GRAY OYSTER MUSHROOM AUTOMATED SYSTEM WITH IOT MONITORING

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Computer Engineering with Honours

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DEDICATION

I was able to complete this Final Year Project (FYP) successfully within the given timeline despite having difficulties during the progress of completing this project. I faced many challenges that needed to be overcome but I received so much help from my surroundings people. A special feeling of gratitude to my loving parents, Low Tee Hock and Fong Yap Hoon whose words of encouragement and push for tenacity ring in my ears. My sister Janet has never left my side and is very special. Besides that, I feel very grateful to my beloved friends who became a helping and supported me whenever needed. Nevertheless, I encountered several difficult situations due to that I made mistakes and neglected many things.

ABSTRACT

The cultivation of gray oyster mushrooms is purposefully growing in controlled conditions, providing the right environment to thrive and be harvested for food or commercial use. The cultivation of gray oyster mushrooms is influenced by several factors such as ambient temperature and humidity. The inconsistency of Malaysia's weather makes it challenging for this plant to maintain the ideal temperature for healthy growth and microbial avoidance. The objective is to develop an automated monitoring control temperature system for gray oyster mushroom. Next, the project's second objective is to analyze the performance production of gray oyster mushrooms. This project is an automatic temperature control system for the gray oyster mushrooms by using the DHT22 sensor to measure and regulate the temperature and humidity including transmitting the data to Arduino and ESP8266-01 to automatically start the system when the temperature reaches 30 °C by misting and display the reading on the LCD. In addition, the project is conducted for 30 days to obtain accurate results. With the operations of this automated monitoring system, agropreneurs can avoid losses from the damage to the mushrooms. The IoT platform was able to enhance the company's operation efficiency and also relevant to help entrepreneurs toward technological entrepreneurship.

ABSTRAK

Penanaman cendawan tiram kelabu bertujuan tumbuh dalam keadaan terkawal, menyediakan persekitaran yang sesuai untuk membesar dan dituai untuk makanan atau kegunaan komersial. Penanaman cendawan tiram kelabu dipengaruhi oleh beberapa faktor seperti suhu dan kelembapan persekitaran. Ketidakkonsistenan cuaca Malaysia menjadikan tumbuhan ini mencabar untuk mengekalkan suhu yang ideal untuk pertumbuhan yang sihat dan mengelakkan mikrob. Objektif adalah untuk membangunkan sistem kawalan suhu pemantauan automatik untuk cendawan tiram kelabu. Seterusnya, objektif kedua adalah untuk menganalisis prestasi pengeluaran cendawan tiram kelabu. Projek ini ialah sistem kawalan suhu automatik untuk cendawan tiram kelabu dengan menggunakan penderia DHT22 untuk mengukur suhu dan kelembapan termasuk menghantar data ke Arduino dan ESP8266-01 untuk memulakan sistem secara automatik apabila suhu mencapai 30 °C dengan meresap. dan paparkan bacaan pada LCD. Selain itu, projek ini dijalankan selama 30 hari untuk mendapatkan hasil yang tepat. Dengan operasi sistem pemantauan automatik ini, usahawan pertanian boleh mengelakkan kerugian daripada kerosakan cendawan. Platform IoT mampu meningkatkan kecekapan operasi syarikat dan juga relevan untuk membantu usahawan ke arah keusahawanan teknologi.

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LIST OF SYMBOLS AND ABBREVIATIONS

IoT	:	Internet of Things
DHT22	:	Temperature and humidity sensor
LCD	:	Liquid crystal display
LM35	:	Linear model 35
COM	:	Relay common terminal
NO	:	Relay normally open terminal
NC	:	Relay normally closed terminal

CHAPTER 1

INTRODUCTION

1.1 Background

Gray oyster mushrooms, also known as Pleurotus Ostreatus or tree oyster mushrooms as Figure 1.1 shown are a type of edible mushroom that belongs to the Pleurotus genus [1]. They are native to North America and are commonly found growing on trees or logs in the wild. Gray oyster mushrooms have a gray or brownish-gray cap that is typically 3-10 inches in diameter [2]. The flesh of the mushroom is white or pale grey and has a smooth, meaty texture. In 1960, the mushroom industry began to expand rapidly [3]. Asian countries pioneered this industry. For example, China is the world's largest producer of mushrooms, but 95% of its output is destined for domestic consumption [4]. The global market demand for fresh, dried, and processed mushrooms is increasing year after year, owing to their high potential in the development of pharmaceutical, nutraceutical, cosmeceutical, and other downstream industries [5].

Figure 1.1 Pleurotus Ostreatus [6]

Currently, this cultivation activity is growing and thriving due to high demand in the Malaysian market. The government recognizes the mushroom industry to have the potential to be developed as demand is increasing in tandem with the increase in population and consumption [7]. The consumption of mushrooms is expected to increase from 1.0 kg in 2008 to 2.4 kg in 2020 per capita [8]. In 2008, there were 648 mushroom entrepreneurs in Peninsular Malaysia [9]. The demand for gray oyster mushrooms is increasing but in Malaysia, the number of cultivators and production is decreasing. This is due to the inconsistent environmental conditions with the high temperature of 32–35 °C and low humidity of 60%–70% [10]. The higher demand for mushroom cultivation is an opportunity for entrepreneurs in Malaysia.

Gray oyster mushrooms are a popular choice for cultivation because they are easy to grow and have a fast growth rate. It can be grown on a variety of substrates, including straw, sawdust, and wood chips, and is often used in commercial mushroom production [11]. In addition to their use as a food source, gray oyster mushrooms have also been shown to have medicinal properties and are sometimes used in traditional medicine.

The basic requirements for mushroom growth are a temperature of less than 30 degrees Celsius, relative humidity, carbon dioxide (CO2), light, and adequate airflow in the mushroom house [12]. The unpredictable Malaysia climate makes it difficult for the gray oyster mushroom to grow healthily and the employee of the company can only check the temperature manually or set the timer for the water to spray to lower the temperature below 30 degrees Celsius for the mushroom to grow but ineffectively in term of workforce and bills [13].

1.2 Problem Statement

Several issues have been identified as a result of the manual and semi-automated monitoring system to control the temperature and humidity in the mushroom house [14], [15]. For example, the workers find it difficult to control the temperature in the mushroom house, so regular monitoring is required to ensure the temperature is always at an appropriate level [16]. In addition, all of the workers have off day on Sunday which means there are no workers to take care of the gray oyster mushroom on that day [17]. This will lead to the risk which the gray oyster mushroom being damaged caused of overheating. In addition, if the temperature in the mushroom house exceeds the temperature suitable for mushroom cultivation, the workers need to manually reduce the temperature by spraying water on the floor, walls, and even blocks of wood [18]. This will cause the wastage of water in addition to the risk of disease and insect attacks due to mushroom houses in damp conditions [19].

Also, mushroom yields become of poor quality, small in size, and the weight of mushrooms becomes light due to the negligence of the operator to manually control the temperature of the mushroom house [20]. In addition, the manual and semi-automated monitoring system is not able to analyze the performance of gray oyster mushrooms since there is no IoT platform involved [21]. Both existing monitoring systems are not able to monitor remotely, which still needs the workers to monitor [22]. The workers in the mushroom farm are also not able to calculate the utility usage since no data is being analyzed in the mushroom house [23]. Hence, the implementation of an automated system with IoT monitoring is needed to improve the performance production of gray oyster mushrooms.

1.3 Project Objective

The project objectives are basically the actions that are taken in order to achieve the aim that intends the betterment of the problem statement: -

i. To develop an automated monitoring control temperature system for gray oyster mushroom.

ii. To analyze the performance production of gray oyster mushrooms.

1.4 Project Scope

This project was primarily concerned with determining the components and materials. This section will cover the process of determining the components and materials that will be used to complete this project. A checklist is prepared for needed materials and items needed for this project prototype. Nevertheless, the job scope for this project has four parts. The first part is coding, the second part is circuit design and hardware, the third part is the installation, and the last part is analysis. Firstly, for coding, the Arduino IDE software is used to interface project coding with the flowchart and coding references design coding to execute all the digital and analog pins of the Arduino and ESP8266-01. Secondly, Proteus is used to draw circuit designs with Arduino, ESP8266-01, sensors, and other component devices. The hardware part interfaces the software coding with the built circuit. Third, the installation needs to consider the length and type of the pipe and wire needed to be used. The project hardware circuit is placed in a cover casing box to keep things tidy and portable. Lastly, the analysis result obtained from the project to analyze the performance production of gray oyster mushrooms. The sensors detect and control the temperature and humidity by using the DHT22 and send data to Arduino to run the system automatically when the temperature exceeds 30˚C by spraying or misting. The LCD is interfacing with Arduino and ESP8266-01 sends data to Blynk to display the reading of the temperature and humidity of the mushroom house. Once the project hardware has been thoroughly tested, then install it in the mushroom house in the company.

1.5 Thesis Outline

This thesis has a total of five chapters including an introduction, background study, methodology, results and discussion, and conclusion and future works. This project presents the introduction of temperature control becoming an important task in many automated operations. There are sensors used for detecting temperature. The problem statement, objectives, and project scope will be explained in this section.

Chapter 2: Background study explains the overview of gray oyster mushrooms and all monitoring techniques for gray oyster mushrooms in the mushroom house. Besides that, it also considers the background study that was used as a reference in this project where the evaluation of gray oyster mushroom scheme is done in this section. The theory and literature review on existing projects is also discussed.

Chapter 3: Methodology describes the method used to complete this project to show excellent knowledge in engineering management with achievable timeframe and milestones and within the financial budget. In addition, the identification of the production process and development simulation framework on temperature & humidity monitoring in mushroom houses. Furthermore, validation on temperature & humidity monitoring and development of IoT platform. Besides that, the evaluation and analysis of the performance production of the automated gray oyster mushroom system also are explained.

Chapter 4: Results and discussion highlight the results obtained from this project such as gray oyster mushrooms production process, analysis simulation result by using software applications, validation of temperature & humidity monitoring by using hardware circuits, development monitoring system via IoT platform. Lastly, results obtained from evaluation and analysis of the performance of the automated gray oyster mushroom system by doing calculation to support the evidence.

Chapter 5: Conclusion and future works summarize the conducted project, mainly focusing on the gray oyster mushroom automated system with IoT monitoring. Finally, recommendations to advance, future works can be done on this area, and achievement objectives from this project are discussed.

CHAPTER 2

BACKGROUND STUDY

2.1 Introduction

The literature review briefly describes the type of mushroom where the mushroom involvement in human lives and production process of mushroom. Next, the theory research of the project gray oyster mushroom with manual, semi-automated and automated systems with IoT technique monitoring. The purpose of the project is to control the temperature and humidity of the gray oyster mushroom production house so that mushroom production can be increased.

2.2 Overview of gray oyster mushroom

The overview of gray oyster mushroom explains the role of the mushroom in human lives and its contribution to humans. The literature in this field shows that one of the edible mushrooms is gray oyster mushrooms. The production process and cultivation of the mushroom are also defined.

2.2.1 Type of mushroom

There are three major components which are edible, medicinal, and wild mushrooms in the global mushroom industry. Since 1978, the world production of cultivated, edible mushrooms has increased more than 30-fold [24]. China is the main producer of cultivated edible mushrooms. The are about 22% of the world's supply is *lentinus edodes* which now the world's leading cultivated edible mushroom [25], [26]. Next, there are 85% of the world's total supply is Lentinula and four other genera (*Pleurotus*, *Auricularia*, *Agaricus*, and *Flammulina*) account for cultivated edible mushrooms [27]. China became the world's largest producer of *Flammulina velutipes* at the beginning of 1997 as Figure 2.1 shown below [28]. The average consumer now enjoys about 5 kg of mushrooms per person each year [26]. Per capita consumption is expected to continue to increase due to consumers becoming more aware of the healthful benefits of incorporating mushrooms into their diet [29]. To determine their biological responses in humans, there is more research is needed on the bioactive components in mushrooms [30]. Hence, the gray oyster mushroom was selected for this research as Figure 2.2 shown below.

Figure 2.1 Flammulina Velutipes [31]

Figure 2.2 Gray Oyster Mushroom [32]

2.2.2 Production Process

The mushroom substrate needs to be prepared using a mixture of sawdust (wood dust), with a ratio of 100 rice bran: 10 calcium carbonates :1 water [33]. The water will be the final substance to be added to the mixture so that it is easier to achieve the desired texture. Next, the wet substrate will be filled into polypropylene bags as Figure 2.3 shown and each of the bags will be tied up into cylindrical shape and sealed with cotton stuffed caps. The substrate in the bag needs to be incubated at 28-30°C in a mushroom house which is relatively dark compared to the usual room with 5% light [34]. Water needs to be regularly sprayed into the surroundings or on the floor of the incubation area to increase the humidity level [35]. The optimum condition for gray oyster mushrooms to grow is the surrounding temperature in the range of 28-30°C and humidity of 80 to 90% [36]. After the incubating process, the gray oyster mushroom will grow and be ready to be harvested.

Figure 2.3 Polypropylene Bags

2.3 Monitoring techniques for gray oyster mushroom

The monitoring techniques for gray oyster mushrooms in the mushroom farm have 3 techniques which are manual technique monitoring where there is human intervention, semi-automated technique monitoring with half of the automated technique and half of the human intervention, and automated monitoring technique where there is no human intervention and fully automated.

2.3.1 Manual technique monitoring

Sinar Syukrawie Enterprise is a gray oyster mushroom company that is currently located at Lot 762, Jalan Gadek Ampang BT. Gadek, Alor Gajah, Melaka as Figure 2.4 shown. A survey has been done in Sinar Syukrawie Enterprise and found that the company has 6 houses. The size of each house is 40'foot length, 20'foot. In the mushroom cultivation house, air ventilation is vital because carbon dioxide will be released from the gray oyster mushroom as a result of the respiration process. A high percentage of carbon dioxide will reduce productivity and the shape of the mushroom. If the mushroom cultivation house has low air ventilation, the carbon dioxide level will be high which will cause the mushroom to be distorted, small and low in productivity [37]. Hence, a solution has been devised where the mushroom cultivation house used a greenhouse mushroom planting net to make the wall of the house instead of using brick [38]. This will ensure good airflow in the mushroom house.

Figure 2.4 Sinar Syukrawie Enterprise

The manual technique monitoring involved human intervention in regulating and maintaining the temperature environment by manually spraying the water. The workers need to regularly monitor the temperature in the mushroom house. The workers control the temperature by pouring water using the bucket. There are 3 sessions per day and 5 buckets per session. The manual monitoring technique was used on the mushroom house as Figure 2.5 shows [39]. The goal is to create a balanced and consistent temperature environment that enables the growth of gray oyster mushrooms without creating conditions conducive to mold or bacterial growth. The advantage of manual technique monitoring is the ability to adapt to the immediate environment. The workers can respond immediately to environmental changes, providing flexibility in controlling misting. Lastly, a lower initial setup with less technical setup is needed compared to automated systems.

Figure 2.5 Manual monitoring technique

2.3.2 Semi-automated technique monitoring

A semi-automated system is used in Sinar Syukrawie Enterprise where it can only turn on the mist using the timer. The timer will trigger the mist system to turn on for 10 minutes each hour to ensure the surrounding temperature will decrease and the surrounding humidity increase. The real-time temperature will be displayed on the LCD on the cover box. The system operates 24 hours per day and 7 days per week based on a timer or scheduling mechanism. This timer triggers the misting system to be active at regular intervals. At every 1-hour interval, the system initiates the misting system for 10 minutes and this activation occurs automatically based on the programmed schedule. During the 10-minute misting period, the surrounding temperature will drop.

Between misting periods, the system remains inactive for the remaining 50 minutes of the 1-hour interval. While the misting system is off, there is the possibility that the temperature will rise to a level that will bring damage to the mushroom. In other meaning, if the temperature is still high, the workers must spray the mushroom house manually to control the mushroom house temperature. So, this is called semi-automated technique monitoring because half of the automated technique and half of the human intervention. The semi-automated system implemented is working partially effectively because it uses a lot of water causing the wastage of water and the high utility bill. This is because the system operates 24 hours per day and 7 days per week which means it also operates at night when the temperature is low. Figure 2.6 below shows the example of a timer used in the semi-automated technique monitoring [40].

Figure 2.6 Timer used in the semi-automated technique monitoring.

2.3.3 Automated technique monitoring

Current technological developments enable the maintenance of oyster mushroom cultivation. The automated technique monitoring is without human intervention and acts as an independent system. With automated temperature control, it can facilitate the treatment of mushrooms. In realizing the simulation of creation, the temperature and humidity automated system consists of the DHT22 temperature and humidity sensor units, LCD, and Arduino Uno as the processors which are then combined into a system [41]. The software part is designed to use C language in Arduino IDE as the programming language to regulate the temperature and humidity based on Arduino Uno. The DHT22 temperature and humidity sensor circuit acts as the input, Arduino Uno is the processing, and misting is the output. The advantage of this automated technique monitoring is the workers do not always have to manually spray water in the mushroom house [42].

When the temperature reaches the limit that is being set the misting system will be activated to control the temperature. The misting system turns off when the temperature is below the limit temperature being set in the program. After that, the IoT platform monitors the temperature and humidity of the mushroom house by using the ESP8266-01 Wi-Fi module. With the IoT platform, it enables workers to monitor from anywhere with internet access. This remote capability provides convenience and flexibility in managing operations. IoT also can predict when the equipment fails or is damaged. It allows the company to schedule maintenance before it causes a breakdown, eventually saving companies money [43]. In addition, IoT also enhanced safety because there is no human intervention in the automated technique monitoring. IoT can minimize potential accidents or risks such as slippery floor water in manual technique monitoring during the pouring water session [44].

2.4 Evaluation of gray oyster mushroom monitoring scheme

Temperature control becomes an important task in many automatic operations. In existing literature, many research papers are on temperature control with some of them using Arduino and some of it not for automatic control of temperature, especially for monitoring applications. Several research papers are studied and important contributions are presented here.

M. K. I. Noraziz et al. presented a case study of the temperature and humidity control in a refrigerator using Arduino UNO with IoT to maintain food quality. It stated that the output 12V fan turned on when the temperature detected was 27°C and turned off when below 27°C. The author mentions that the fan can control the temperature but is slow in terms of speed to decrease the temperature compared to irrigation, misting, or sprinkler systems [45]. Gurmu M. Debele et al. designed an automatic room temperature control system using Arduino UNO and DHT11 sensor. The output is the fan's speed which is controlled and monitored according to the number of duty cycles and Pulse Width Modulation (PWM). There are 0%, 25%, 50%, 75% and 100% duty cycles. Its corresponding fan speed is zero, slow, medium, fast, and very fast. This project is more efficient compared to [45] but becomes more complex because of the adjustment of fan speed [46].

K. Srujan Raju and Frederick Ojiemhende Ehiagwina et al. proposed a temperature control system using LM35 which has larger temperature range than DHT11 and DHT22 sensors. The LM35 is only suitable to monitor on LCD because the sensor is too sensitive. The LM35 is not suitable for data reading graphs because it's too hard to read. So, the author suggests DHT22 sensor for detecting temperature [47], [48]. Ms. R. Sujeetha and S. Kalairasi et al. designed an IoT system to monitor temperature and humidity by using DHT11. Both case studies proposed to use DHT22 to have better reading results [49], [50].

Mon Arjay Fernandez Mailborg presented the automatic misting control system for indoor gardens using Arduino UNO. The misting nozzle will turn on when the temperature is 35°C. Each of the plants has their suitable temperature which depends on the type of the plant. The author suggests using the DHT22 to increase the temperature range for better reading [51]. Muhammad Amiruddin Kamaruddin et al. present the development of the Blynk IoT platform weather information monitoring system by using an OLED display module as output. The author states that OLED display screens need to be covered because they are easily damaged by sunlight and water since it susceptible to water. The OLED display is expensive and short lifespan compared to LCD [52].

Adam Samsudin and Mochammad Haldi Widianto et al. designed the Blynk IoT monitoring system by using NodeMCU ESP8266 and WEMOS ESP32. The author states that both Wi-Fi modules can be used for monitoring systems but the device functions and specs have more than they needed since Arduino UNO was also used in the project. The component pin can be connected to Arduino UNO to reduce space. At the recommendation of the study case, both Wi-Fi modules can be replaced with ESP8266-01 which is smaller and cheaper [53], [54]. Ti-An Chen et al. presented an intelligent programmable IoT controller for emerging industry applications. The purpose of the project is to calculate and collect the time to set the timer to prevent sensor abnormalities such as water overflowing from the bucket of water if added to the bucket for too long [55].

Atilla et al. presented the design of a heating system controlled by Arduino, has studied the technology, software, and hardware used in the heating system which consists of an isolated box, dry resistance, voltage regulator, thermocouple, air fan, microcontroller and computer. Proportional Integral Derivative (PID), neural network, and fuzzy logic are mainly used for the temperature control of heating systems. The system uses a PID controller and exhibits satisfactory value of stability, good reliability, and sensitivity. Microcontroller-based temperature control was designed by comparing theoretical values of temperature. However, Arduino control and implementation was not done [56].

Wayan Widhiada et al. designed the temperature distribution control for baby incubator applications. In this system, it is very important to maintain a certain temperature inside the room to take care of the proper health of a baby. Humidity was also included in the study of an experiment using microcontroller-based system for temperature measurement and control. This proved to be a very important application for baby care and health [57]. In Europe, the EC Council and Parliament are proposing to designate food organizations to comply with temperature and humidity regulation standards and microbiological guidelines specific to food products, as well as cold chain management standards. The rule builds up the importance of monitoring temperatures and humidity and bonafide operation of refrigeration equipment with regards to this last element, considering that regular temperature reading can be a significant strategy for managing the cold chain in retail establishments by using cooling fan when food is hot and heater when food was cold. However, studies have shown that this strategy is unable to ensure compliance with perishable food safety requirements [58].

Abdullah Alhamdan et al. proposed that to prevent food waste, factors that cause the food to get spoiled and rotten should be observed. These factors include temperature, humidity or dryness. Especially in food stores, the need to have a food quality checking device is very much needed. The device is needed to examine the factors that cause the food to get rotten. Then, the variables can be controlled such as by refrigeration, vacuum storage, and many others [59]. Courier Newspaper proposed that there are companies specializing in refrigerator equipment temperature and humidity control states that are suitable for all food by 30°C - 40°C temperature and 65% humidity, but the equipment has the drawback of being expensive and does not offer the prospect of going effectively [60].

Nagendra Dangi et al. presented a design of an Arduino UNO-based temperature sensor to monitor environment parameters which are used to measure temperature and humidity level. The sensor used was DHT11 and the output was LCD [61].

Meream El-Rubaiy et al. proposed the design and development of a remote-controlled temperature monitoring system using Arduino UNO. The LM35 was used for reading the temperature surrounding it. When the temperature was below 30°C the blue LED turned on, at 30°C - 60°C the green LED turned on and above 60°C the red LED turned on. The Arduino serial monitor in the Arduino IDE was used for output to monitor temperature [62].

Norhidayah binti Masstor presented a case study for alarm systems based on sensing temperature and humidity by using Arduino UNO. The LM35 was used in this project because the sensitivity is higher than DHT11 and DHT22. The alarm (buzzer) will turn on when the surrounding temperature reaches a certain degree Celsius to indicate there is fire in that place. The temperature is also monitored in the Web Temperature Monitoring System. The author mentions that Arduino-controlled GSM/GPRS module was suggested but temperature measurement was not accurate in the system as [47], [48] mentions that LM35 is too sensitive to monitor [63]. P. Singhala et al. studied a fuzzy-based temperature control system by using LM35 that was completely simulation-based and no hardware implementation was achieved. The output was a fan, heater, and LCD. The system suggested was very simple and effective, but hardware implementation and realization remain as future scope of the work [64].

2.5 Summary

The author K. Srujan Raju and Mon Arjay F. Malbog, both present the automatic temperature control by using Arduino UNO as a microcontroller and the inputs are LM35 and DHT11 respectively in Table 2.1. Both research papers suggest that DHT22 temperature sensors are most suitable for detecting the surrounding temperature. M.K.I Noraziz mentioned in his case study that the 12V fan is not effective in terms of controlling temperature compared to irrigation, misting, or sprinkler systems. Next, the author Muhammad Amiruddin suggests the suitable output is LCD since the LCD has a longer lifespan compared to OLED and the price of LCD is lower than OLED. After that, Adam Samsudin stated that the NodeMCU ESP8266 Wi-Fi module had more than they needed to monitor their data since Arduino UNO was used as a microcontroller in their research. The author suggests that the Wi-Fi module can be switched to ESP8266-01 since it's smaller, cheaper, and able to reduce space where the components pins can be connected to Arduino UNO.

Next, some mushroom houses on the farm don't have semi-automated systems that use timers. The workers must manually control the temperature inside the mushroom house by spraying the water surrounding it. Both manual and semi-automated technique monitoring was not an effective way to control the temperature. An improvement is needed to reduce the wastage of the automated system, so a temperature sensor is added to the automation system so that the mist system will be turned on when the temperature is high. The IoT also needs to be added to let the workers monitor the live situation of the mushroom house and the duration of the system turns on. This will improve the performance production of the gray oyster mushroom.

Table 2.1 Summary of the monitoring scheme

Ref	Author	Title	Micro-controller	IoT Wi-Fi Module	Sensor	Output
[48]	K. Srujan Raju (2020)	Automatic Temperature Control System Using Arduino	Arduino UNO	Not available	LM35	12V fan
[51]	Mon Arjay F. Malbog (2020)	Mistmatic: Automatic Misting Control System for Indoor Garden with Rule-Based Approach	Arduino UNO	Not available	DHT11	Misting nozzle
[45]	M.K.I Noraziz (2021)	Automatic Room Temperature and Humidity Control In A Refrigerator Using Arduino UNO	Arduino UNO	ESP8266-01	DHT11	12V fan
[52]	Muhammad Amiruddin (2022)	Development of Blynk IoT Platform Weather Information Monitoring System	Arduino UNO	ESP8266 NodeMCU	DHT11	OLED display module
[53]	Adam Samsudin (2022)	Development of IoT Smart Power Meter Using Blynk Application	Arduino UNO	ESP8266 NodeMCU	ACS 712 Current sensor	I2C LCD

CHAPTER 3

METHODOLOGY

3.1 Introduction

Agriculture is one of the most common sources of economic growth in Malaysia even in Melaka itself. The student is required to help those in need with new ideas and solutions for problems and issues that are being raised. One of the common and largest scopes being claimed is controlling and monitoring systems. A few research were conducted including reading articles, journals, and any published materials. The brainstorming session was done by students to provide ideas or solutions [65]. Then the component has been determined for this project and the project is constructed using Proteus 8 Professional software for simulation where the component is added and excluded to ensure the project can run smoothly. After that, C++ codes that were obtained by exploring the internet were modified and compiled together to suit the project.

The project was installed in the field experiment to obtain temperature data in the mushroom house for the cultivation of gray oyster mushroom. After that, the data obtained in Blynk application is analyzed and compared to determine the performance of the production mushroom in the mushroom farm. The comparison is to determine whether the automated system can improve mushroom production.

3.2 Methodology flowchart gray oyster mushroom automated system with IoT monitoring.

The flowchart from Figure 3.1 shows the full process project flow. The first step is the identification of the production process for gray oyster mushroom were knowing the mixture material, duration steam, and harvest time. The research is to acknowledge the parameters involved in the mushroom cultivation process. To build a project, the circuit design of the project and implementation codes must be done. In the meantime, the component was decided to be used in the project and started to gather all the equipment needed to complete this project. After the project has been successfully run in simulation, assemble the hardware of the project. Followed by a few tests to validate the DHT22 sensor. Next, develop the IoT platform to monitor the temperature, then the project ready to be implemented inside the mushroom house. The data can be started to collect for 30 days once the hardware being implemented. Then the data was analyzed to make the comparison between manual system, semi-automated system, and automated system. Lastly, made up a conclusion on the experiment conducted.

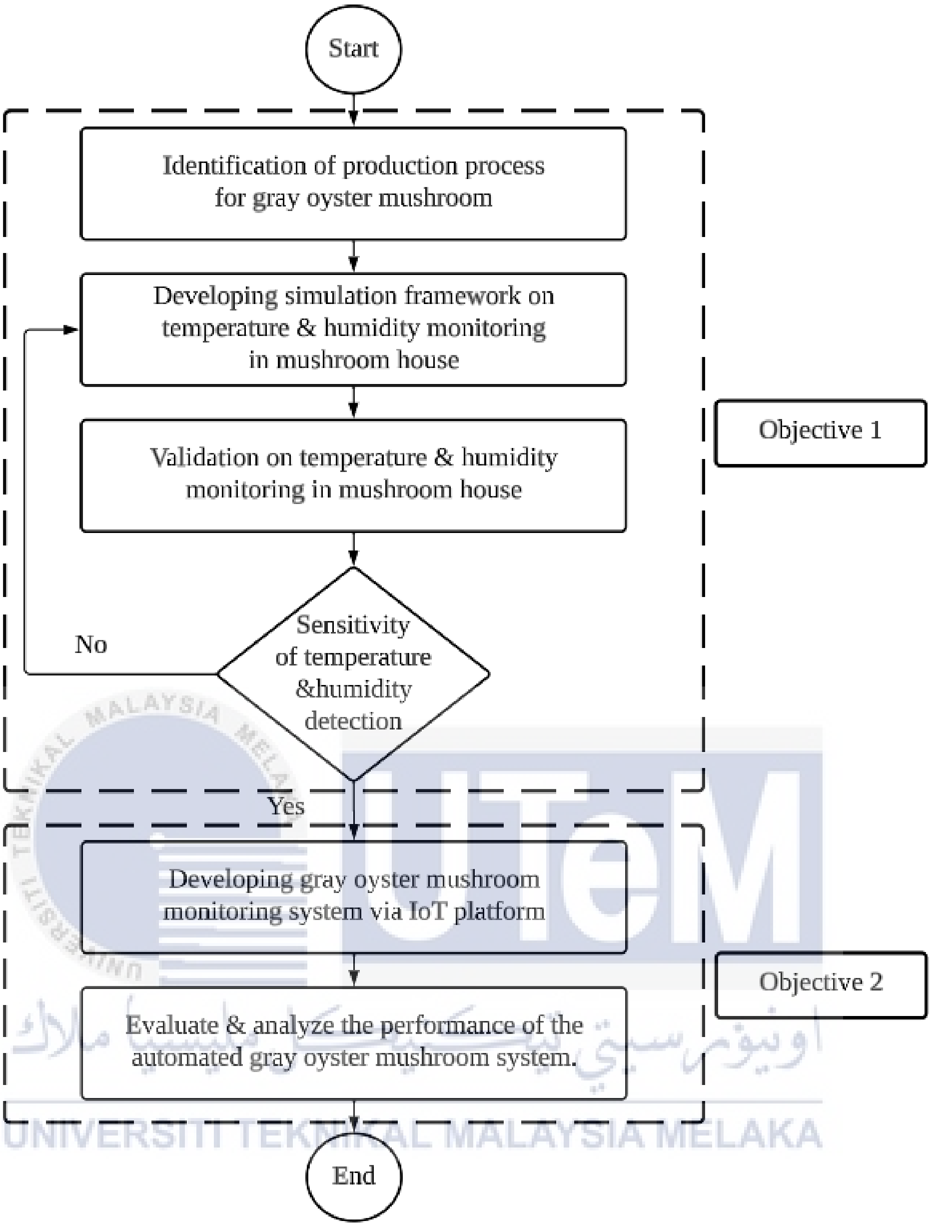


Figure 3.1 Methodology flowchart for full project

3.3 Identification of production process for gray oyster mushroom

The first step to this project is to identify and understand the production process for gray oyster mushroom. The substrate is the mixture of rubber sawdust, bran, chalk, and water that act as the base for gray oyster mushroom cultivation with ratio 100kg : 10kg : 1kg : 70L respectively. After the substrate is uniform, package the substrate into the mushroom bag, then apply the cap to each of the mushroom bags to prevent mixture spill and to enable the mushroom to grow through the lid. Furthermore, the mushroom chunks are steamed for 10 hours to disinfect bacteria inside the mushroom chunks. After steam processing, open the cap to insert the gray oyster mushroom and close the cap again. Then, the mushroom chunks are put on the prepared shelf for 45 days to let the chunks mature. After the mushroom chunks were 100% matured, the gray oyster mushroom was ready to be harvested. The flowchart of the production process gray oyster mushroom is shown in Figure 3.2 below.

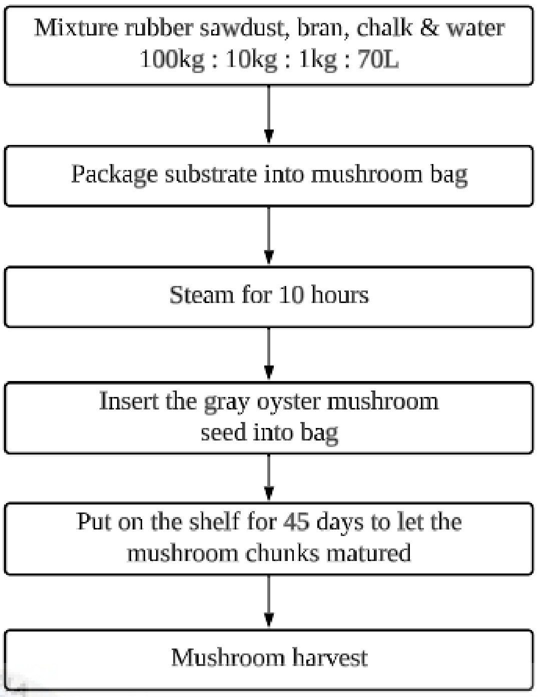


Figure 3.2 Production process for gray oyster mushrooms

3.4 Developing simulation framework on temperature & humidity monitoring in mushroom house

After a few research on involved components such as the DHT22 temperature & humidity sensor [47], [48] and LCD 16x2, the next progress is the designation of the circuit. The Proteus 8 Professional software is used in this project for circuit design. Some of the components used in the project are not available in the Proteus software. Therefore, to solve this problem is download the library of components from online such as OneWire.g, DallasTemperature, TheEngineeringProjects and LiquidCrystal.h. The library is downloaded in GitHub where it was the place of 25 obtaining electronic component libraries. After the project build is complete the C++ code is programmed.

The microcontroller used in the project is Arduino UNO R3 and the codes are developed in Arduino IDE software. There are two DHT22 sensors used which are connected in the Arduino ports 9 & 10. Both of the sensors can detect the temperature and humidity of the surrounding area. Next, build a simulation framework that enables data display from the sensors and user-friendly interface presentation. The temperature values from each sensor will be shown on the interface, which will be created using Arduino software. The temperature and humidity data from both of the sensors is passed the data every second to Arduino and displayed on the LCD (Liquid Crystal Display). The transistor BC547 is used as current amplification and the diode 1N4001 is to ensure the current flow in one direction, which is from GND to VCC.

When both of the sensor temperatures ≤ 30°C, the LED A2 Relay Off indicator turns on, the LED A3 Relay On indicator and LED A1 Mist indicator turn off. The relay is connected to NC (Normally Connected) where there is no circuit and therefore doesn't have any output. When one or both of the sensor temperatures ≥ 30°C, the LED A2 Relay Off Indicator turns off, LED A3 Relay On indicator and the LED A1 Mist indicator turn on. The relay is connected to NO (Normally Open) and turns on the DC 5V Solenoid Valve (LED D6 is used as a substitution in Proteus). Then, the circuit is ready to implement in hardware. The flow of the project software is shown in Figure 3.3. After a few tests were carried out, the software showed a promising result, so the project proceeded by assembling the hardware component which it concluded at the next subtopic.

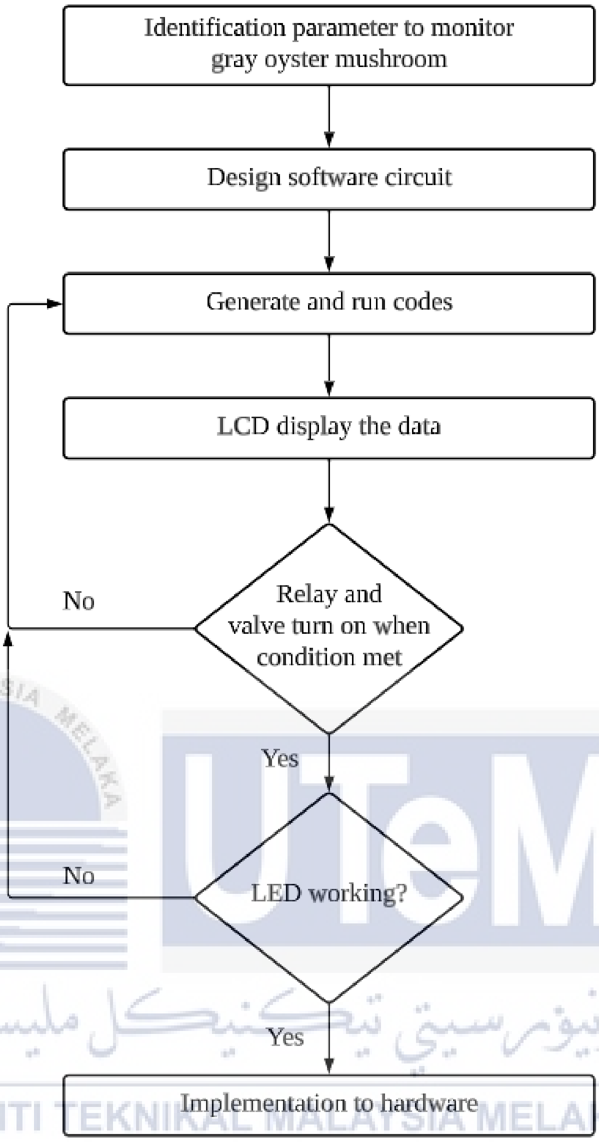


Figure 3.3 Flowchart simulation framework

3.5 Validation on temperature & humidity monitoring in mushroom house

The construction of the hardware of the project is shown in Figure 3.4. Most of the components used in the project are gathered from FTKEK Laboratory and FTKEK Store Component. Some of the components that cannot be obtained from FTKEK need to be bought from Shopee such as Valve 12V and DC Step Down Converter 12V to 5V. The circuit is assembled according to the software circuit design.

The system initializes by counting five seconds delay decrement to indicate the system will start after five seconds. Next, both DHT22 sensors started detecting the temperature and humidity surrounding the area. Then, the LCD 16x2 displayed the data temperature and humidity from sensors with T1, T2, H1, and H2. The brightness of the LCD is controlled by a potentiometer which helps enhance the quality of the LCD.

When both sensors' temperatures ≤ 30°C, the LED A2 Relay Off Indicator turns on, the LED A3 Relay On indicator and the LED A1 Mist indicator turn off, relay and mist turn off. The sensors continued to detect temperature & humidity surrounding them. This process is called Standby Mode. When one or both sensor temperatures are≥ 30°C, the LED A2 Relay Off indicator turns off, the LED A3 Relay On indicator and LED A1 Mist indicator turn on, relay and mist also turn on. This will cause the surrounding temperature to drop. The sensors continued to detect the temperature & humidity surrounding them. This process is called Misting Mode.

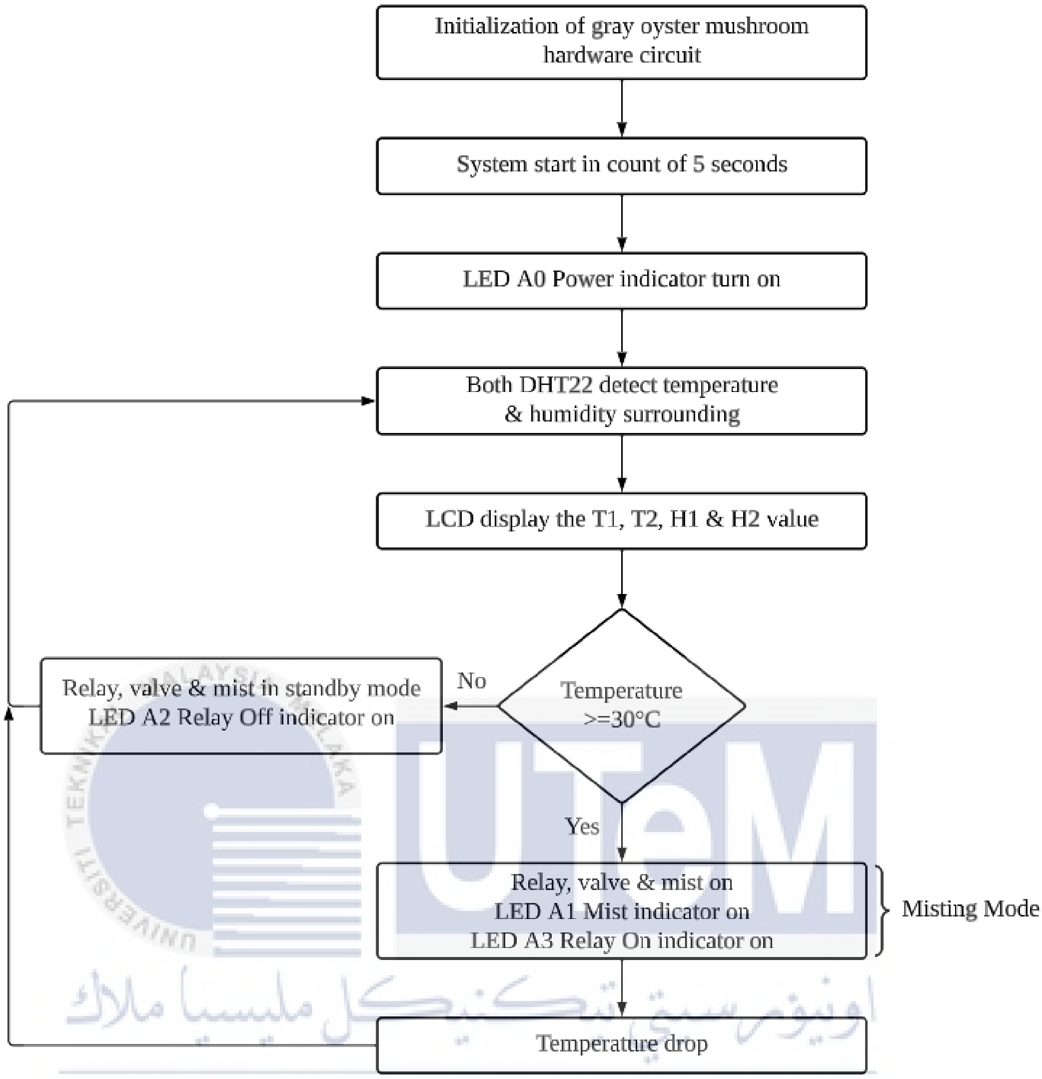


Figure 3.4 Flowchart validation project

3.6 Developing gray oyster mushroom monitoring system via IoT platform

The development of the IoT Platform flowchart is shown in Figure 3.5. After some research on determining the monitoring parameters via IoT Platform, the ESP8266-01 Wi-Fi module was decided to be used in the project [53], [54]. The LCD 16x2 was also swapped with I2C LCD to simplify the complexity of the hardware circuit. The Wi-Fi module TX and RX connected to Arduino ports 2 and 3 respectively. After that, the C++ codes were developed in the Arduino IDE to make the Arduino and ESP8266-01 communicate with each other.

The Blynk application is initiated with TEMPLATE_ID and AUTH_TOKEN which are automatically generated by the Blynk server used for recognition of devices in the Blynk Cloud. Then, connect to Wi-Fi network credentials with ssid[] and pass[]. After the devices are connected to the Blynk application, both DHT22 sensors begin to read the temperature and humidity. In the setup function, the serial communication is initialized for debugging purposes. The Blynk.begin() function is called to establish a connection with Auth Token and Wi-Fi credentials to the Blynk server. In the loop function, Blynk.run() is called to maintain communication with the Blynk server. Next, Blynk.virtualWrite() sends the obtained data from both sensors to the virtual pin in the Blynk application. The virtual pin is linked to virtualized data from ESP8266-01. After that, the real-time temperature and humidity data are displayed in the Blynk application. Then, the Blynk application saves the data to plot into the graph.

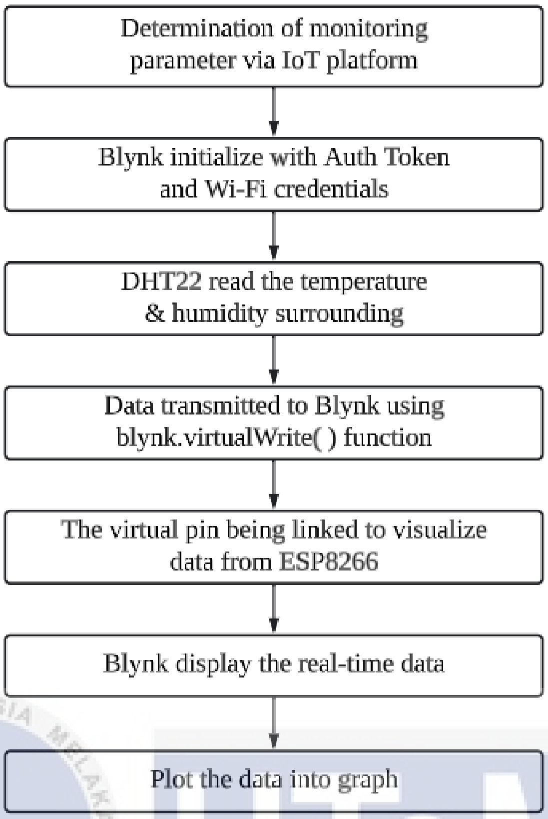


Figure 3.5 Flowchart development of IoT platform

3.7 Evaluate & analyze the performance of the automated gray oyster mushroom system.

The evaluation and analysis of the performance of automated gray oyster mushroom are shown in Figure 3.6. The installation of the project will be done at Sinar Syukrawie Enterprise mushroom house. To run an on-field project, permission is needed from the industries so that they are informed of the project implementation. The length of the required pipe and wire was calculated according to the location plan and the size of the mushroom house. Each length of the mushroom house is 40’ which will use 8 pieces with each misting nozzle spacing 5’ and 2 pieces misting nozzle for 20’ width with nozzle 7’ spacing [66]–[68]. The total misting nozzle that will be used for this project is 20 pieces (8+2+8+2).

The water pipe from the water pump at mushroom house was modified from two ways to three ways piping valve to create a new water flow to mushroom house. After the piping is done, the next step is the installation of the wiring of the system. All wires have been covered with uPVC Wire Cover (0.5 inches). Next, the Arduino is installed inside the cover box. All the connections such as the 12V Valve, DHT22 sensor, DC Step Down Converter 12V to 5V, AC to DC Adapter 12V, and I2C LCD are connected inside the Arduino cover box. The DHT22 temperature sensor was connected from the cover box to mushroom house ceiling by using 3 core wire.

After installation was done, the duration of collection data was 30 days to have better evaluation and analysis data. For the supporting evidence, the utility usage from all systems was calculated to have comparison between them. The temperature data collected was saved in the Blynk application and plotted into graph to summarize the result obtained. The graph result is analyzed for choosing which system is most suitable for mushroom performance.

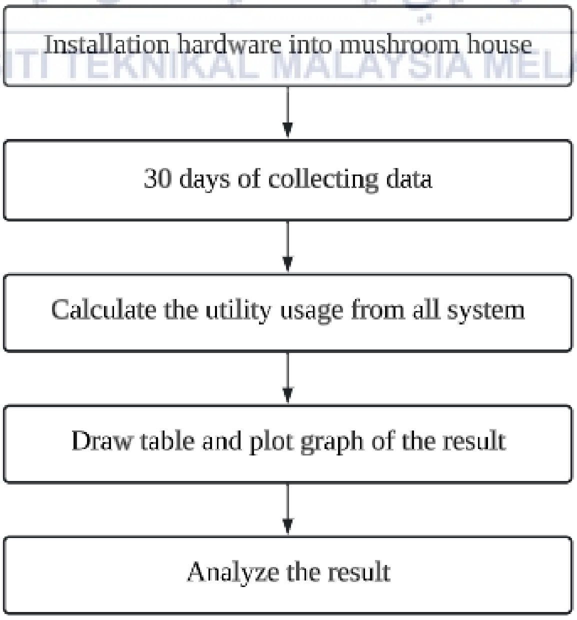


Figure 3.6 Flowchart evaluation and analysis of performance automated gray oyster mushroom system

3.8 Summary

This chapter outlines the process production of gray oyster mushroom, integrated circuit to misting mode, hardware configuration, and process developing IoT platform. To meet the project's objectives, it was completed using a chosen and appropriate mix of hardware and software. To obtain the desired result, the temperature of mushroom house was monitored for 30 days by using Blynk application. The utility usage of mushroom house was calculated from the data obtained in Blynk. The result from calculation is compared with the conventional method will prove the functionality.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

The results that were attained during the project's development will be covered in this chapter. Additionally, this project's performance will be described. This chapter contains all the data that is required to complete this project requirement. The aim must be supported by the data collected. It demonstrated that the project's goal could be met and aided in the comprehensive development of the application.

The project serves as the basis for the analysis. DHT22 senses surrounding temperature to determine the misting mode or standby mode for the system in the mushroom house. The Blynk IoT platform is developed to monitor the temperature and collect the data. The data is collected for evaluation and analysis of the performance of the automated gray oyster mushroom will be explained in this chapter.

4.2 Gray oyster mushroom production process

The mixture of the substrate is shown in Figure 4.1 and Figure 4.2 which contains rubber sawdust, bran, and chalk that act as a base for the substrate. According to workers in the company, water was added to increase the moisture level in the substrate to ensure that the substrate was not too dry. Water also enables root expansion by allowing the roots to easily penetrate the substrate for a mature process. The mixture ratio of rubber sawdust, bran, chalk, and water is 100kg, 10kg, 1kg, and 70L respectively.

(a) (b) (c)

Figure 4.1 Mixture substrate of gray oyster mushroom production process. (a) Rubber sawdust (b) Bran (c) Chalk

Figure 4.2 Mixture substrate machine

After the substrate was packed into the mushroom bag by the packaging machine as Figure 4.3 shows below, it was called mushroom chunk. According to workers in the company, the mushroom chunks were placed vertically into the metal basket and cap was put on top to seal the mushroom chunks from water entering during the steam process as Figure 4.4 shows below.

Figure 4.3 Packaging machine

Figure 4.4 The mushroom chunks were placed into metal basket and cap was put on top to seal the mushroom bag from water entry during steam process.

The metal basket that contains mushroom chunks is being moved into the steamer for the steam process as Figure 4.5 shows. The steam process takes 10 hours to complete to eliminate the bacteria inside the mushroom chunks. The steam process is essential since it can greatly increase the rate of growing mushrooms infected by bacteria during the mature period in 45 days.

Figure 4.5 The mushroom chunks were moved into the steamer and steamed for 10 hours.

After the steam process, the mushroom chunks are moved out from the steamer to let the temperature drop. After the mushroom chunks cooled down, the cap was opened and the gray oyster mushroom seed was inserted at the top (cap of mushroom chunks) of the mushroom chunks as Figure 4.6 shows. This process is letting the gray oyster mushroom grow mature by letting the root grow in the substrate inside the mushroom chunks.

(a) (b)

Figure 4.6 Insertion of mushroom seed on top of mushroom chunks after steam process. (a) Before insertion mushroom seed (b) After insertion mushroom seed.

After that, the mushroom chunk was put on the shelf for the maturing process as Figure 4.7 shows. In this process, the root slowly grows in the mushroom chunks until the root completely covers the mushroom chunks with white color. The white color indicates the percentage (%) of mushroom chunks matured. From the left 0%, 10%, 30%, 60%, and 100% mushrooms matured for 45 days matured process is shown in Figure 4.8.

Figure 4.7 The mushroom chunks are put on shelf to let them mature.

Figure 4.8 Process mushroom chunks matured percentages for 45 days.

The mushroom harvest frequency is shown in Table 4.1. There are total of 14 weeks in one cycle for mushroom harvest. In week 1 and week 2, the mushroom was harvested three times for each mushroom chunk. The weight of mushrooms harvested in week 1 and week 2 is 255g where each mushroom chunk is 85g. In week 3, the cap is closed to let the mushroom chunks rest. The purpose of letting the mushroom rest is to maintain the size of the mushroom harvested. The reason is each time the mushroom is harvested, the size of the mushroom will become smaller than the previous harvest period. To prevent that from happening, the mushroom chunks need to be rested for one week after being harvested two or three times in the harvest period. Next, the cap was opened and the mushroom was harvested twice in week 4. The weight of the mushroom harvested is 170g. After that, the process was repeated from week 5 until week 14 for the mushroom harvest and resting process.

Table 4.1 Mushroom harvest frequency.

Week(s)	Harvest Frequency (Per Chunk)	Weight Harvested (85g per chunk)
1,2	3	255
3	Cap closed	Cap closed
4	2	170
5	Cap closed	Cap closed
6	2	170
7	Cap closed	Cap closed
8	2	170
9	Cap closed	Cap closed
10	2	170
11	Cap closed	Cap closed
12	2	170
13	Cap closed	Cap closed
14	2	170

The specific date of the harvested mushroom and the cap closed is shown in Table 4.2. The dates of harvested mushroom in week 1 and week 2 is from 31st August till 10th September which takes 11 days for harvest. During these 11 days, the mushroom chunk was harvested on the 3rd, 6th, and 9th of September. The total harvested mushroom was 255g with 85g per chunk. Next, the cap closed from 10th September till 17th September for one week in week 2 for resting. Furthermore, the cap was opened from 17th September to 24th September for mushroom chunk harvest purposes. During these 7 days, the mushroom chunk was harvested on the 20th and 23rd of September. The total harvested mushroom was 170g with 85g per chunk. After that, the process was repeated from 24th September to 3rd December for the mushroom harvest and resting process.

Table 4.2 Date of harvested mushroom and the cap closed.

Cap Opened Date	1st Harvest	2nd Harvest	3rd Harvest	Cap Closed Date	Weight Harvest (85g per chunk)
31-08-23	03-09-23	06-09-23	09-09-23	10-09-23	255
17-09-23	20-09-23	23-09-23	[redacted]	24-09-23	170
01-10-23	04-10-23	07-10-23	[redacted]	08-10-23	170
15-10-23	18-10-23	21-10-23	[redacted]	22-10-23	170
29-10-23	01-11-23	04-11-23	[redacted]	05-11-23	170
12-11-23	15-11-23	18-11-23	[redacted]	19-11-23	170
26-11-23	29-11-23	02-12-23	[redacted]	03-12-23	170

The mushroom grows out through the cap after 45 days on the shelf for the mature process as shown in Figure 4.9 below. After the cap is opened, the mushroom will grow out through the cap within 3 days. The mushroom will reach the perfect size during these 3 days and is ready to harvest.

Figure 4.9 Mushrooms grow out through the cap after 45 days on the shelf.

4.3 Analysis simulation temperature and humidity result by using software applications.

The initialization of the simulation circuit in the Proteus 8 Professional application is shown in Figure 4.10. The microcontroller used in this project is Arduino UNO R3. The input is two DHT22 temperature and humidity sensors. The output is LCD 16x2, 12V valve, and 4 LED which is power on indicator (A0), mist system indicator (A1), off relay indicator (A2), and on relay indicator (A3). The valve is substituted with an LED-labeled valve indicator. The electronic components used are diode 1N4001, transistor BC547, and 5V relay. When the simulation is run, the LCDs the system start counting in 5 seconds and the LCD will display the data from both DHT22 sensors.

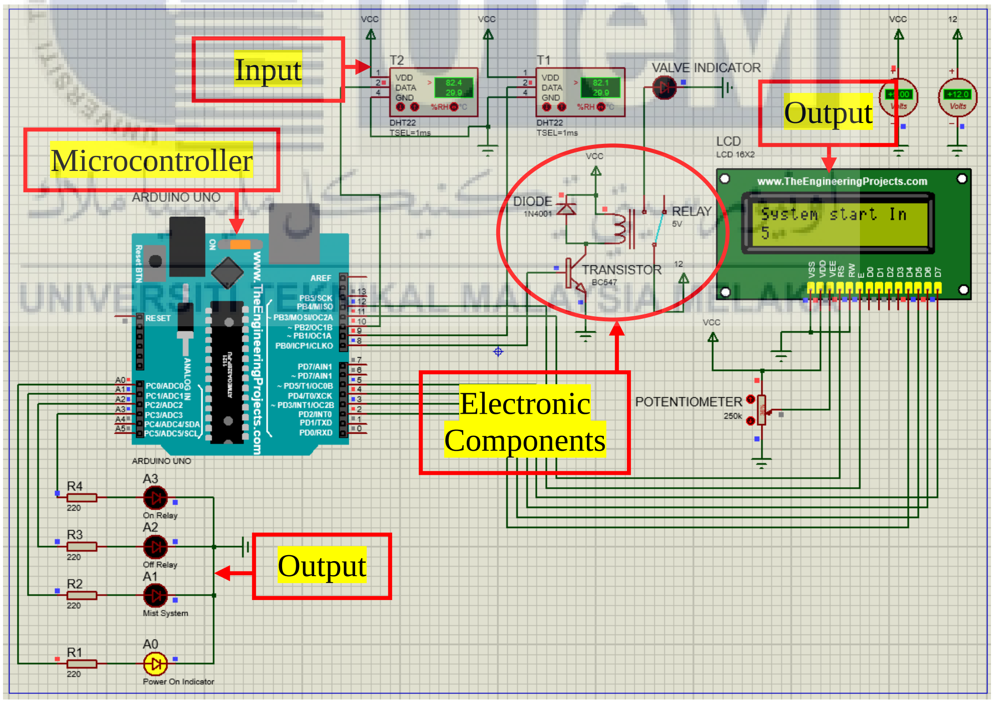


Figure 4.10 Initialization of simulation circuit.

The LCDs both DHT22 sensors T1 and T2 are below 30°C which is in standby mode in Figure 4.11. The standby mode is Arduino continues to read the data from both DHT22 sensors and execute it when the condition is met. The LED A2 is turned on, and the LED valve indicator and relay turn off where the relay COM terminal is connected to the NC terminal. The LED A0 keeps turning on to indicate power on.

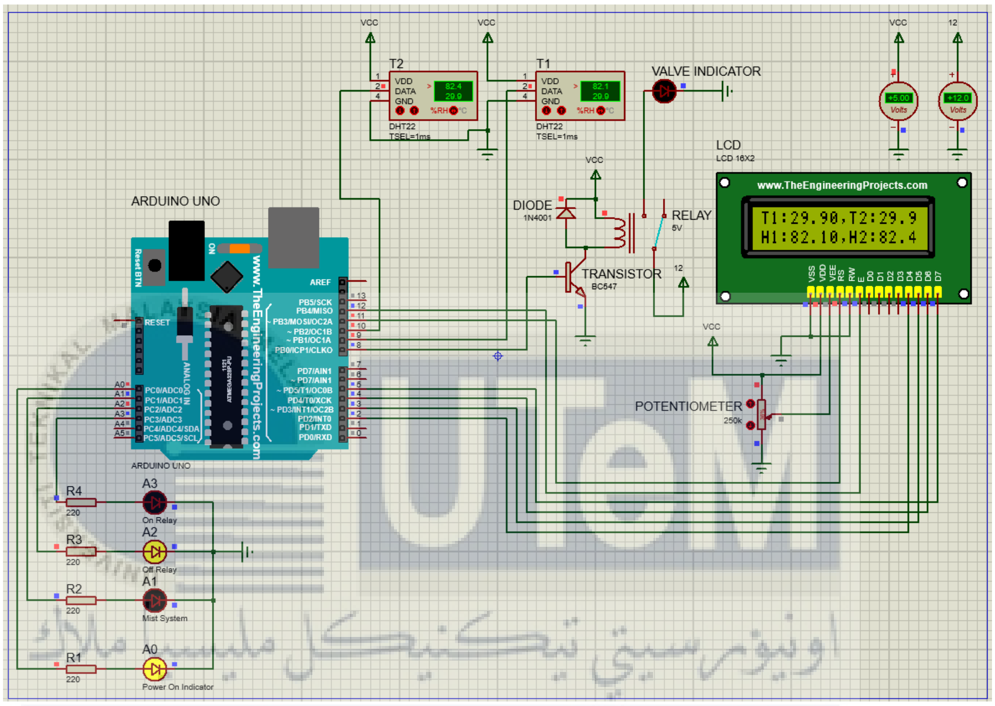


Figure 4.11 The LCD displays both sensors T1 and T2 below 30°C which are in standby mode.

The LCD displays the sensor T1 greater than 30°C and sensor T2 greater than 30°C in Figure 4.12 and Figure 4.13 respectively which triggers misting mode. The LCD displays both sensors T1 and T2 are greater than 30°C in Figure 4.14 which also triggers misting mode. When T1 and/or T2 are greater than 30°C, the Arduino will trigger the relay, LED valve indicator, LED A1, and A3 to turn on which indicates the misting mode. The relay also turns on where the relay COM terminal is connected to the NO terminal. The LED A0 keeps turn on to indicate power on.

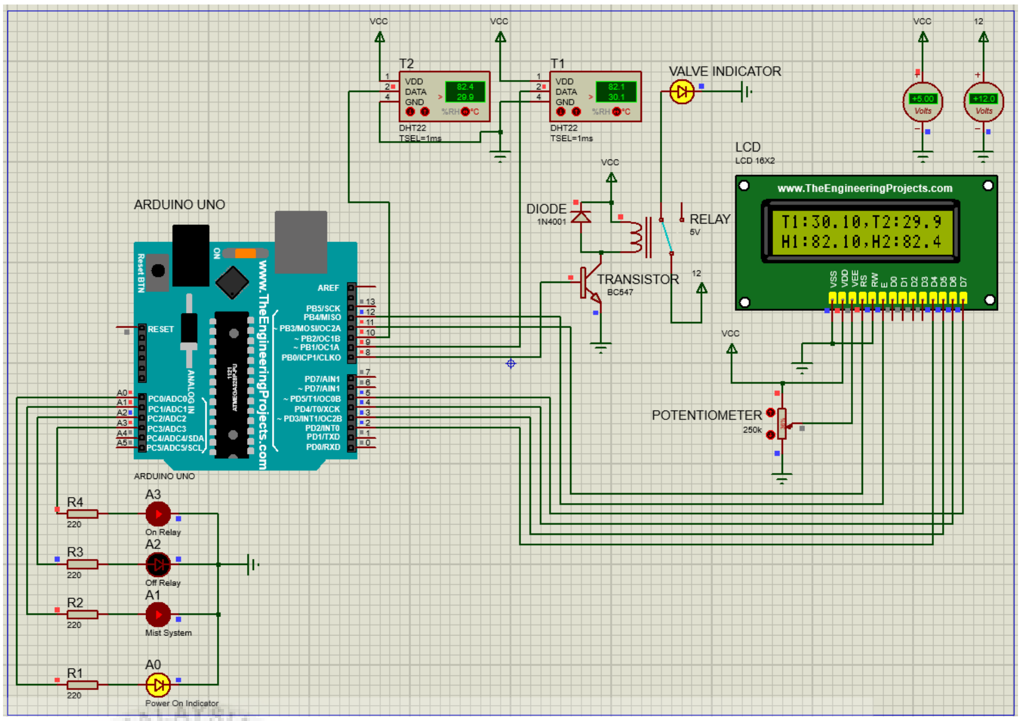


Figure 4.12 The LCD displays the sensor T1 is greater than 30°C which triggers misting mode.

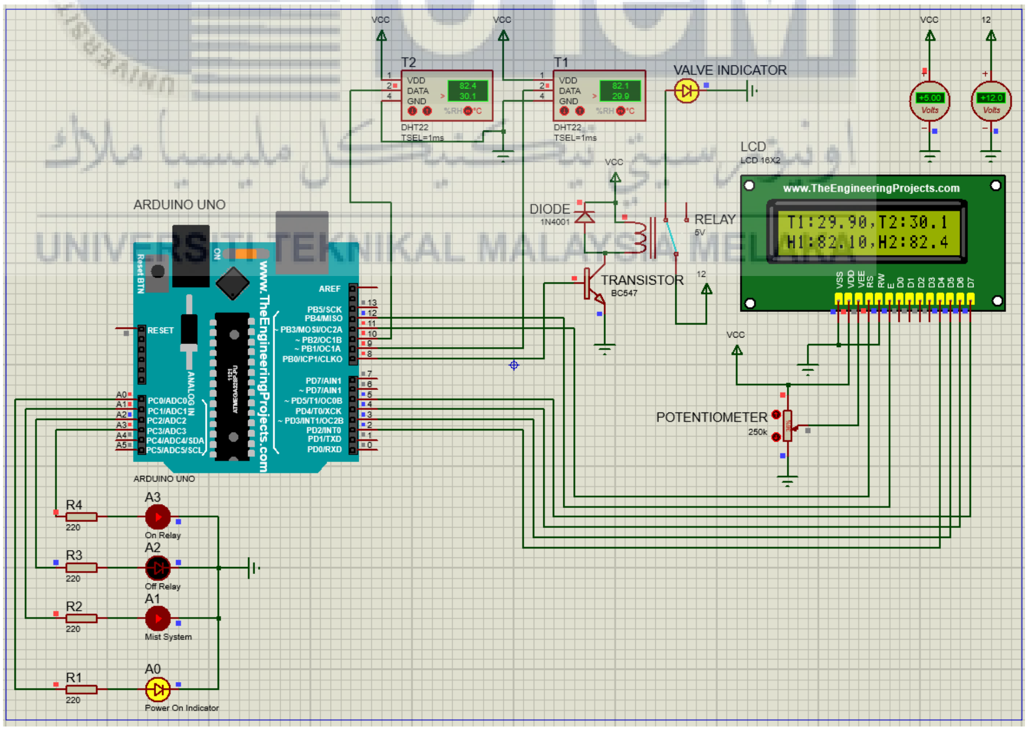


Figure 4.13 The LCD displays the sensor T2 is greater than 30°C which triggers misting mode.

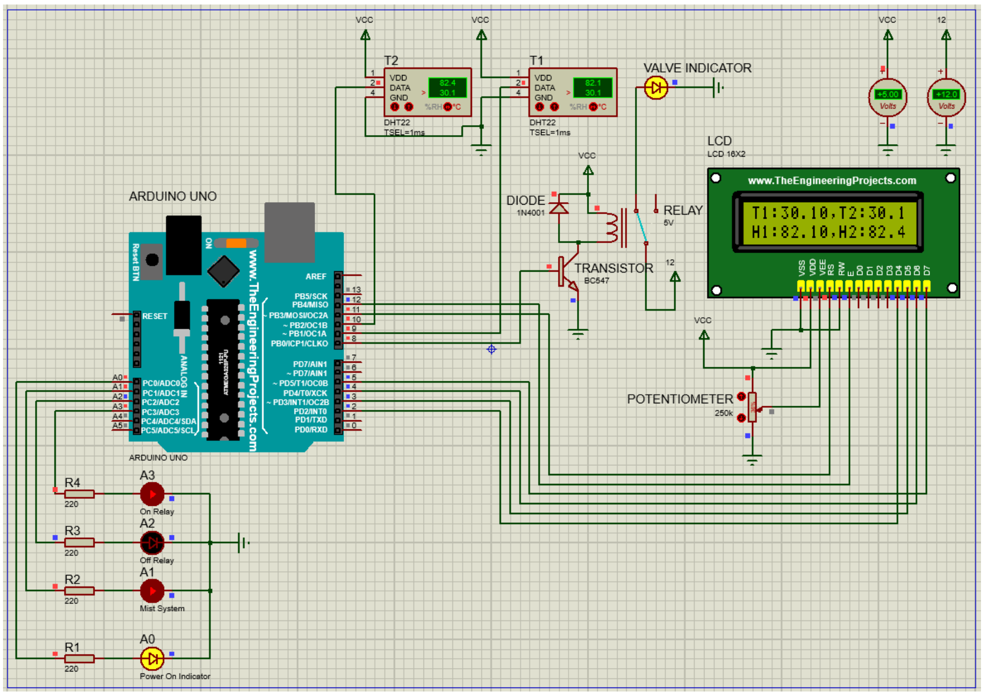


Figure 4.14 The LCD displays both sensors T1 and T2 are greater than 30°C which triggers misting mode.

4.4 Validation on temperature & humidity monitoring by using hardware circuit in mushroom house.

After the simulation is done, the next step is the validation of temperature and humidity monitoring by using hardware circuit in the mushroom house as Figure 4.15 shows the components installed inside the cover box. The cover box is used to keep the components dry and reduce the risk of electric shock or fire. The cover box can shield components from water entry, humidity, and extreme temperatures. Therefore, the lifespan of components can be increased, and the hazards can be prevented. The position components inside the cover box are shown in Figure 4.16. From the top, Arduino UNO, DC step-down converter, relay, and wire connection to sensors. The DC step-down converter is needed since the 12V adapter is used for the 12V valve in this system. The DC step-down converter will convert the input 12V to 5V since the Arduino UNO and other components require a 5V Vin.

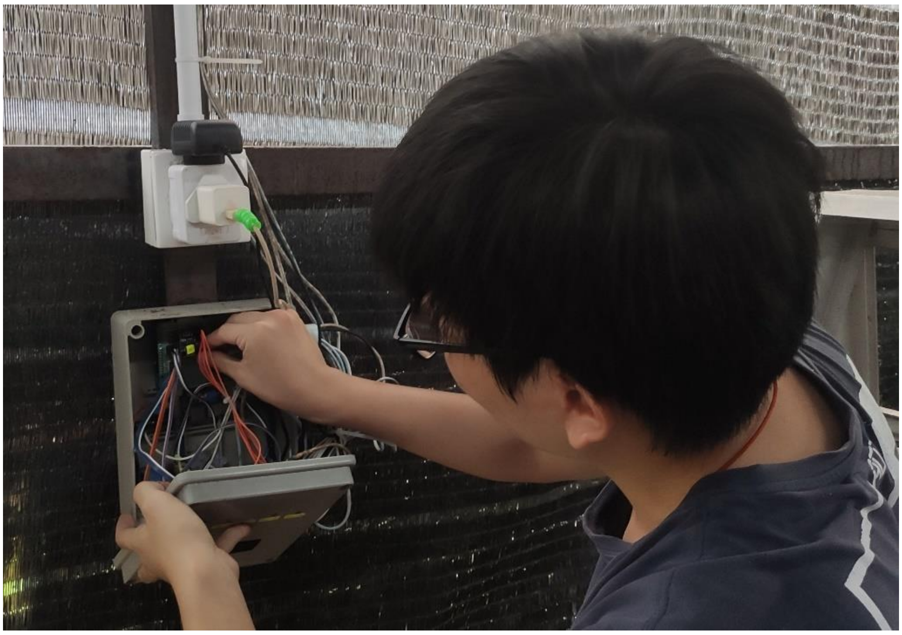


Figure 4.15 The components installed inside the cover box.

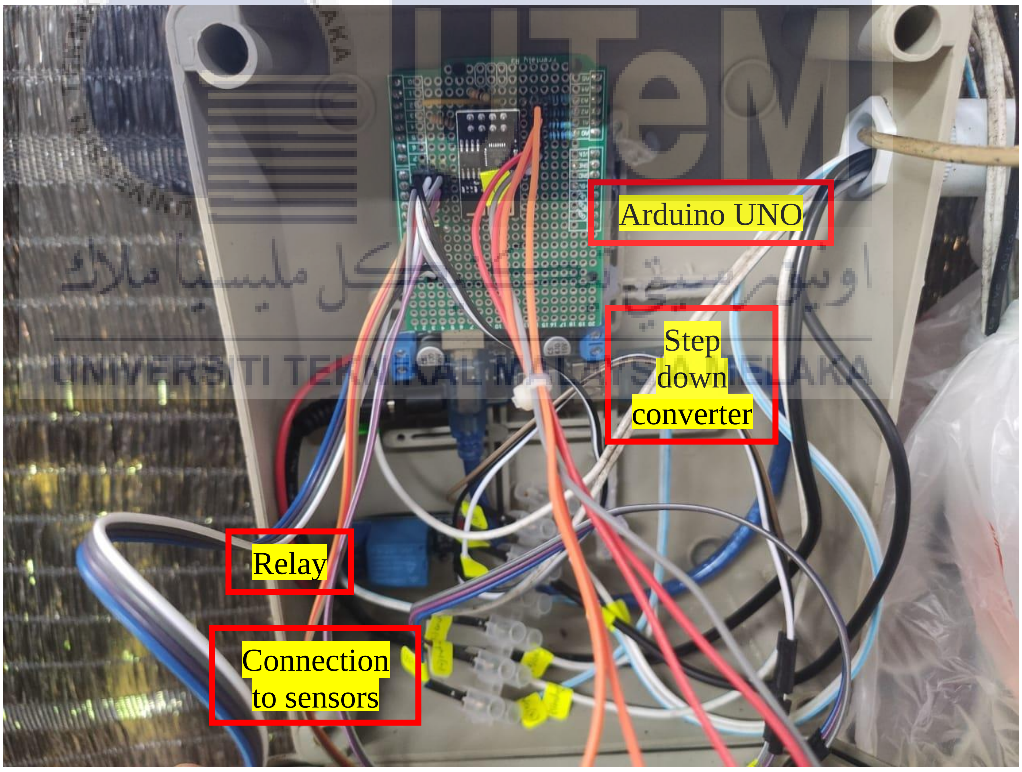
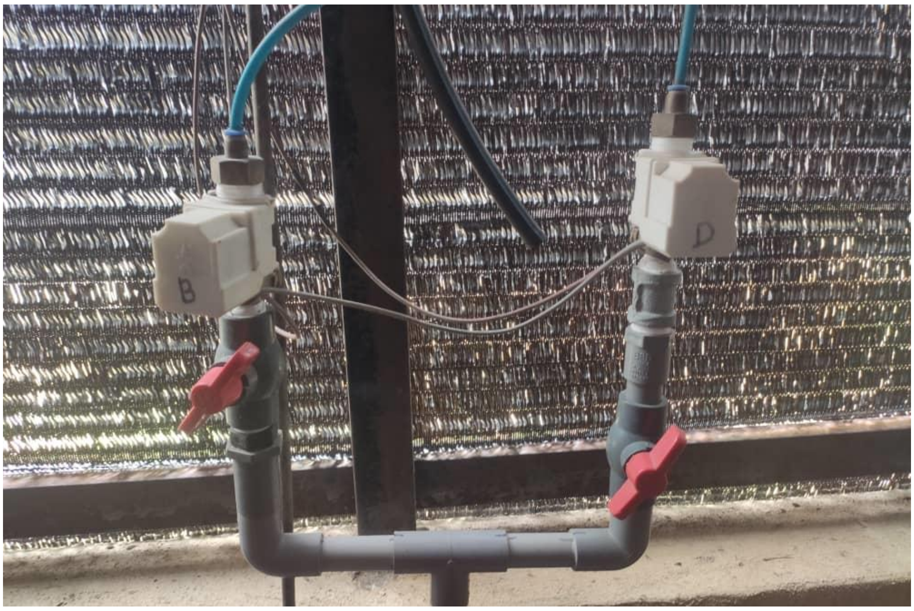


Figure 4.16 Position components inside the cover box.

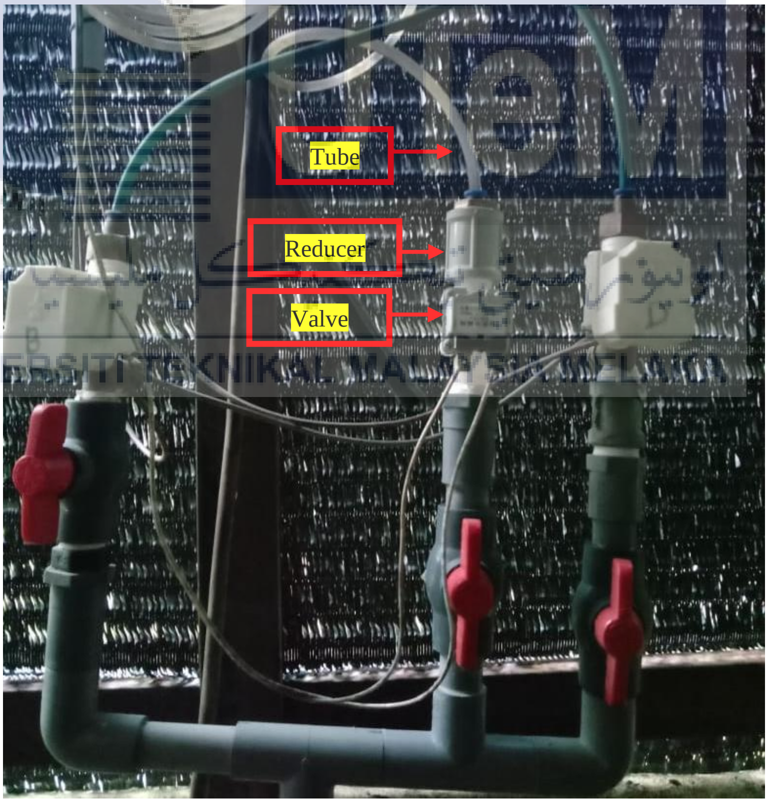
The wire connection to sensors in a cover box in Figure 4.16 is the connection to DHT22 temperature and humidity sensors. The sensors were installed on the ceiling mushroom house as Figure 4.17 shows. The reason DHT22 is installed on the middle ceiling is to prevent wetness from mist since the direction of misting is the interior side of the mushroom house. The mushroom chunks cannot be exposed to water since the mushroom only requires humidity to grow.

Figure 4.17 Installation DHT22 on ceiling mushroom house.

After all the wiring process was done, the before and after piping ways modified for the system are shown in Figure 4.18. The existing piping is two-way piping as shown in Figure 4.18(a) and the modified three-way piping is shown in Figure 4.18(b). The tube from the nozzle mist is connected to the reducer and valve. The function of the reducer is the medium that connects the tube and valve. The reducer also increases the pressure of the water flow which increases the water flow velocity since the size of the pipe becomes smaller from valve to reducer.



(a)

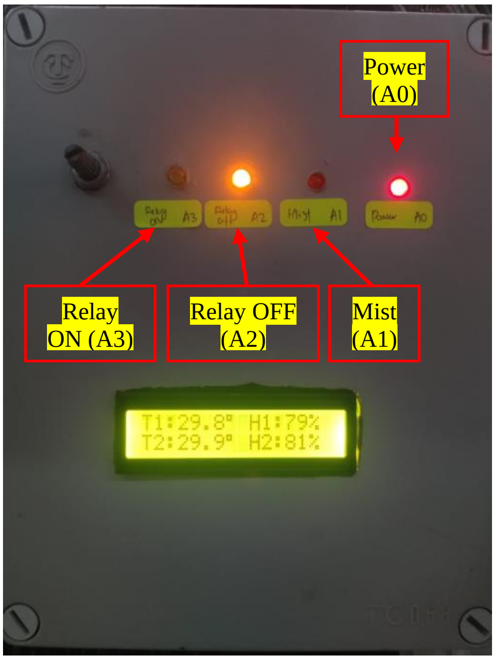


(b)

Figure 4.18 Before and after modification of piping. (a) Two-way piping before installation system. (b) Water tube connected to reducer and valve in three-way piping

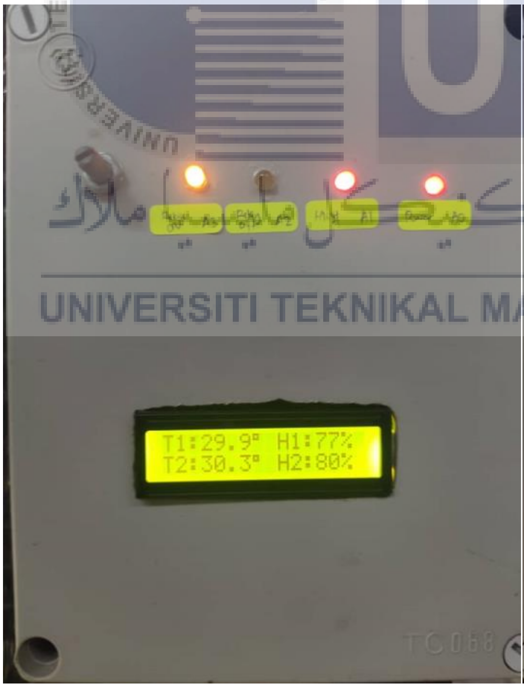
The LCD displays the temperature and humidity values T1, T2, H1, and H2 reading in Figure 4.19. The system initializes within 5 seconds in Figure 4.19(a). After 5 seconds, the DHT22 temperature and humidity sensors begin to detect the temperature and humidity surrounding them. The LCD displays both sensors T1 and T2 is lower than 30°C which is in standby mode in Figure 4.19(b). The LED A2 turned on to indicate the relay was off when the temperature was below 30°C. From the right, the LED shows the power on LED indicator (A0), mist system LED indicator (A1), off relay LED indicator (A2), and on relay LED indicator (A3). Next, the LCD displays the sensor T1 reading is greater than 30°C in Figure 4.19(c). The LED A1 and A3 are turned on to indicate the system is in misting mode. The relay and valve are turned on to allow water slowly to evaporate from the mist nozzle to control the surrounding temperature. The LED A0 will remain turned on if the whole system is running. The system is also in a misting mode where the sensor T2 and both sensors T1 and T2 readings are greater than 30°C shown in Figure 4.19(d) and Figure 4.19(e) respectively. In other words, whether sensor T1 or sensor T2 or both sensor T1 and T2 are greater than 30°C, the system will be in misting mode.

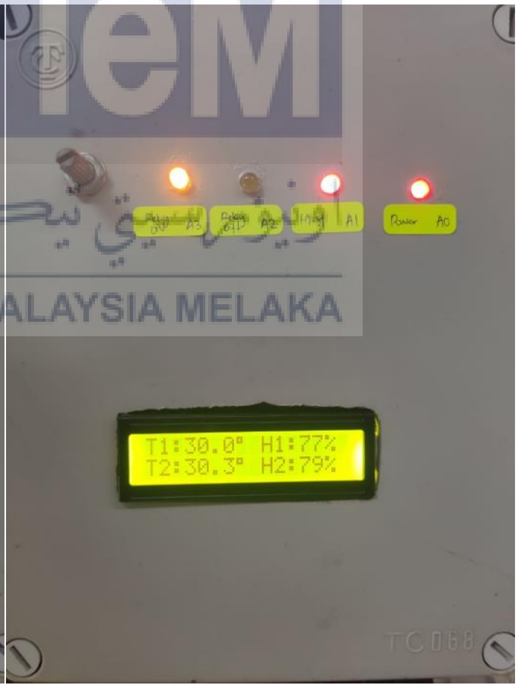
(a)



(b)

(c)





(d)

(e)

Figure 4.19 The LCD displays temperature and humidity values T1, T2, H1, and H2 (a) Systems initializes in 5 seconds. (b) Both sensors T1 and T2 lower than 30°C. (c) Sensor T1 greater than 30°C. (d) Sensor T2 greater than 30°C. (e) Both sensors T1 and T2 are greater than 30°C.

When the sensors detect the temperature is greater than 30°C, the Arduino triggers the COM terminal relay is connected to the NO terminal, and the valve is turned on by allowing the water to flow through the tube. Then, the water sprayed through the nozzle in the form of tiny droplets as Figure 4.20 shows the water misting from the nozzle to let the temperature surrounding the drop.

Figure 4.20 Water misting from the nozzle.

4.5 Development monitoring system via IoT platform

The development of the monitoring system via the IoT platform is done by using the ESP8266-01 Wi-Fi module to communicate between the Arduino and Blynk application as Figure 4.21 shows below. This Wi-Fi module allows Arduino access to the Wi-Fi network via a UART serial connection. Once connected to Wi-Fi, the ESP8266-01 establishes a connection to the Blynk server using the Blynk library and the authentication token provided. After that, the ESP8266-01 reads the temperature and humidity data from the DHT22 sensors and sends it to Blynk.

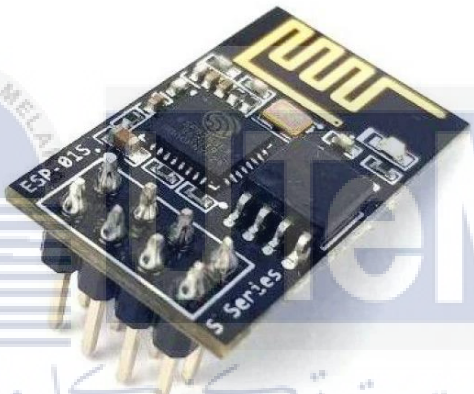
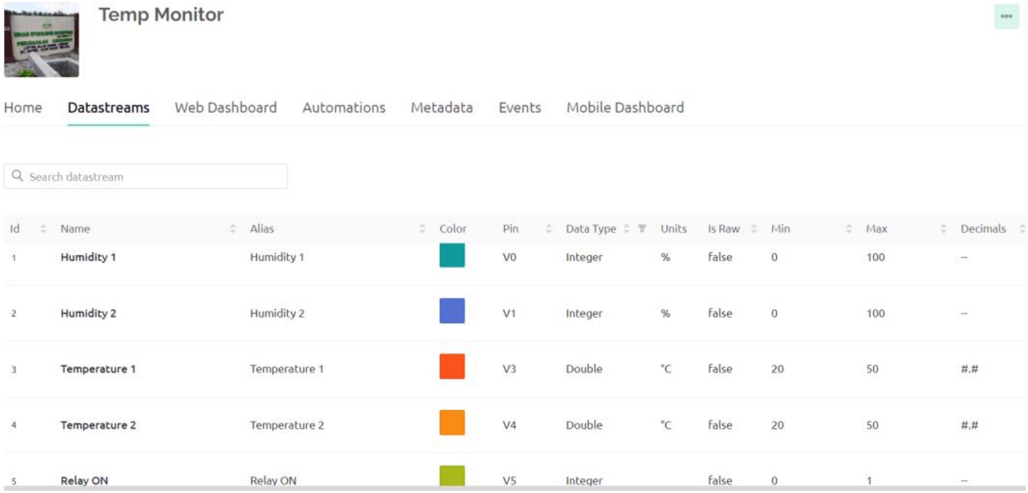


Figure 4.21 ESP8266-01 Wi-Fi module

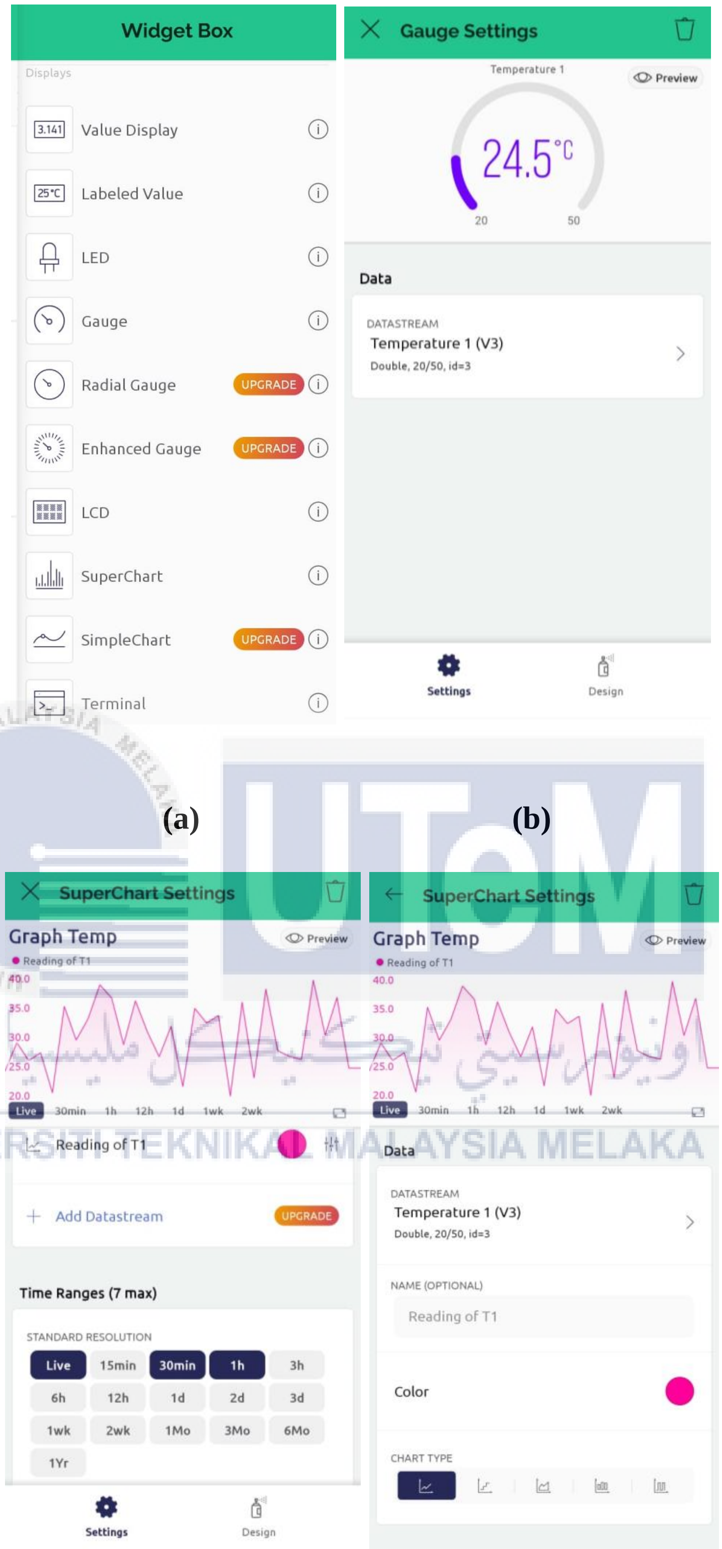
Next, setting the Datastreams parameter in the Blynk website as Figure 4.22 shows. The setting included the name for reference input, an alias for alternative Datastreams name, virtual pin for interface with libraries and DHT22 sensors, units for temperature and humidity, minimum and maximum limit for display, and decimals displays in the Blynk application. The virtual pin is determined in codes with the function Blynk.virtualWrite() sends the obtained data from both sensors to the virtual pin in the Blynk application.



Id	Name	Alias	Color	Pin	Data Type	Units	Is Raw	Min	Max	Decimals
1	Humidity 1	Humidity 1		V0	Integer	%	false	0	100	–
2	Humidity 2	Humidity 2		V1	Integer	%	false	0	100	–
3	Temperature 1	Temperature 1		V3	Double	°C	false	20	50	#.#
4	Temperature 2	Temperature 2		V4	Double	°C	false	20	50	#.#
5	Relay ON	Relay ON		V5	Integer		false	0	1	–

Figure 4.22 Setting the Datastreams parameter in the Blynk.

In the Blynk application, suitable widgets were selected such as Gauge and SuperChart as Figure 4.23(a). The configuration of the virtual pin in Gauge settings is shown in Figure 4.23(b). The virtual pin V3 is selected based on the Datastream setting earlier which is Temperature 1. The Gauge settings included data type double, from minimum of 20 to maximum of 50, and id is 3. The process was repeated for Humidity 1, Humidity 2, and Temperature 2. Next, configuration time ranges in SuperChart settings are shown in Figure 4.23(c). There is maximum of seven time ranges is selected to plot the data reading into a graph. The time range 'live' is real-time monitoring from sensors at the graph. In addition, the configuration Datastream in SuperChart settings is shown in Figure 4.23(d). The selection for Datastream settings is the same as Gauge settings for Temperature 1. The process was repeated for Humidity 1, Humidity 2, and Temperature 2 in SuperChart settings.

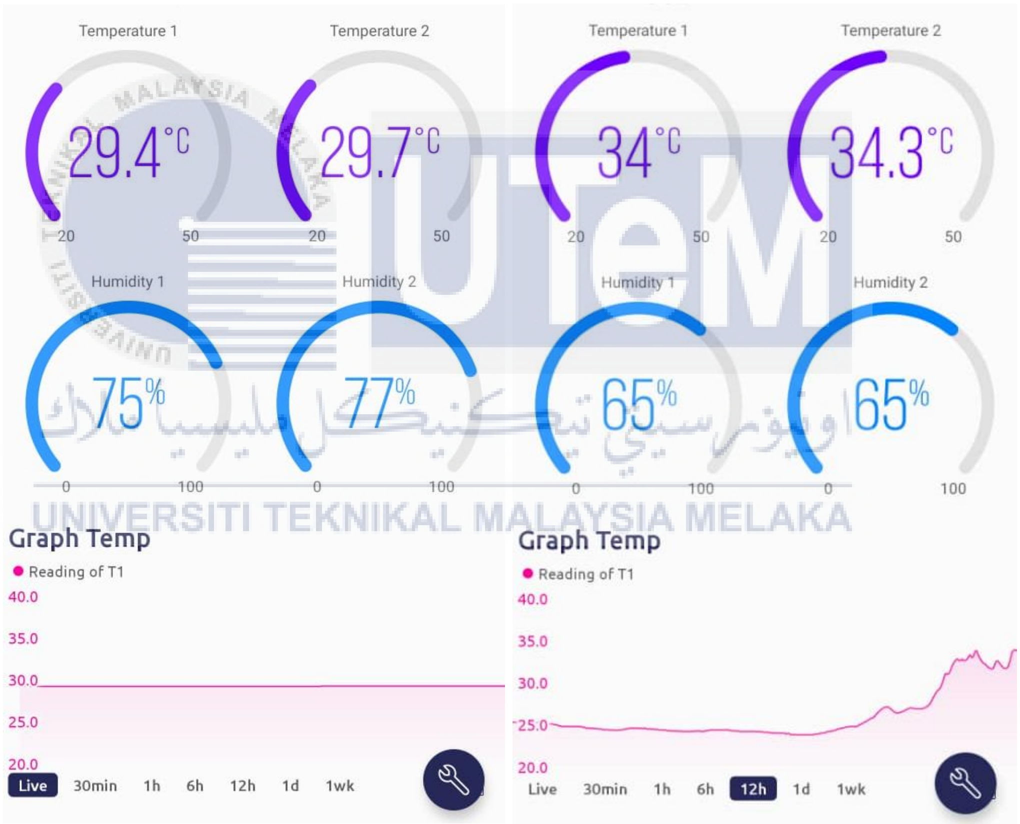


(a) (b)

(c) (d)

Figure 4.23 Selection widget in the Blynk application (a) Selection widget (b) Configuration virtual pin in Gauge settings (c) Configuration time ranges in SuperChart settings (d) Configuration virtual pin in SuperChart settings

The widget being arranged and customized in the Blynk application is shown in Figure 4.24(a) below. The gauge shows the real-time data monitoring from DHT22 sensors where Temperature 1, Temperature 2, Humidity 1, and Humidity 2. The limit of the temperature and humidity gauge is from 20 to 50 and from 0 to 100 respectively. The graph below the gauge is a superchart that was configured earlier and shows the reading and the data being saved for graph plotting. The selection of time ranges in the graph is determined by the user in Figure 4.24(b). The data is saved and plotted into a graph for monitoring the temperature mushroom house.



(a) **(b)**

Figure 4.24 Customization widget in the Blynk application (a) Arrangement of the widget (b) Selection time ranges in the graph

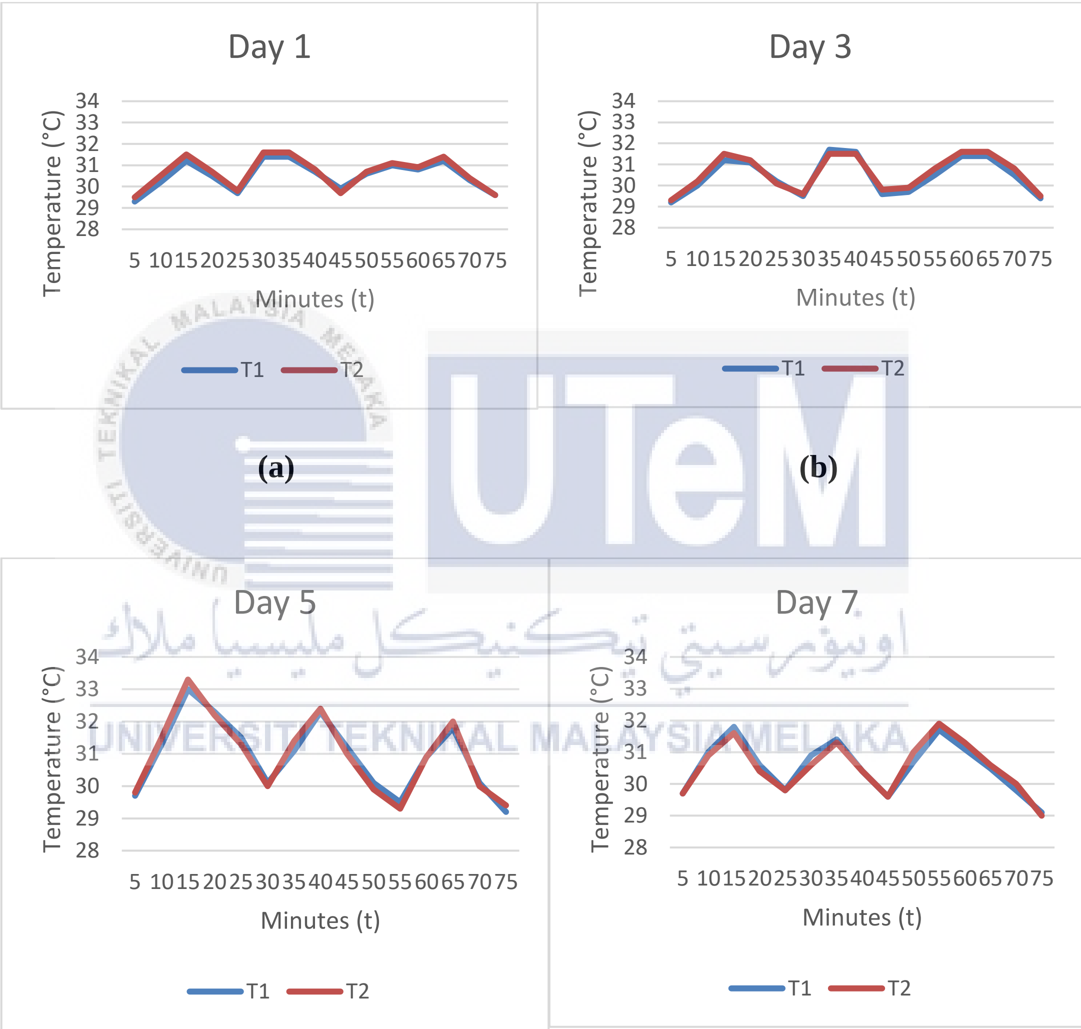
4.6 Evaluation and analysis the performance of the automated gray oyster mushroom system

The temperature and humidity raw data from the Blynk have been saved in an Excel file. The raw data is collected 1 of the 30 days data from the mushroom house as Figure 4.25 shows below. The raw data contains the general time format, H1, H2, T1, and T2 from the sensors. The raw data obtained is used to evaluate and analyze the performance of the automated gray oyster mushroom system.

	Time	H1	H2	T1	T2
1448	2023-09-04 11:50	78	77	29.29666667	29.5
1449	2023-09-04 11:55	74.23333333	73.83333333	30.22333333	30.49666667
1450	2023-09-04 12:00	71.6	71.63333333	31.18666667	31.45333333
1451	2023-09-04 12:05	78.16666667	77.16666667	30.52333333	30.72
1452	2023-09-04 12:10	79	78.63333333	29.7	29.83
1453	2023-09-04 12:15	72.13333333	71	31.4	31.6
1454	2023-09-04 12:20	73	71	31.38666667	31.57
1455	2023-09-04 12:25	75	73.16666667	30.68666667	30.75666667
1456	2023-09-04 12:30	75.8	75.93333333	29.9	29.71111111
1457	2023-09-04 12:35	78	76	30.62	30.74333333
1458	2023-09-04 12:40	76	77	31	31.1
1459	2023-09-04 12:45	77	77	30.8	30.91666667
1460	2023-09-04 12:50	77.4	76	31.19333333	31.41666667
1461	2023-09-04 12:55	78	77.16666667	30.32333333	30.4
1462	2023-09-04 13:00	80	81	29.61111111	29.6

Figure 4.25 Raw data from both sensors

The graph below is generated by the raw data obtained from the mushroom house for day 1, day 3, day 5, and day 7 as Figure 4.26 shows. The data is randomly selected from the selected day. The reason for choosing these 4 days out of 30 days is all the data obtained have the same trend. For the day 1 graph, the system is in misting mode when the mushroom house temperature is greater than 30°C in Figure 4.26(a). The time taken to control the surrounding temperature is around 10-20 minutes. After that, the temperature slowly drops to below 30°C and the system will be in standby mode. When the nozzle stops misting, the temperature rises caused by the outside temperature. Then, the system turns into misting mode when the mushroom house temperature is greater than 30°C. The process is repeated to keep the temperature below 30°C as Figure 4.26(b), Figure 4.26(c), and Figure 4.26(d) shows.



(c) **(d)**

Figure 4.26 Graph generated from the raw data obtained in the mushroom house where the time taken is random (a) Random raw data from day 1 (b) Random raw data from day 3 (c) Random raw data from day 5 (d) Random data from day 7.

The total finance used for all 3 methods systems in 1 month is shown in Table 4.3 below. The calculation finance for electric and water usage is according to [69], [70]. There are RM280.80 from RM1,500 from the worker's salary given by the company to control the temperature in the mushroom house for 1 month. The total water used by workers is RM14.04 in 1 month to control the mushroom house temperature. Next, the electricity used in the semi-automated system is RM23.44 and the water are RM178.18. The semi-automated system turns on 10 minutes per hour and 24 hours daily. Furthermore, the electricity used in the automated system is RM 37.07 and the water is RM323.53. The automated sensor is using the sensors to control the system. When the condition is met, the system will act to control the temperature. The semi-automated system has the lowest usage financially at RM201.62 and the highest is automated at RM360.59 among all 3 systems. The most suitable selection system will be explained in the next chapter which is in summary.

Table 4.3 Total finance used for all 3 methods system in 1 month.

	Manual (Human)		Semi-Automated (Alarm)		Automated (Sensor)	
	Salary (RM)	Water (RM)	Electricity (RM)	Water (RM)	Electricity (RM)	Water (RM)
1 Month	280.80	14.04	23.44	178.18	37.07	323.53
Total (RM)	294.84		201.62		360.59	

4.7 Summary

Before moving on to analysis, which is this chapter's primary goal, some other processes needed to be completed. The initial stage is to identify the production process for gray oyster mushrooms to have more understanding of mushroom requirements to grow. Next, develop a simulation on a software application for choosing the suitable components for the project. The simulation must first be functionally evaluated when it is finished to ensure that it will perform properly before being applied to the hardware. Before beginning the installation of the mushroom house, the collected component was assembled and subjected to a few functional tests. The project is now prepared to be implemented in the mushroom house.

Chapter 4.6 mentions the selection of the most suitable system in the mushroom house. The automated system is selected to control the temperature in the mushroom house even though the electricity and water bill is the highest among all 3 systems. The reason is the automated system has more efficiency by using sensors. The systems may activate the misting nozzle only when necessary, based on real-time sensor data. When the temperature rises, the systems can control the temperature to maintain the freshness and productivity of the mushroom. The semi-automated system turned on for 10 minutes per hour and according to the result obtained in Chapter 4, the automated system results show that the time taken to control the temperature is around 10-20 minutes. So, in semi-automated system there may be a possibility that these 10 minutes of misting the temperature are not able to fully control the temperature and this will cause the freshness and productivity of the mushroom can be affected. For the manual system, the human has potential for errors such as human error, oversight, or delays that can impact the effectiveness of the system. In addition, there are labor-intensive that require constant human presence and intervention which can be tiring and inefficient over time. The manual system controls the temperature 3 times per day which is 9am, 12pm, and 3pm with 3 hours apart. Same with the semi-automated system, there are no guarantees that the temperature is controlled and there may be a possibility that the freshness and productivity of the mushroom can be affected.

After that, the automated system can be monitored by using the IoT Blynk application anywhere. In addition, the data collection and analysis from the IoT Blynk application enhances the company’s operation efficiency and performance. Compared to the semi-automated, the system uses timer or alarm to control the system activation and manual system uses human intervention. Both systems cannot be monitored remotely and vice versa both needed manual monitoring. In conclusion, the automated system is selected as most suitable system to control the temperature in the mushroom house which can improve the performance production of gray oyster mushrooms.

CHAPTER 5

CONCLUSION AND FUTURE WORKS

5.1 Conclusion

The existing system in the mushroom house is a semi-automated (timer-based) mist system it will spray the water every hour to ensure the temperature is lower than 30°C. Water is wasted for this system because the water will be sprayed out even if the temperature is below 30°C. When the DHT22 sensor is utilized, the mist system will only be turned on according to the temperature value from the DHT22 sensor. Besides that, the success percentage of mushroom cultivation will increase because the water will not spray water when the temperature is below 30°C as the optimum growing temperature is between 28°C and 30°C. This will result in lesser losses for Sinar Syukrawie Enterprise.

The goal of this project is to develop an automated monitoring control temperature system for gray oyster mushrooms and to analyze the performance production of gray oyster mushrooms with the IoT platform Blynk application. The result obtained from the prototype and the implemented hardware in mushroom house is the same as the expected output result of the system in the simulation. The expected outcome of the automated system is to make sure water is automatically sprayed when the temperature exceeds 30°C. After the temperature decreases below 30°C, the mist system will automatically stop spraying the water. Besides that, the LED indicator will automatically turn on and off depending on the temperature except for the LED power on indicator which is always on. In addition, the result obtained from Chapter 4 proves that the development of automated monitoring control temperature system able to control the temperature inside the mushroom house and improve the performance production of the mushrooms.

In conclusion, the gray oyster mushroom automated system with IoT monitoring project was successfully developed within the time frame set and met the study's stated goal at the outset. The development of this gray oyster mushroom automated system with IoT monitoring project may assist agropreneurs in controlling mushroom houses more systematically and efficiently, as well as reducing the rate of mushroom damage due to excessive watering. The system can assist new or long-term agropreneurs in the field of gray oyster mushroom cultivation. This system can assist agropreneurs in more systematically and efficiently controlling mushroom houses. Agropreneurs can more easily monitor and control the temperature and humidity in the mushroom house by using this system.

5.2 Future work

The future work section briefly explains several possible directions that can be considered to improve the conducted project work. In the current project work, the adaptor was used to supply the voltage to the water pump is 240V and 0.37kW. For future work, it is proposed to use solar power as a power supply to the water pump in the mushroom house. With these energy-saving features, the electricity bill will be greatly saved from misting schedules during peak hours. In addition, solar power has a long lifespan and requires minimal maintenance.

Next, the current project work is an automated monitoring system without alarm or notification features. For future work, the implementation of an alarm feature can be added to the project. With the alarm feature, the Blynk application can notify the users when the critical temperature or humidity thresholds exceed in the mushroom house. These alerts can prompt immediate actions or adjustments to prevent adverse effects such as adjusting the misting system or addressing environmental factors impacting crops or sensitive equipment.

Besides that, the current project work is using Arduino UNO as microcontroller. For future work, the microcontroller Arduino UNO can be substituted to Raspberry Pi for more power and memory. Raspberry Pi has built-in networking capabilities, including Wi-Fi and Ethernet, simplifying connectivity to IoT platforms, cloud services, and remote monitoring solutions. In addition, with its higher storage capacity, Raspberry Pi can efficiently log and store more extensive datasets from sensors, enabling long-term data analysis, trend monitoring, and historical data retrieval.

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