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Controlling environment system for mushroom house with Internet of Things (IoT) technology

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Abstract

This article aims to study, develop, and test the temperature and humidity control system. The greenhouses grow fairy mushrooms and oyster mushrooms with Internet of Things technology (IoT) inside the greenhouse, temperature and humidity sensors are installed. DHT22 Then send the value to be processed at the microcontroller. ESP8266 NodeMCU To control the water pump for spraying water and ventilation fans to the specified values. There is a display. LCD The results of the experiment showed that the specified temperature value is when the temperature is greater than 30 °C Less moisture 70%HR The pump sprays water mist to increase humidity and the ventilation fan works. To cool the temperature in the mushroom house to drop below 30 °C When the humidity is greater than 90%HR The ventilation fan will run to drain out excess moisture and the mist pump will stop working. It has also tested an open control system.-It was found that it can meet the needs of users and can put the system into practice for its intended purpose.

Keywords: Mushroom house, Temperature, Humidity, IoT

1. Introduction

Mushrooms are highly nutritious food, rich in minerals and vitamins. Additionally, the various nutrients in mushrooms help combat free radicals. Mushrooms also have a taste and texture suitable for cooking, making them an easily accessible and affordable food with a wide variety of options for consumption. Particularly, oyster mushrooms and angel mushrooms stand out. Oyster mushrooms are clean white, highly nutritious, and have a fragrant sweet taste with a non-rubbery texture. Angel mushrooms have a delicious taste similar to oyster mushrooms and a crispy texture that makes them appetizing when cooked. These mushrooms can be dried and stored for later use. When rehydrated in water, they regain their original form.

Generally, one cup of mushrooms (96 g) provides approximately 21.1 Kcal and various vitamins and minerals, including 3 g of protein, 3.1 g of carbohydrates (total sugars 9.1 g), 2.9 mg of calcium, 0.5 mg of iron, 8.6 mg of magnesium, 82.6 mg of phosphorus, 305 mg of potassium, 4.8 mg of sodium, 0.5 mg of zinc, 305 mg of copper, 8.9 mg of selenium, 2 mg of vitamin C, 0.2 mg of vitamin D, 16.3 µgEq of folate, 16.6 mg of choline, and 3.5 mg of vitamin B3 or niacin. Beyond their nutritional benefits, mushroom production is on the rise annually. Most of the production is consumed domestically, with a small portion exported internationally. The Thai Mushroom Researchers and Growers Association reported 41,322 T of mushroom production valued at 2,291 million baht in 2017. By 2020, the production reached 20 million bottles, estimated to produce 150,000 T of fresh mushrooms valued at 9,000 million baht. This demonstrates Thailand's potential as one of the world's economic mushroom producers [1].

Creating a mushroom house requires an understanding of the suitable environmental conditions for optimal mushroom cultivation. Typically, the cultivation area should be open and well-ventilated, without standing water or excessive moisture, and with a good drainage system free from pesticide and disease contamination. Mushroom houses without humidity and temperature control systems often fail to produce suitable yields and cannot cultivate mushrooms year-round. Therefore, the internal environment of the mushroom house, such as temperature and humidity, is crucial for mushroom growth. Different types of mushrooms have varying temperature requirements. Mushrooms can be categorized based on their preferred climate into three groups: those that thrive in cool climates (below 25 °C to nearly 0 °C), such as button mushrooms, enoki mushrooms, and shiitake mushrooms; those that grow well in hot, humid climates (above 35 °C), such as white jelly fungi, black jelly fungi, and straw mushrooms; and those that prefer moderate climates (27-35 °C), such as angel mushrooms, oyster mushrooms, and wood ear mushrooms. Moderate climate mushrooms require relative humidity between 70-90%, which is essential for mycelium growth, fruiting, and mushroom development. Excessive humidity can lead to waterlogged mycelium and death, while insufficient humidity can cause dry, cracked mushrooms that do not develop properly [2].

Due to the limitations in controlling the environment within mushroom houses, there has been research interest in developing mushroom houses with humidity and temperature control systems. Examples include the Mushroom Growing Monitor Device (MusMoD), which uses Raspberry Pi as the processing board, though it is expensive [3]. Simulink Software, which uses MATLAB for environmental simulation, design, and analysis but is complex and suitable for coding experts [4]. Smart Farm System (SFS), which controls the environment via mobile commands using the Blynk program and is user-friendly compared to farms without this system and the Controlling Environment Mushroom House (CEMH) [5], which uses the ADAM-3600 board for processing and device control, suitable for large-scale mushroom houses due to its high cost. Studies indicate that controlling the environment in mushroom houses enhances cultivation efficiency. Therefore, this research aims to study, develop, and test a temperature and humidity control system for oyster and angel mushroom houses to improve mushroom quality and increase farmers' income, thereby boosting the Gross Domestic Product (GDP) and overall economic growth through increased financial circulation in the country.

2. Materials and methods

2.1 Conducting tests of temperature- and humidity controlled mushroom houses for fairy mushrooms and oyster mushrooms

The conducting tests of temperature- and humidity controlled mushroom houses for fairy mushrooms and oyster mushrooms as show in Figure 1.

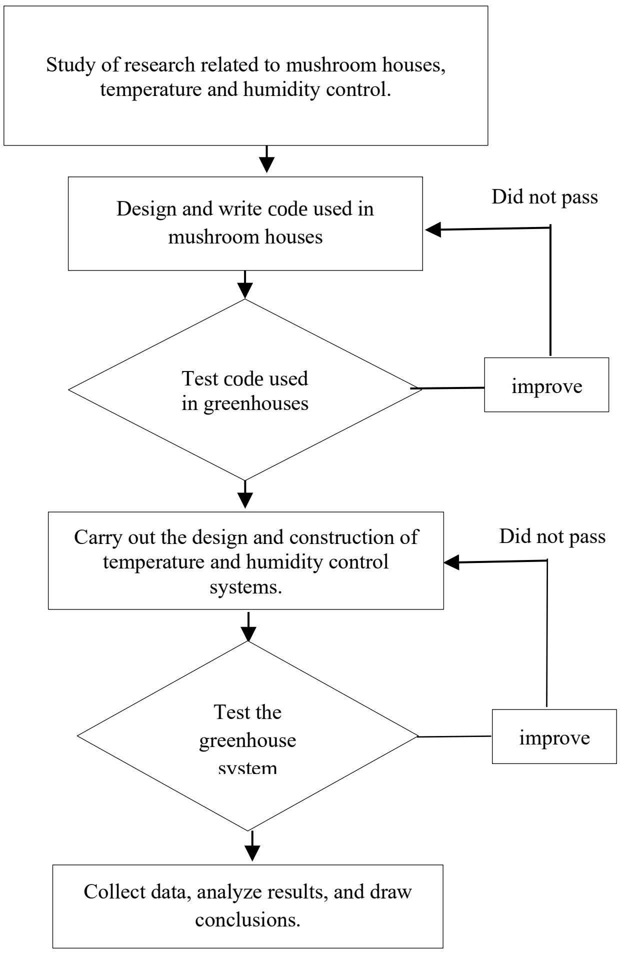


Figure 1 Operation steps

2.2 Temperature and humidity control system design

2.2.1 System operation circuit design (Figure 2 Designing operate system circuit)

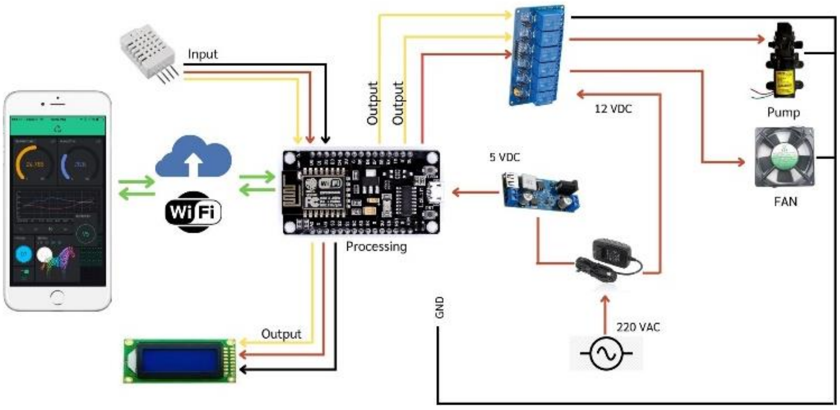


Figure 2 Designing operate system circuit

Based on the study of information about microcontroller boards. ESP8266 temperature and humidity measuring device DHT22 Module input temperature and humidity values to the microcontroller board ESP8266 temperature and humidity values are displayed on the display. LCD and meet the working conditions from code that is inserted into the microcontroller board to send signals to the relay panel and continue to operate the pump and fan. with 12 lights. VDC keep supplying pumps and fans. Power section supplied to the microcontroller board ESP8266 will use stepdown to reduce the fire from 12 VDC as fire 5 VDC

2.2.2 System operation

1) Temperature and humidity sensor operation DHT22 Module In temperature conditions (Figure 3 General scheme of the temperature circuit)

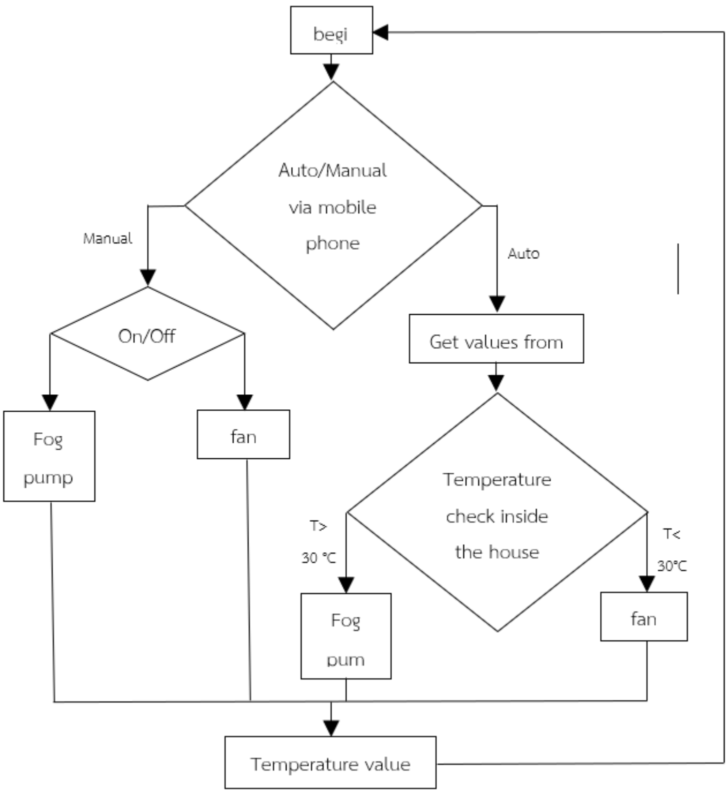


Figure 3 General scheme of the temperature circuit

System operating conditions (Figure 3 General scheme of the temperature circuit) It starts by allowing users to select the system automatically (Automatic Mode) or manual (Manual Mode) If the user chooses to automate (Automatic Mode) The system receives values from sensors to process and fulfill the decision conditions of operation with pumps and fans. If the temperature is lower 25 °C The system will instruct the fan to rotate. If the humidity is higher 30 °C The system will trigger the pump to operate, which is designed according to the weather conditions suitable for the growth of fairy mushrooms.Manual Mode) Users can choose to operate on-off pumps and fans instantly.

2) Operation of DHT22 Module temperature and humidity sensor in humidity conditions (Figure 4 General scheme of the humidity circuit)

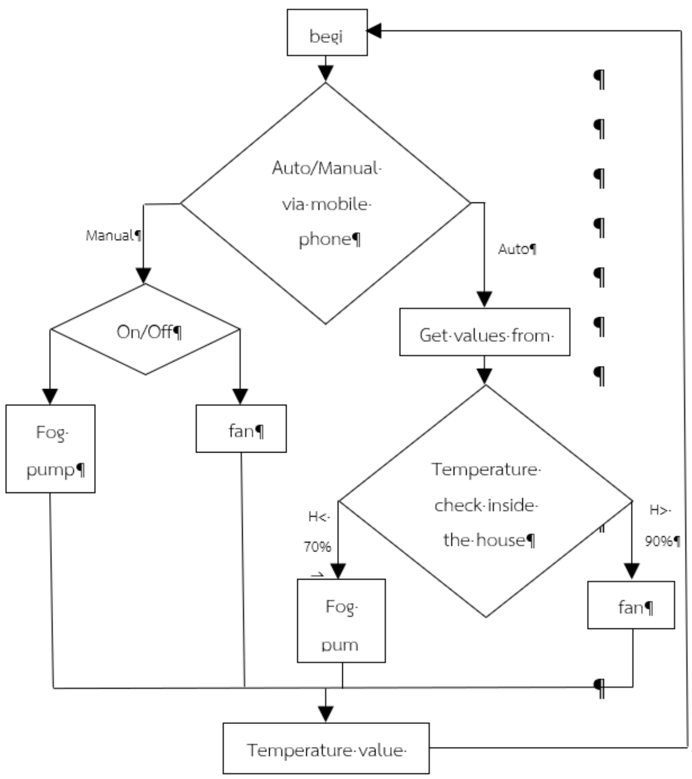


Figure 4 General scheme of the humidity circuit

System operating conditions (Figure 4 General scheme of the humidity circuit) It starts by allowing users to select the system automatically (Automatic Mode) or manual (Manual Mode) If the user chooses to automate (Automatic Mode) The system receives values from sensors to process and fulfill the decision conditions of operation with pumps and fans. If the humidity is higher 90 % The system will instruct the fan to rotate. If the humidity is lower 70 % The system will trigger the pump to operate, which is designed according to the weather conditions suitable for the growth of fairy mushrooms.Manual Mode) Users can choose to operate on-off pumps and fans instantly.

2.3 Creating a temperature and humidity control system in mushroom houses

1) Use temperature and humidity factors to write code automatic operating conditions and adjust the code to be able to operate via mobile phone.

2) Assemble a prefabricated greenhouse measuring 70x50x159 cm by assembling the finished house to become a greenhouse.

3) Install the equipment into the finished assembly shed (Figure 5 Accessories position in the mushroom house). Electronic devices that are exposed to moisture and malfunction are installed outside the house. Figure 6 Electronic devices in the control box includes:

(1) Control Box
(2) DHT 22 Module
(3) Moisture mist spraying pump 8 bar
(4) Fan size 5 finger
(5) Water filter
(6) Water Tanks
(7) Fog head

4) Figure 7 Mushroom house ready to experiment

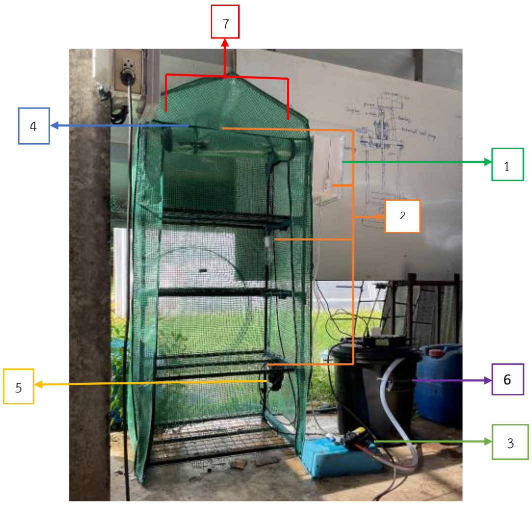


Figure 5 Accessories position in the mushroom house

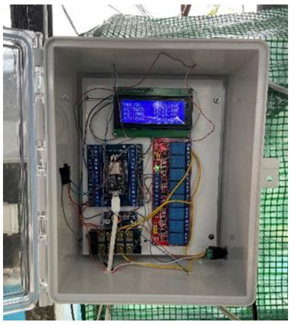


Figure 6 Electronic devices in the control box

Figure 7 Mushroom house ready to experiment

2.4 Test sensor accuracy

The accuracy of the automatic temperature and relative humidity control system developed by the researcher. The project team conducted a test to measure the accuracy of the values obtained from the sensors. The readings from the temperature and humid ity sensors are checked. DHT22 Module compares the results with the values obtained from standard measuring instruments. Thermo hygrometer: If the value does not match the standard measuring instrument, the DHT22 Module sensor or calibrate in the operation code may be replaced (Figure 8 Temperature and humidity from measuring sensors and 9 Temperature and humidity measuring device Testo 635).

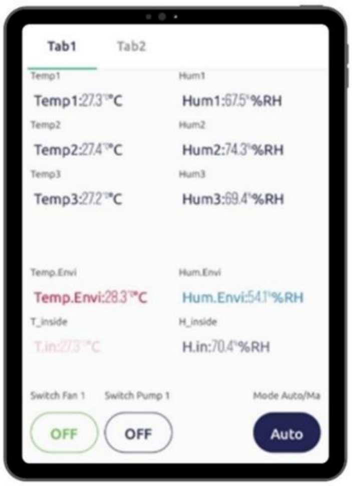


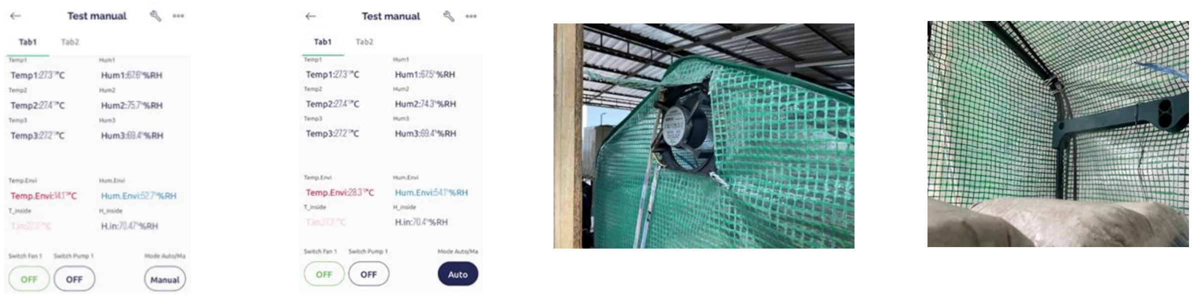
Figure 8 Temperature and humidity from measuring sensors

Figure 9 Temperature and humidity measuring device Testo 635

3. Results and Discussion

3.1 Manual and automatic mode test manually via Blynk application

Manual on-off testing via the Blynk application to validate the system's network performance. In the test on and off the manual part, which can work according to the commands of the normal user by being able to turn on-off the water pump and fan at any time. When the user selects Manual Mode and Automatic Mode, the display operation is exactly as the Blynk application (Figure 10 Operation performance from the Blynk application).



(a) Manual mode performance (b) Automatic mode performance (c) Ventilation performance d) Humidifier performance

Figure 10 Operation performance from the Blynk application

3.2 Test the stability of the DHT22 Module temperature and humidity sensor

Sensor Stability Test DHT22 Module that stores temperature and humidity data inside compared to outside greenhouses. The test results will be collected from September 1, 2022 to October 15 , 2022 from 00.00-23.00 hours to check the operating conditions of the system.

Figure 11 Temperature average per day inside and outside the mushroom house with a controlling temperature and humidity system shows the temperature relationship inside and outside the mushroom house with temperature and humidity control system. From 7:00

pm to 6:00 am, the temperature inside and outside the mushroom house is approximately the same. The temperature inside and outside the mushroom house began to differ between 7:00 am and 6:00 pm, ±0.6 percent apart, but at 1:00 pm, the temperature difference was ±1.4 °C.±

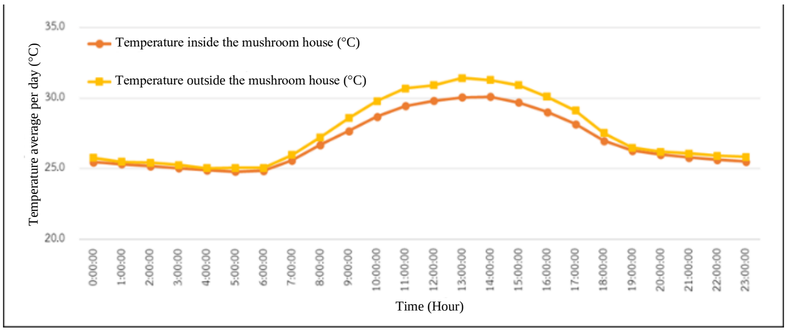


Figure 11 Temperature average per day inside and outside the mushroom house with a controlling temperature and humidity system

Figure 12 Humidity average per day inside and outside the mushroom house with a controlling temperature and humidity system It will be found that between 23.00-07.00 hours, the humidity inside and outside the house is approximately the same. The difference in humidity inside and outside the mushroom house was observed between 08.00-22.00 hours, which was ±7.1% humidity, while at 14.00 hours, the humidity gap was ±11.9%.±

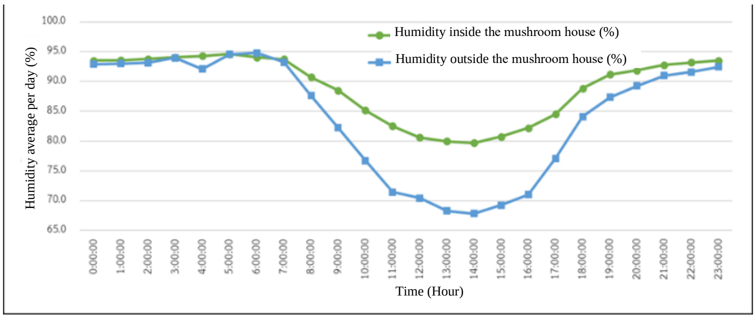


Figure 12 Humidity average per day inside and outside the mushroom house with a controlling temperature and humidity system

3.3 Productivity of fairy mushrooms and oyster mushrooms

It is an experiment with nodules of fairy mushrooms and oyster mushrooms that bloom each day. There are 160 cubes divided into controlled greenhouses using 40 fairy mushrooms and 40 oyster mushrooms, respectively. For greenhouses without control systems, 40 fairy mushrooms and 40 oyster mushrooms, respectively, obtained the following test results.

Figure 13 Comparison of mushroom weight average per lump in the mushroom houses with and without controlling temperature and humidity system Each day the value is collected, the weight obtained is compared. It was found that the weight of controlled greenhouses averaged 80.3 g of fairy mushrooms and 65.7 g of oyster mushrooms, while greenhouses without control had an average weight of 62.1 g of fairy mushrooms and 55.9 g of oyster mushrooms. There is a difference of about 18.2 g of fairy mushrooms and 9.8 g of oyster mushrooms , which is the result of temperature and humidity control.

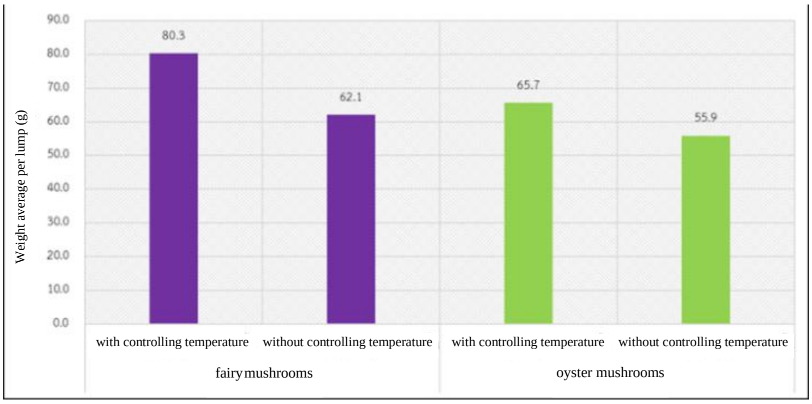


Figure 13 Comparison of mushroom weight average per lump in the mushroom houses with and without controlling temperature and humidity system

Figure 14 Comparison of grey oyster mushroom cultivation round in the mushroom houses with and without a controlling temperature and humidity system showed that the number of fairy mushroom nodules in mushroom greenhouses with mushroom flowering control was greater than without temperature and humidity control systems in rounds 2 and 3. The reason for this is that the angel mushroom nodules of the two mushroom plants have been exposed before the data is collected for the project. It is necessary to stimulate the nodules of the mushroom infection by casing the mushroom nodules up to the shoulders of the mushroom nodules. And another reason is that after picking the fairy mushrooms, there is still a stuck mushroom cone and the spoon is not removed T his prevents the mushrooms from continuing to bloom after we have collected the flowers [6]. Figure 15 Grey oyster mushroom product in the mushroom house with and without a controlling temperature and humidity system

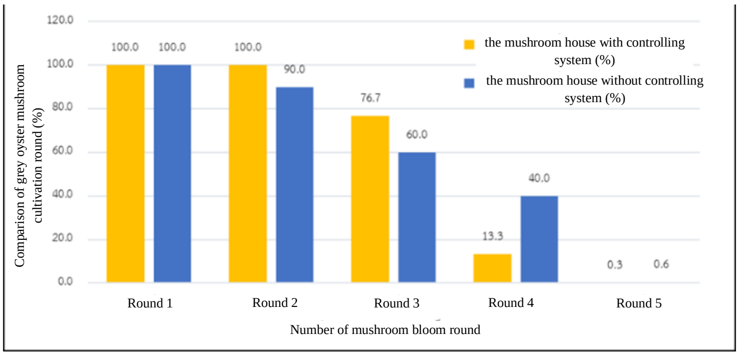


Figure 14 Comparison of grey oyster mushroom cultivation round in the mushroom houses with and without a controlling temperature and humidity system

(a) Grey oyster mushroom with a controlling system (b) Grey oyster mushroom without a controlling system

Figure 15 Grey oyster mushroom product in the mushroom house with and without a controlling temperature and humidity system

Figure 16 Comparison of oyster mushroom cultivation round in the mushroom house with and without a controlling temperature and humidity system shows that in mushroom houses without a control system, there are more oyster mushroom flowering cycles with temperature and humidity control systems. But if you compare the average weight of oyster mushrooms per cube, a mushroom house with a control system weighs more than a greenhouse without a temperature and humidity control system. Before collecting the data, the researcher had already opened the oyster mushroom flower page in a mushroom house with a control system and without a temperature and humidity control system, but the oyster mushrooms in both greenhouses rarely bloomed. The researcher then stimulated mushroom flowering by widening the mouth of the bag. The bag may be scraped with a spoon if necessary [6], in which the researcher stimulates mushroom flowering at the end of fruit collection. As a result, the percentage of flowering in the second cycle onwards is still small. If the harvest is continued, it is expected that the yield of oyster mushrooms with temperature and humidity control systems has a greater percentage of flowering. Figure 17 Oyster mushroom product in the mushroom house with and without a controlling temperature and humidity system

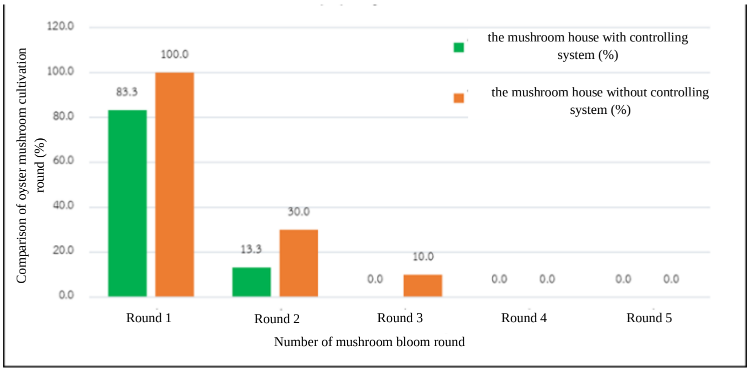


Figure 16 Comparison of oyster mushroom cultivation round in the mushroom house with and without a controlling temperature and humidity system

(a) Oyster mushroom with a controlling system

(b) Oyster mushroom without a controlling system

Figure 17 Oyster mushroom product in the mushroom house with and without a controlling temperature and humidity system

3.4 Cost comparison

1) Cost comparison of cultivation of fairy mushrooms and oyster mushrooms

Table 1 Net cost summarize in the mushroom house with and without a controlling system

Total cost	Cost (Baht)	
	There is a control system.	There is no control system.
Fixed costs	2,431.0	996.0
Variable costs	1,511.6	2,527.9
sum	3,942.6	3,523.9

2) Weight measurement results of fairy mushrooms and oyster mushrooms

After cultivating fairy mushrooms and oyster mushrooms for a period of 45 days. From September 1, 2019 to October 15, 2022, fairy and oyster mushroom weights can be collected in both controlled and non-controlled mushroom houses with and without temperature and humidity control systems. Using The Queen Bakery scale to determine the average fresh mushroom weight and using the obtained data to analyze the cost and compare the payback period between controlled and non-controlled mushroom houses. Table 2 Comparison of grey oyster mushroom and oyster mushroom weight

Table 2 Comparison of grey oyster mushroom and oyster mushroom weight

How to plant	Fairy mushroom weight (g)	Oyster mushroom weight (g)
Mushroom houses with temperature and humidity control systems	3,212.0	2,628.3
Mushroom houses without temperature and humidity control systems	2,484.0	2,236.0
difference	722.0	392.3

3) Comparison of the performance of cultivation of fairy mushrooms and oyster mushrooms.

Comparison of the total mushroom weights of fairy mushrooms and oyster mushrooms cultivated in controlled versus non-controlled mushroom houses. To use the data for further cost analysis. (Table 3 Payback period of grey oyster mushroom and oyster mushroom cultivation in the mushroom house with and without a controlling temperature and humidity system)

Table 3 Payback period of grey oyster mushroom and oyster mushroom cultivation in the mushroom house with and without a controlling temperature and humidity system

Greenhouse type	Income (Baht)	Total Cost (Baht)	Payback period (month)
Mushroom houses with temperature and humidity control systems	404.3	3,942.6	9.8
Mushroom houses without temperature and humidity control systems	325.9	3,523.9	10.8

From Table 3, Payback period of grey oyster mushroom and oyster mushroom cultivation in the mushroom house with and without a controlling temperature and humidity system Bring the income together to earn the total income. From Table 4.3, mushroom houses with control systems have a payback period of 9.8 months and mushroom houses without temperature and humidity control systems have a payback period of 10.8 months. If tested on larger greenhouses, the payback period may be shortened even further [7].

4. Conclusions

Temperature and humidity control systems for mushroom houses can operate according to the temperature and humidity conditions inserted into the microcontroller board. There are fans and humidity nozzles to adjust the temperature and humidity inside the house. Factors affecting control within mushroom houses are cold temperatures, cost comparisons in controlled mushroom houses and no temperature and humidity control. Each house of 80 cubes had payback periods of 9.8 months and 10.8 months, respectively, for the production of fairy mushrooms and oyster mushrooms in temperature-controlled the houses. and moisture content of approximately 3,212.0 g and 2,628.3 g, while mushroom houses without temperature and humidity control were approximately 2,484.0 g and 2,236.0 g, respectively.

4.1 Suggestion

The temperature and humidity sensor should be changed to DHT11. when the data is transmitted far away, it is more accurate. Reduce the problem of not distributing moisture evenly throughout the mushroom house. In permanent houses, water tanks should be installed underground to reduce the water temperature and retrieve the remaining water for reuse, which helps to save more water. In the mushroom house there should always be good ventilation. This control system is suitable as a basis for designing other larger greenhouse systems.

5. Acknowledgements

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