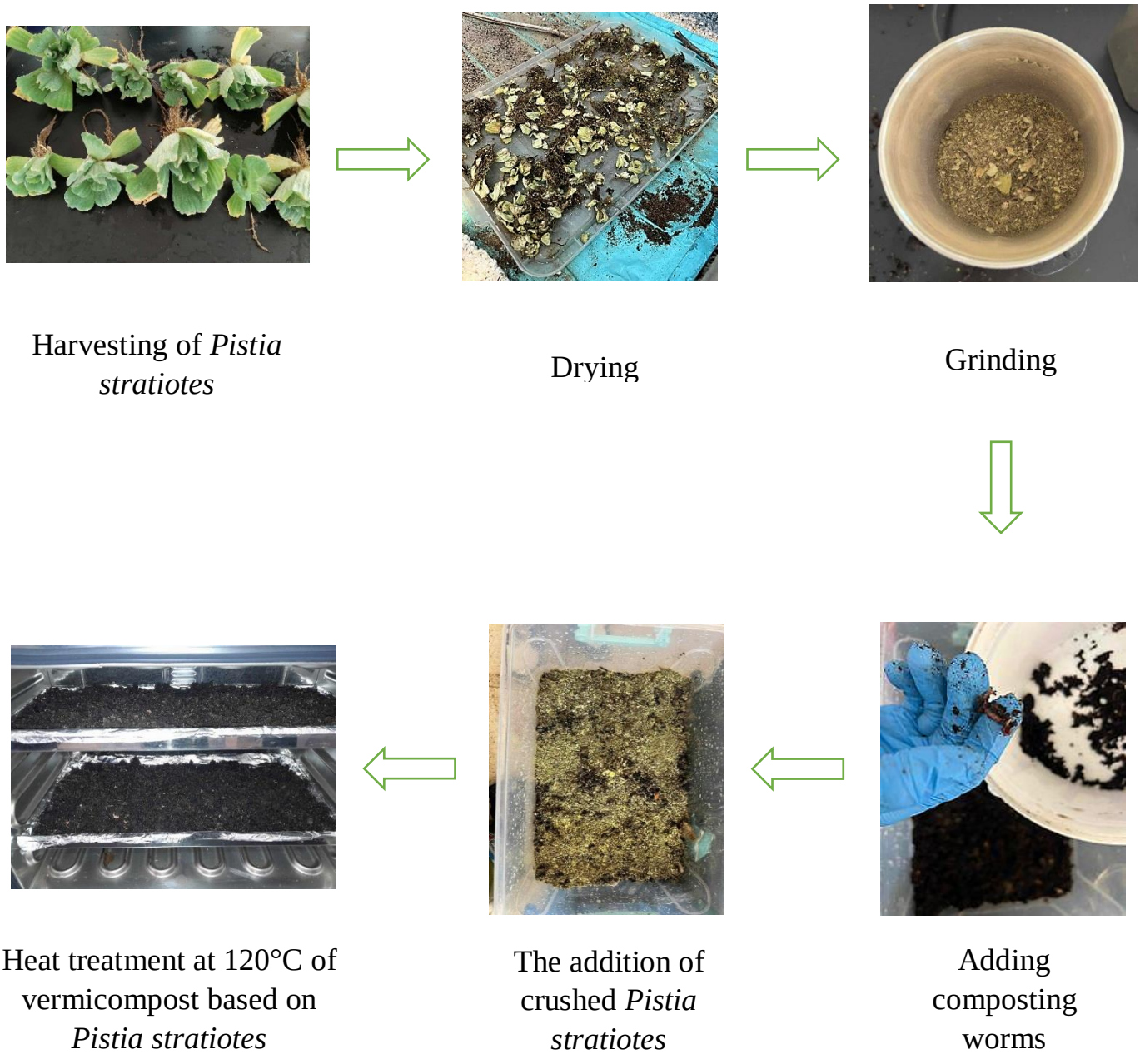


Figure 2. Preparation of vermicompost of *pistia stratiotes*.

5.2. design and fabrication of the mycoculture machine:

The machine is composed of the following parts:

Plastic boxes

Humidifier

Humidity controller

Temperature controller

Fan

Electrical wire

Plug head (02)

Figure 3. Components required for the design of the mycoculture machine.

5.3. Machine operation tests:


Adding the culture

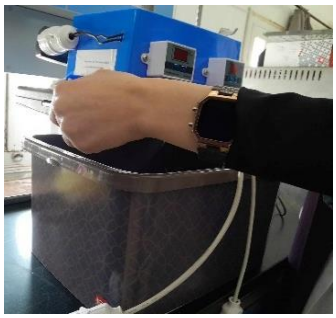
Moistening with distilled water

Filling the humidifier tank

Installation of the humidifier tank

Inoculating the Paris mushroom mycelium

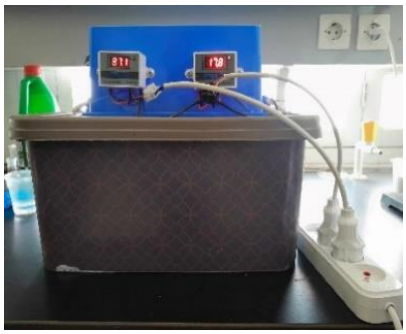
Installation of humidity and temperature detection probes and the humidifier



Closing the lid

Electrical wiring

Adjustment of parameters



Harvested Paris mushroom

Machine operation

Figure 4. Machine operation tests.

5.4. Validation and documentation:

- Validation of machine performance at a small scale under real cultivation conditions.

- Development of technical documents, user manuals, and maintenance guides for the machine.

- Preparation of marketing materials to promote the machine to potential clients.

6.The innovative aspect:

This project lies in several key elements:

6.1. Automation: integration of automated systems to control and adjust parameters such as temperature, humidity, light and ventilation.

6.2. Space optimization:

Designing the machine to maximize space utilization while facilitating access for harvesting and maintenance.

6.3. Water management: integration of water management systems that minimize wastage.

6.4. Use of renewable energy sources: exploring the use of renewable energy sources such as solar energy to power the machine, if possible.

6.5. Accessibility and ease of use: simple design of the machine, allowing even less experienced individuals in mycoculture to use it effectively.

7.Market analysis:

The mushroom market, valued at USD 50.3 billion in 2019, is projected to grow from USD 55.18 billion in 2023 to USD 126.95 billion by 2031, with an impressive compound annual growth rate (CAGR) of 9.7% during the forecast period from 2024 to 2031.

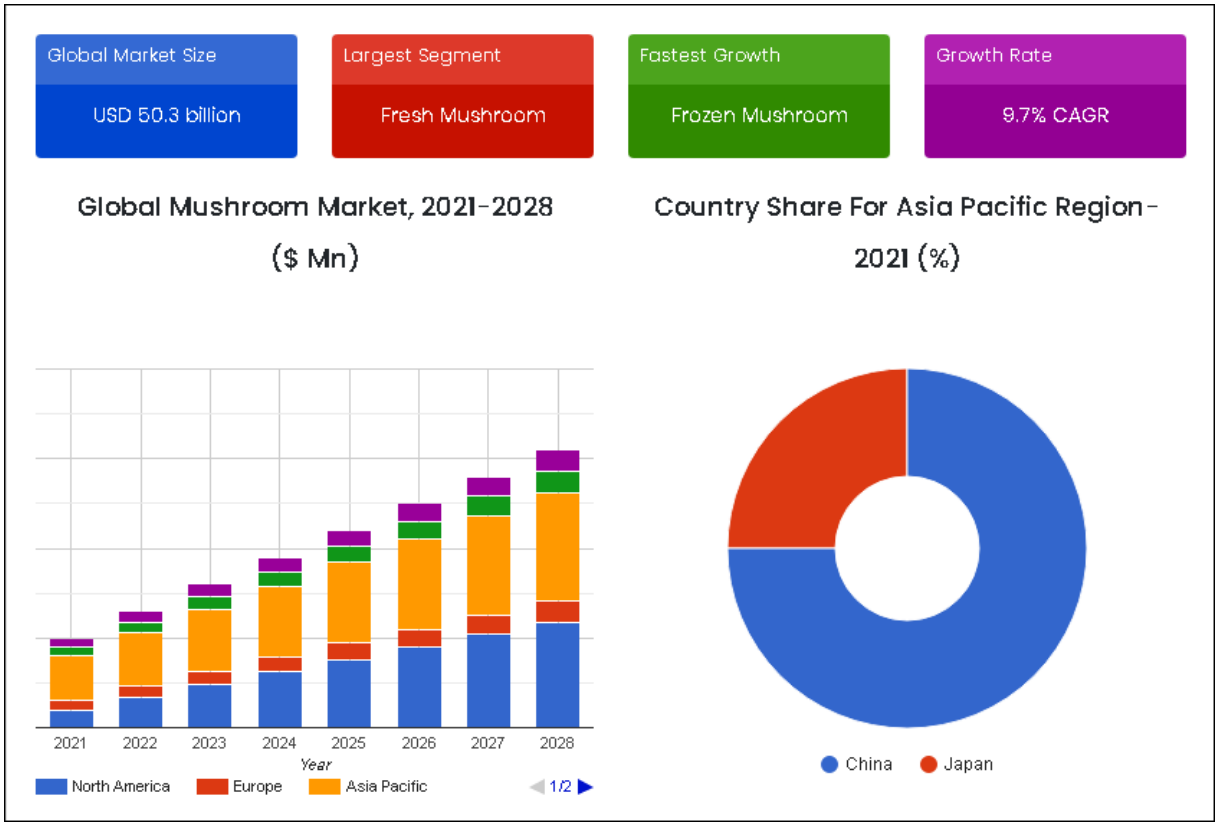


Figure 5. Global mushroom market.

7.1. Market demand:

The mushroom market is poised for significant growth driven by several key factors.

7.1.1. Increasing Consumption in Foodservice: Restaurants, Supermarkets, and Cafeterias: The rising popularity of mushrooms in various foodservice

establishments is a major growth driver. As consumers become more health-conscious and seek diverse culinary experiences, mushrooms are increasingly featured in menus and prepared food sections of supermarkets and cafeterias. Their versatility in a wide range of dishes from gourmet to everyday meals enhances their appeal.

7.1.2. Shifts in Consumer Preferences:

- Vegan and Plant-Based Diets: There is a notable shift in consumer preferences towards vegan and plant-based foods, which significantly boosts the demand for mushrooms. As more people adopt vegetarian and vegan diets for health, ethical, and environmental reasons, mushrooms, with their rich nutritional profile and umami flavor, have become a staple in plant-based diets.

- Meat Replacements: Mushrooms, particularly varieties like Paris mushrooms (also known as button mushrooms), are high in protein and can serve as effective meat substitutes. Their texture and ability to absorb flavors make them ideal for creating dishes that cater to meat-reducing or meat-free diets.

7.1.3. Health and Nutritional Benefits:

Mushrooms are not only rich in protein but also contain essential vitamins, minerals, and antioxidants. Their low-calorie content and health benefits, such as boosting the immune system and providing anti-inflammatory properties, further increase their attractiveness to health-conscious consumers.

The fresh mushroom segment is expected to maintain its dominance in the global mushroom market, having accounted for over 89.5% of total market revenue in 2021. This segment has experienced substantial demand growth in recent years, driven by a rising number of consumers prioritizing organic and unprocessed foods to maximize health benefits. Although the short shelf life of fresh mushrooms presents challenges for producers and distributors, technological advancements, such as modified atmosphere packaging, have mitigated these issues, facilitating segment expansion and ensuring the continued prominence of fresh mushrooms in the market.

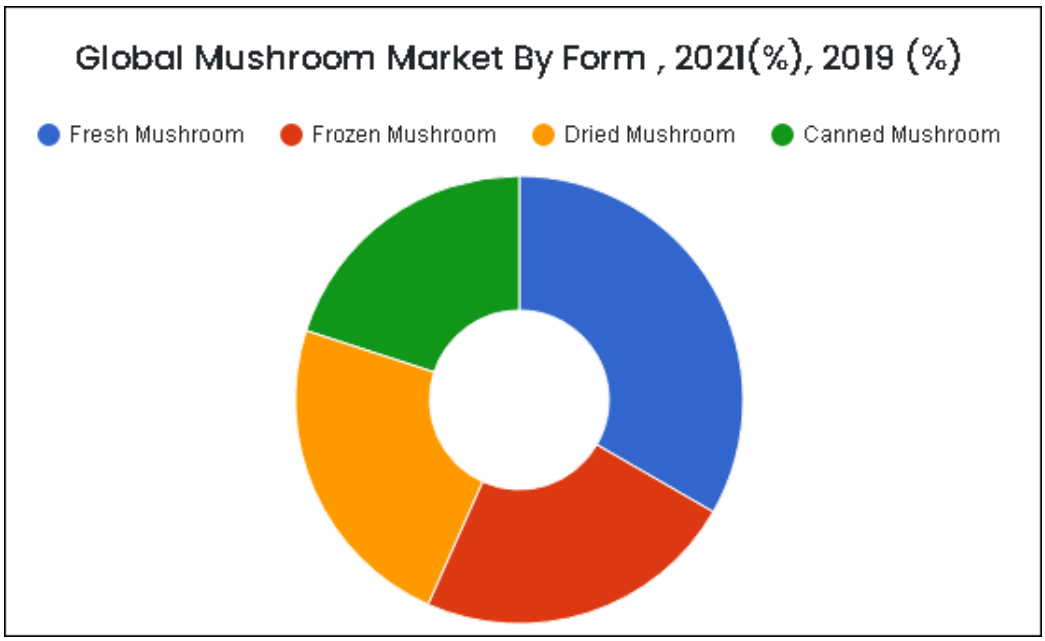


Figure 6. Global mushroom market by form, 2021(%), 2019 (%).

7.2. Mushroom Market Restraints:

Despite the positive growth trends, the mushroom market faces several significant restraints that could limit its expansion:

- Short Shelf Life:

Mushrooms have a very short shelf life, which presents a considerable challenge for storage, transportation, and distribution. This limitation can lead to increased waste and financial losses for producers and distributors.

- Labor-Intensive Farming and High Operating Costs:

Mushroom cultivation is highly labor-intensive, requiring significant manpower for tasks such as substrate preparation, inoculation, harvesting, and monitoring environmental conditions. Additionally, the operating costs associated with maintaining optimal growing conditions and managing pests can be substantial, limiting the scalability of mushroom farming operations.

- Harmful Production Methods in Developing Nations:

To meet the rising demand, some farmers in developing nations have resorted to using excessive pesticides and fertilizers, which can be harmful to both the environment and consumer health. These practices undermine the sustainability and safety of mushroom production, potentially leading to market instability.

- Health Risks to Workers:

Mushroom spores can cause allergies and other respiratory disorders, posing health risks to those who work in the mushroom industry. This can lead to

increased healthcare costs, decreased productivity, and challenges in maintaining a healthy workforce.

7.3. Competition:

7.3.1. Competitors:

In the mycoculture sector, several competitors play prominent roles, each with distinct strengths and weaknesses:

- Monaghan Mushroom:
  - Strengths: Largest producer with extensive distribution networks and a strong focus on sustainable practices. They are innovating with reusable packaging and have established brand recognition.
  - Weaknesses: Vulnerable to market fluctuations due to reliance on large-scale production. May face challenges in adapting quickly to niche market demands.
- Smithy Mushrooms:
  - Strengths: Known for diverse product offerings and efficient regional distribution channels. They excel in supplying gourmet mushrooms to high-end markets.
  - Weaknesses: Limited scalability compared to larger competitors like Monaghan Mushrooms. May struggle with maintaining cost efficiency on a larger scale.

- Fungi Co.:

- Strengths: Specializes in organic and specialty mushrooms, appealing to health-conscious consumers. Strong brand equity through organic certifications and unique product range.
- Weaknesses: Relatively small market share and potential challenges in scaling operations. May face competition from larger players in broader market segments.

- Mycotech Innovations:

- Strengths: Focuses on technological advancements in mycoculture, such as automation and biotechnological innovations. Positioned as a leader in innovative cultivation methods.
- Weaknesses: Limited market presence compared to traditional growers. May require significant capital investment for scaling up technological solutions.

7.3.2. Evaluation of Competitors:

- Products: Each competitor offers a unique array of mushroom catering to different market segments, from common varieties to specialty and gourmet options.
- Market Shares: Monaghan Mushroom dominates with its scale, followed by regional strength from Smithy Mushroom and niche appeal from Fungi Co. and Mycotech Innovations.

- Strategies: Competitors vary in their strategies, from sustainability initiatives (Monaghan Mushroom) and product diversity (Smithy Mushroom, Fungi Co.) to technological innovation (Mycotech Innovations). Each approach reflects their strengths and limitations in the evolving mycoculture market.

7.4. Customer needs:

- Understanding the specific needs of mushroom growers in terms of condition control and energy efficiency.

- Obtaining feedback from potential customers through surveys, interviews or focus groups.

7.5. Economic aspects:

Analyzing the financial viability of mushroom farms, particularly focusing on energy costs, involves several key aspects:

- Energy Consumption: Mushroom farms typically require controlled environments with specific temperature, humidity, and ventilation conditions. Energy-intensive processes include heating, cooling, lighting (for some varieties), and ventilation systems.
- Cost Analysis: The financial viability hinges on balancing energy costs against revenue from mushroom sales. Efficient energy management is crucial to minimize operational expenses and maximize profitability.
- Technological Solutions: Adoption of energy-efficient technologies such as LED lighting, automated climate control systems, and renewable energy

sources (like solar or biomass) can significantly reduce energy costs over the long term.

- Market Factors: Economic viability also depends on market prices for mushrooms, which can fluctuate seasonally and regionally. High-value specialty mushrooms may justify higher production costs compared to common varieties.
- Operational Efficiency: Optimizing production processes, crop rotation strategies, and waste management can indirectly impact energy costs by reducing resource consumption and enhancing overall farm efficiency.
- Financial Planning: Long-term financial planning should consider capital investments in energy-efficient infrastructure and ongoing operational expenses related to energy consumption.

7.6. Possible partnerships:

- Identifying potential partnerships with agricultural businesses, distributors or other supply chain actors.

7.7. Sustainability:

- Identifying the ecological aspects of our machine, including energy efficiency, waste reduction and overall environmental impact.

7.8. Swot analysis:

conducting a swot analysis (Strengths, Weaknesses, Opportunities, Threats) to assess the project's market position.

SWOT ANALYSIS

STRENGTHS	WEAKNESSES
• High-quality product. • Requires minimal space for mushroom cultivation. • Ensured energy efficiency and reduces labor costs. • Suitable for use in markets as a small business venture. • Sustainability: Uses renewable energy and recycles waste. • Quality Control: Ensures high-quality yields. • Scalability: Fits various operation sizes.	• High Initial Investment: Costly setup may deter smaller farms. • Technical Complexity: Requires skilled personnel. • Short Shelf Life: Limited fresh mushroom shelf life poses logistical challenges. • Dependence on Technology: Technical failures can disrupt yield quality.
OPPORTUNITIES	**THREATS**
• Weak local competition in the field of mushroom production • Rising demand for mushrooms as a meat alternative and Increased awareness of mushroom health benefits. • Market Expansion: Potential in new regional and international markets. • Partnerships: Collaboration opportunities with food industries. • Government Support: Grants and subsidies for innovative agriculture.	• The many diseases that affect Mushrooms and their fast impact. • Lock of strage and religestive places for the type of cultivation. • Potential difficulty in accessing to national market. • Market Competition: Competition from producers and startups. • Economic Fluctuations: Economic downturns affecting spending. • Regulatory Challenges: Complex agricultural regulations.

7.9. Marketing and positioning:

In our project, developing a clear marketing strategy is crucial to effectively promote our innovative mushroom cultivation machine, emphasizing its competitive advantages. This strategy will focus on:

- Target Audience Identification: Identifying and understanding our target audience, including commercial mushroom growers, agricultural cooperatives, and urban farming initiatives. This involves grasping their specific needs and preferences regarding mushroom cultivation technology.
- Unique Selling Proposition (USP): Clearly defining and showcasing the machine's competitive edge, such as:
- Technological Innovation: Highlighting advanced features that enhance yield, efficiency, and consistency in mushroom production.
- Sustainability: Emphasizing eco-friendly aspects like reduced energy consumption and sustainable farming practices.
- Cost Efficiency: Demonstrating how the machine lowers operational costs through automation, energy savings, and reduced labor requirements.
- Scalability: Illustrating its ability to scale production seamlessly, catering to both small-scale and large-scale growers.
- Messaging and Communication: Crafting compelling messages that resonate with our audience's values and needs. This includes highlighting

benefits such as increased yield, improved quality control, and reliability compared to traditional methods.

- Distribution Channels: Determining the most effective channels to reach our audience, whether through direct sales, partnerships with agricultural suppliers, or online platforms.

Promotional Tactics: Implementing a variety of promotional tactics, including:

- Digital Marketing: Leveraging SEO, social media, and online ads to build awareness and generate leads.
- Demonstrations and Trials: Offering demonstrations or trial periods to allow potential customers to experience the machine's benefits firsthand.
- Industry Events: Participating in relevant trade shows and events to showcase the machine and connect with potential customers and partners.
- Customer Support and Feedback: Establishing robust customer support channels and gathering feedback to continuously enhance the machine and refine marketing strategies based on customer insights.

7.10. Distribution and sales plan:

defining the method of distribution and sale of the machine, considering existing distribution channels and potential partnerships.

8.organization and production plan:

8.1. Manufacturing process:

- Detailed description of the mycoculture machine manufacturing process, from initial design to mass production.

- Identification of potential suppliers of materials and components.

8.2. Technology and innovation:

- Explanation of the technology used to optimize production and machine design.

- Integration of innovative elements into the production process to remain competitive in the market.

8.3. Supply chain management:

- Implementation of an efficient supply chain management system to ensure a steady flow of materials.

- Identification of key partners in the supply chain and establishing strong relationships with them.

- Implementation of contingency plans in case of disruptions in the supply chain.

8.4. Quality control:

- Development of quality control procedures through out the manufacturing process.

- Description of how defects will be identified and rectified.

8.5. Cost management:

- Establishing a detailed budget for the project, considering research and development costs, production, marketing, etc.

- Implementation of cost tracking mechanisms to ensure budget adherence.

8.6. Maintenance and after-sales service:

- Development of a plan for machine maintenance after sale.

- Establishment of procedures to quickly respond to after-sales service requests and ensure customer satisfaction.

8.7. Information systems:

- Implementation of computer systems to track production, inventory management and sales.

9.Budget plan:

9.1. Research and development costs:

- Material costs.

- Research and development fees

9.2. Design and engineering costs:

- Prototyping materials and testing.

9.3. Production costs:

- Materials and manufacturing components.

- Costs related to production machinery and equipment.

9.4. Marketing and sales costs:

- Marketing strategies, advertising, and promotion.

- Promotional materials and samples.

9.5. Distribution costs:

- Shipping and logistics expenses.

- Packaging and handling.

9.6. Staff training costs:

- Costs related to the training of production, sales and after-sales service.

9.7. Overhead costs:

- the costs of dealing contengencies.

- Legal and regulatory compliance fees.

- Insurance costs.

9.8. Capital investments:

- Acquisitions of major equipment.

- Facility improvements.

- Capital expenditures for future expansion.

9.9. Reserves for cost fluctuations:

- Provision for possible fluctuations in raw material costs, energy, etc.

9.10. Financial expenses:

- Interest on loans.

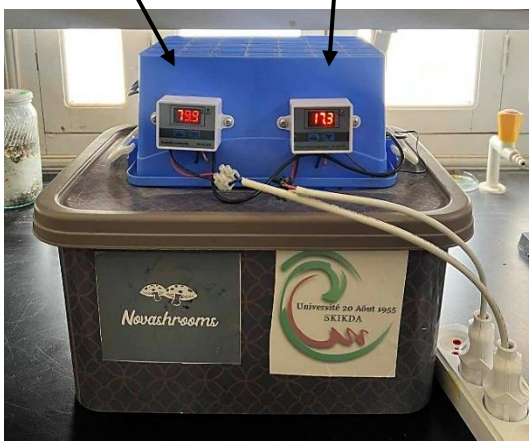
- Banking fees.

10.prototype:

Culture medium based on water lettuce

Humidity controller

Temperature controller



Humidifier

Humidity detector fan

Temperature detector

Humidifier head

Ventilator

Figure 5. Final prototypes manufactured (machine + culture medium).

11. The business model canvas (BMC) of the project

<table>
<tr>
<td rowspan="2">Key partners
- Suppliers of materials and components.
- Distributors and resellers.
- Agricultural companies for research collaborations.</td>
<td>Key activities
- Research and development of new features.
- Manufacturing and production of machines.
- Marketing and promotion of the product.
- Training of staff and customers.</td>
<td rowspan="2">Value propositions
- Controlled-environment mushroom cultivation machines that are energy-efficient.
- Enhancement of productivity and quality of harvests.
- Reduction of operational costs through energy efficiency.</td>
<td>Customer relationships
- After-sales service for maintenance and repairs.
- Technical support for users.
- Training of customers on optimal machine usage.</td>
<td rowspan="2">Customer segments
- Large-scale mushroom growers.
- Agricultural farms.
- Agri-food companies.
- Agricultural solution providers.</td>
</tr>
<tr>
<td>Key resources
- Research and development team.
- Design and production engineers.
- Production facilities.
-partnerships with
- Key component suppliers.</td>
<td>Distribution channels
- Direct sales to growers.
- Partnerships with agricultural distributors.
- Online platforms for direct sales and marketing.</td>
</tr>
<tr>
<td colspan="3">Cost structure
- Research and development costs.
- Machine production costs.
- Marketing and sales costs.
- Maintenance and after-sales service costs.</td>
<td colspan="2">Revenue streams
- Sales of mushroom cultivation machines.
- After-sales service contracts.
- Long-term leasing or maintenance contracts.</td>
</tr>
</table>

12. Conclusion:

In conclusion the design of an innovative mushroom cultivation system represents a groundbreaking advancement in agricultural technology, addressing the pressing challenges of traditional mushroom farming through a holistic approach that combines cutting-edge automation, sustainable practices, and economic efficiency. Our system revolutionizes the cultivation process by automating the regulation of environmental conditions, thus ensuring optimal growing conditions and consistent, high-quality yields. It promotes sustainability by utilizing renewable energy and recycling organic waste into valuable substrates, significantly reducing the environmental footprint. Economically, the system lowers production costs and labor dependency, making advanced cultivation methods accessible and profitable for both small-scale and industrial producers. By enhancing productivity, supporting environmental stewardship, and fostering economic resilience, this project not only meets the immediate needs of mushroom farmers but also contributes to the broader goals of global food security and sustainable development, setting a new benchmark for future agricultural technologies.