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Implementation of Temperature and Humidity Control in Tiramite Mushroom Cultivation Based on IoT

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Abstract

The development of tiramite mushrooms in Indonesia encounters difficulties in sustaining ideal temperature and humidity levels, particularly due to erratic climate variations. This study utilizes Internet of Things (IoT) technology to resolve these challenges by creating an automated, real-time system for monitoring and controlling temperature and humidity at JJ Srister Mushroom. The Research & Development (R&D) methodology employing a prototyping approach facilitates ongoing testing and enhancement of the system. This system employs DHT22 sensors and interfaces with a web page and control box for real-time monitoring. Test results indicate that the system effectively regulates temperature and humidity within suitable parameters for the growth phases of mycelium and mushroom fruit bodies, maintaining temperatures of 22-28°C and humidity levels of 80-90% during the mycelium phase, and temperatures of 16-25°C with humidity levels of 90-95% during the fruit body phase. The authors assert that this IoT system offers significant advantages and advocate for further investigation to enhance sensor precision and develop a mobile application as a supplementary monitoring tool.

Keywords : *Internet of Things (IoT), Research & Development (R&D), Prototype Method, Mushroom Mycelium and Fruiting Body*

INTRODUCTION

Indonesia, characterized by a prominent agricultural industry, consistently innovates in crop cultivation, particularly in the production of mushrooms, which is a significant food commodity. (Dhanaraju et al., 2022) Tiramite mushrooms (Pleurotus ostreatus) have gained popularity for their capacity to thrive on decomposing substrates, including decayed wood. The success of tiramite mushroom growing is contingent upon appropriate climatic conditions, specifically temperature and humidity. The optimal temperature for fruit body development is between 16 and 22°C, with humidity levels of 95 to 98%. (Ezzahoui et al., 2021; Pratyush Reddy et al., 2020) Conversely, mycelium thrives best at temperatures ranging from 22 to 28°C and humidity levels of 80 to 95%.

Nonetheless, producers frequently face difficulties in regulating temperature and humidity, which can profoundly impact the quality and yield of tiramisu mushrooms. Data from the Central Statistics Agency (BPS) indicates that fluctuations in temperature and humidity have resulted in a decrease in termite mushroom production in Indonesia, particularly in East Java Province, where production fell from 312,977 kg in 2021 to 164,737 kg in 2022. The primary obstacle lies in conventional monitoring techniques, which are ineffective and incapable of providing real-time assessments of environmental status. To resolve this issue, Internet of Things (IoT) technology presents a viable option. The Internet of Things (IoT) interlinks diverse devices via the Internet, facilitating more automated monitoring and control. (Patil et al., 2023; Rayhana et al., 2020) The implementation of IoT in termite mushroom farming enables producers to monitor temperature and humidity in real-time via smartphones or computers, in addition to automating irrigation and ventilation systems. (Chamara et al., 2022; Subahi & Bouazza, 2020) Consequently, this method can enhance the efficacy of environmental control in cultivation, thereby improving the output and quality of tiramisu mushrooms. (Rehman et al., 2022; Saptono & Andika, 2020)

Several critical issues identified include challenges in monitoring the cultivation environment, which continues to rely on conventional methods; instability in temperature and humidity that can diminish the quality of termite mushrooms and result in crop failure; obstacles for cultivators in acquiring real-time data on temperature and humidity; strategies to mitigate the instability of temperature and humidity impacting mushroom growth and quality; and measures to ensure the efficient operation of temperature and humidity control devices to enhance productivity and harvest quality. (Halgamuge et al., 2021)

To sustain research focus and accomplish objectives, the defined limitations are: this study exclusively examines termite mushroom cultivation; the temperature and humidity control system employs a 20x4 LCD and a website; the system is implemented during the growth phases of mycelium and fruit bodies until harvest; the development of the temperature and humidity control system utilizes the ESP32 microcontroller; and the system solely regulates temperature and humidity parameters.

The primary objectives of this research are to create an automated and manual control system for temperature and humidity in termite mushroom cultivation, along with a manual emergency control system; to produce real-time monitoring data on temperature and humidity available to cultivators, and to improve termite mushroom production through the implementation of effective temperature and humidity control mechanisms. This methodology aims to provide tangible solutions for enhancing efficiency and output in tiramisu mushroom growing while minimizing dependence on conventional methods.

METHOD

This research methodology uses the ADDIE model as a framework for the Research and Development process. The ADDIE model is a widely utilized framework for creating educational or training programs, comprising five phases: Analysis, Design, Development, Implementation, and Evaluation.

Analysis: The initial phase entails assessing the requirements for new product development, encompassing models, methodologies, media, and educational resources. Current difficulties with existing goods must be identified, particularly if they are no longer pertinent to the target needs, environment, technology, or attributes of the learners.

Design: During the design phase, a conceptual framework for the product is developed using a methodical approach to formulating concepts and information. This design incorporates explicit and comprehensive implementation guidelines while maintaining a conceptual framework to support the ensuing development process.

Development: The development phase entails transforming the conceptual design into a product that is prepared for implementation. At this stage, instruments for assessing product performance are designed to ensure that the product operates by the defined objectives.

Execution: The product is utilized to garner preliminary input regarding its efficacy. This feedback assesses the extent to which the product meets development objectives and enhances key elements.

Evaluation: The concluding phase is evaluation, which seeks to provide feedback to users and refine the product based on the evaluation outcomes. Evaluation is to assess the attainment of development objectives and verify that the product satisfies user requirements.

The software development paradigm entails the creation of a preliminary model (prototype) of the application or system to be developed. This prototype is used to collect feedback from users or stakeholders to identify and clarify actual requirements. The prototype method mitigates the risk of design flaws and application failures by allowing for enhancements to be made prior to final deployment. The primary objective of this strategy is to enhance comprehension of user requirements and gather preliminary feedback, enabling modifications and enhancements before the development of the final product version.

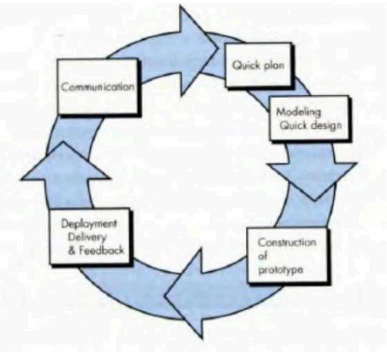

Figure 1. Development Model Prototype

Hardware Control Box Design

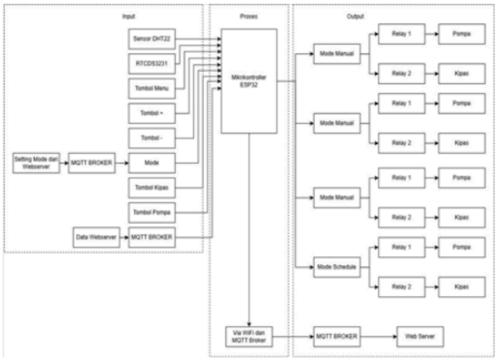

Figure 2. Block Diagram

The block diagram above illustrates that the Control Box contains a DHT22 sensor, which detects temperature and humidity in the mushroom cultivation area. The data collected from this sensor is transmitted to a web dashboard over Wi-Fi and the MQTT protocol, then presented as graphs and historical tables. The system comprises four control methods: manual, automated, hybrid, and scheduling.

Manual: In this mode, cultivators can directly operate the fans and water pumps using buttons on the control box and the real-time monitoring dashboard.

Automatic mode regulates the fans and water pumps according to temperature and humidity metrics detected by the sensor. The system juxtaposes the supplied data with the setpoints established by the cultivator. Should the temperature or humidity exceed the designated setpoint thresholds, the fans or water pumps are automatically activated or deactivated.

Hybrid: This integrated mode facilitates both manual and automatic operation. Cultivators can directly operate the equipment via the control box or dashboard while simultaneously utilizing the automatic mode.

Scheduling: This option regulates automatic irrigation according to a timetable established by the cultivator. The system irrigates at designated times, which can be modified via buttons on the control panel by the cultivator's daily watering routines.

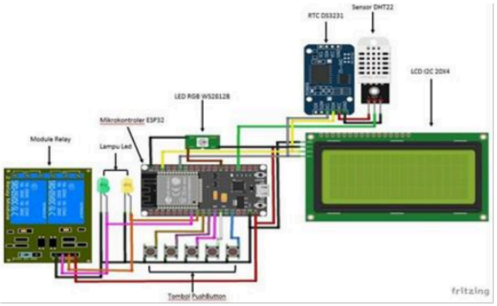

Figure 3. Wiring Diagram

RESULT AND DISCUSSION

The test findings indicate variations in the growth and development of mushroom bags. During the author's two-week studies, distinct variations in the condition of the mushroom bags were observed. The following delineates the distinctions between the bags maintained within the temperature and humidity management system and those that are not.

1. Logistics materials using a control system'

Figure 4. Logistics materials Using Control System

2. Logistics materials without control system

Figure 5. Logistics materials Without control system

Following a 25-day trial, the author noted disparities between the bags utilizing the temperature and humidity management system and those employing conventional methods. The following delineates the distinctions between the bags maintained within the temperature and humidity management system and those that are not. The proportion of cash to total assets has risen from 2021 to 2023. In 2021, the predominant components are credit extended, sharia receivables, and finance, which collectively constitute 64.45% of total assets. The second largest component comprises securities, export notes, reverse repos, and other receivables, totaling 21.18% of total assets. The most minor component in 2021 is net derivative receivables, constituting 0.04%. In 2022, the predominant components are credit extended, sharia receivables, and financing, which collectively constitute 61.06% of assets. The second largest component comprises securities, export notes, reverse repos, and other receivables, accounting for 22.44% of total assets. The minimal element in 2022 is CKPN credit extended, Sharia receivables, and financing at -4.99%. As of 2023, the predominant components are credit extended, sharia receivables, and finance, which collectively constitute 64.45% of assets. The second largest component comprises securities, export notes, reverse repos, and receivables, totaling 21.18% of total assets. The most minor component in 2023 is CKPN credit granted, sharia receivables, and financing at a rate of -4.35%.

In 2021, customer deposits constitute the most significant component of liabilities, accounting for 67.86% of total liabilities. The second-largest liability component is savings, accounting for 29.66% of total liabilities. The least important element of liabilities comprises deposits from other banks and financial institutions, accounting for 0.79% of total liabilities. In 2022, customer deposits constituted the most significant portion of liabilities, accounting for 70.10% of the total liabilities. The second most significant liability component is Savings, constituting 28.01% of total assets. The most minor element of liabilities consists of deposits made with the bank by other banks and financial institutions. Constitute 0.50% of total liabilities. In 2023, client deposits constituted the largest share of liabilities, accounting for 69.13% of total liabilities. The second most significant liability component is Savings, with 26.87% of total liabilities. The minimal element of liabilities is Deposits from other banks and financial institutions, constituting 0.61% of total liabilities.

In 2021, the component of Equity with the most significant proportion is the total attributable to the entity, constituting 17.21% of total liabilities. Retained earnings constitute the second most significant component of Equity, representing 11.02% of total liabilities. The minimal element of Equity comprises the net Profit (loss) from the revaluation of defined benefit plans, representing -0.08% of total liabilities. In 2022, the equity component with the highest percentage is Total Entity, accounting for 16.04% of total liabilities. Retained earnings constitute the second most significant component of Equity, accounting for 10.78% of total liabilities. The minor element of Equity consists of unrealized gains (or losses) on assets assessed at fair value and recorded under Other Comprehensive Income. Constitute -0.24% of total liabilities. In 2023, the equity component with the highest percentage is a total entity, accounting for 15.85% of total liabilities. Retained earnings constitute the second most significant component of Equity, accounting for 10.88% of total liabilities. The minimal element of Equity is acquired share capital (treasury shares) at -0.18% of total liabilities.

1. Logistics materials using a control system

Figure 6. 25-day-old logistics materials with control system

The bags housed in the compact greenhouse equipped with a temperature and humidity control system exhibited significant and accelerated growth of oyster mushroom fruiting bodies by day 25. This technology maintains temperature and humidity within the optimal range of 16–25°C and 80–95%, hence expediting growth relative to conventional culture methods, which often necessitate approximately one and a half months.

2. Logistics materials without using a control system

Figure 7. 25-day-old logistics materials without a control system

At 25 days of age, the bags employing conventional methods exhibited no indications of oyster mushroom fruiting body emergence. This results from inadequate maintenance of temperature and humidity conditions.

CONCLUSION

The testing of the IoT-based temperature and humidity management system yielded numerous significant conclusions. The IoT-based control and monitoring system was effectively constructed utilizing a DHT sensor and a scheduling mechanism. Secondly, this method enables mushroom farmers to monitor temperature and humidity in real time via a web interface and control unit. Third, testing confirmed the system's capability to sustain a temperature range of 22–28°C and humidity of 80–90% during mycelium development, as well as a temperature range of 16–25°C and humidity of 90–95% during fruiting body growth. This enhances mushroom production through improved growth.

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