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# Development of an Automated Mushroom House to Optimize Growth and Production of White Oyster Mushrooms (*Pleurotus ostreatus*)

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**ABSTRACT**

Oyster mushroom cultivation is usually done in the highlands which have very low temperatures, while in the lowlands it is cultivated in mushroom houses that have set the temperature and humidity. The manufacture of mushroom houses in this study can regulate temperature and humidity automatically with physical conditions that are in accordance with oyster mushroom cultivation, so that this system can be implemented in mushroom farmers. This research aims to make a prototype and measure the performance of an automatic-based white oyster mushroom house. To fulfill the design, the tool manufacturing process is carried out. The procedure for making tools is carried out through stages, consisting of: preparation of tools and materials, design procedures, making design drawings, namely structural and functional designs and the last is product testing. Based on the results of research on the development of an automatic-based mushroom house to optimize the growth and production of white oyster mushrooms, it is concluded that this tool was successfully designed in accordance with the targeted plan. Based on the results of functional tests, all have met the criteria of being able to produce mushroom houses that can regulate temperature and humidity automatically with physical conditions that are in accordance with the cultivation of white oyster mushrooms.



## INTRODUCTION

White oyster mushroom *(Pleurotus ostreatus)* is one of the foodstuffs that needs attention in terms of food security for farmers. Currently, white oyster mushrooms are very popular and widely favored by the public, because of their delicious taste and high nutrition. The nutritional value per 100 grams of oyster mushrooms consists of 19-35% protein containing 9 amino acids, 1.7-2.2% fat, consisting of 72% unsaturated fatty acids and carbohydrates (Sumarni, 2006).

The cultivation of white oyster mushrooms in Indonesia has not been able to meet the needs of consumers every day (Suriawira, 2002). In fact, as long as the quality and quantity of products are balanced, the prospect of oyster mushroom entrepreneurship is quite good because the market is wide open, both export and import. (Chazali & Pratiwi, 2009). The cultivation of white oyster mushrooms actually does not require much capital because one of the growing media is sawdust. (Sudirman, 2008; Ginting et al., 2013 and Suharnowo et al., 2012).

The above points indicate that the cultivation of white oyster mushrooms is one of the agricultural businesses with considerable business opportunities to be developed, because of its increasing economic value (Parjimo, 2007). Known as a mushroom that is

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easy to cultivate and is widely developed in wood substrate media that has been packed in plastic bags and then incubated and maintained in mushroom houses (Syammahfuz, 2009). White oyster mushrooms are usually cultivated in mushroom houses to maintain the appropriate temperature and humidity environment and to protect the plants from external disturbances such as wind attacks, pest outbreaks, high rainfall and sunlight.

The growth of white oyster mushrooms is highly dependent on environmental factors that affect the growth of white oyster mushrooms, namely temperature, humidity, light, air, moisture content and acidity (pH) (Meina, 2007). Oyster mushrooms are incubated at a temperature of 22-28$^{O}$ C and humidity of 60-70%, while for the growth period of fruiting bodies *(pin heads)* with temperature and humidity of 16-22$^{O}$ C and humidity of 80-90% (Fitriah & Nengah, 2013).

The manufacture of mushroom houses has been carried out by several previous studies, among others: Husni et al. (2018) designed a room temperature and humidity stabilizer for merang mushroom production based on the arduino uno microcontroller. Anggi & Nurwijayanti. (2016) successfully designed an automatic temperature and humidity regulator in oyster mushroom cultivation using an ATMega16 microcontroller. The results of these studies have successfully designed and implemented a microcontroller-based temperature and humidity stabilization system in mushroom farms and increased yields, and have been able to ease the work of mushroom farmers. However, the mushroom production produced is not optimal because other factors that affect the growth of mushrooms have not been considered in the design of mushroom houses such as the size of mushroom houses. Therefore, this research will consider these factors in making mushroom houses.

The results of making mushroom houses in this study can regulate temperature and humidity automatically with physical conditions that are in accordance with oyster mushroom cultivation and in the end this system can be implemented in mushroom farmers, so it is hoped that the results of making this mushroom house can ease the work of mushroom farmers and be able to optimize the growth of white oyster mushrooms which have an impact on mushroom production more optimally. Thus, the welfare of mushroom farmers can also increase. So that every mushroom farmer who uses this mushroom house can understand and maintain it easily, each component part of the tool is made quite simple both in the work system and the circuit.

## MATERIALS AND METHODS

### Tools and Materials

The tools used in this research are gerindra, solder, drill, electricity, welding machine, meter. While the materials used are *hollow iron,* plywood, 14% UV plastic, Portable Air Cooler 8 Watt, DHT22 sensor, electric water pump DC 12V 3A 100 Psi, arduino uno atmega328, and LCD *(liquid crystal display)*

### Methods of Research

This research was conducted at the Agricultural Technology Education Study Program Laboratory, Faculty of Engineering, Universitas Negeri Makassar. The designed automatic mushroom house has two main components, namely the mushroom house as a place to put *baglogs* and automatic temperature and humidity system hardware.

The type of research used in this research is *Research and Development* (R&D). The development method used is the Prototype method. This method involves creating a prototype or early model of a product or technology to test its concept, function, and design. Prototypes can be used to identify weaknesses or problems that need to be fixed before the final product or technology is developed. Several stages of research, namely the design stage; preparation of tools and materials; design procedures for making design drawings, namely structural and functional designs; and product testing. Each of these research stages is explained as follows:

1. Design stage
   This stage of work includes making detailed structural design drawings, three-dimensional drawings of the parts of the automatic-based mushroom house, determining the size, and determining the material. The design of the automatic mushroom house can be seen in Figures 1, 2 and 3.
2. Tools and materials collection stage
   This stage of work includes activities to determine the amount of materials needed

for the design of an automatic mushroom house, purchasing materials and providing the tools needed for the assembly process.

3. Manufacturing and assembly stage
   At this stage, the frame of the mushroom house and the hardware of the automatic temperature and humidity system are made, the algorithm of the automatic system is created, the algorithm is tested, and the design of the automatic mushroom house is tested.
4. Testing phase
   At this stage, testing of the designed automatic-based mushroom house is carried out. This test aims to determine whether the automatic mushroom house is functioning in accordance with the initial design criteria. In general, there are two tests carried out, namely functional tests and performance tests.

Figure 1. Design of automatic mushroom house

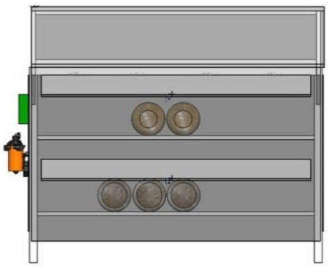

Figure 2. Mushroom house design (Side view)

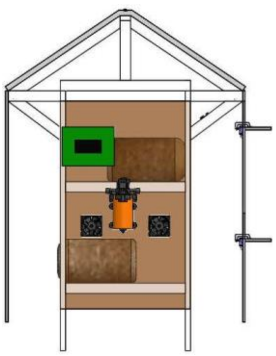

Figure 3. Mushroom house design (front view)

**Structural and Functional Design**

In general, this automatic-based mushroom house consists of two main parts, namely the frame of the mushroom house and the hardware of the automatic temperature and humidity system. The frame is made of *hollow* iron with overall dimensions of 150 cm x 50 cm x 100 cm. The frame of the mushroom house functions as a support and unification of all electronic components in the mushroom house as a whole. In addition, the frame must also be able to withstand the weight of the baglogs that will be put into the mushroom house. The walls of the mushroom house are made of plywood with dimensions of the length of the front and back walls, 150 x 90 cm, the length of the left and right side walls 80 x 50 cm. The roof of the mushroom house is made of nipa leaves with dimensions of 200 x 60 cm in length.

While the hardware of the mushroom house automatic system consists of several components, namely the DHT22 sensor which functions to measure the temperature and humidity of the air in the mushroom house room (Temperature Range:-40-80℃ ±0.5℃), a water pump DC 12V 3A 100 Psi with dimensions of 20.29 x 8.30 cm which functions to absorb and remove water contained in the cooling system so that it can circulate on the engine, *nozzle fittings* with dimensions of 5 x 4 mm which function to break down a liquid, solution or *suspense* into liquid *droplets* or *spray* and this Portable Air Cooler 8 Watt has three functions at once, namely air conditioning, *humidifier* and air *purifier*.

**Product Testing Procedure**

The product testing procedure in this study was carried out in several stages, namely as follows:

1. DHT22 sensor calibration test
   a. Set up the created control system.
   b. Functioning the sensor based on the *set point* used, which is a temperature of 26-30°C
   c. Comparing the sensor reading data of the hygrometer measuring instrument to have the same temperature and humidity, if it is not the same then recalibration is carried out. Laurentius, (2017) the formula used to determine the error rate of the DHT22 sensor is:

$$\%\text{Error} = \frac{\text{Sensor Value} - \text{Hygrometer Value}}{\text{Hygrometer Value}} \times 100\%$$

2. Product Test
   a. Seeing the development of mushroom fruiting that grows on the mushroom *baglog*.
   b. Measure the height and diameter of mushrooms that are ready for harvest.

**Observation**

Observations were made on control system components such as DHT22 sensor readings. The parameters observed are sensor reading *errors*, *errors* in the function of the tool and fungal growth. the experimental and observation data obtained are then analyzed descriptively and presented in tabular form.

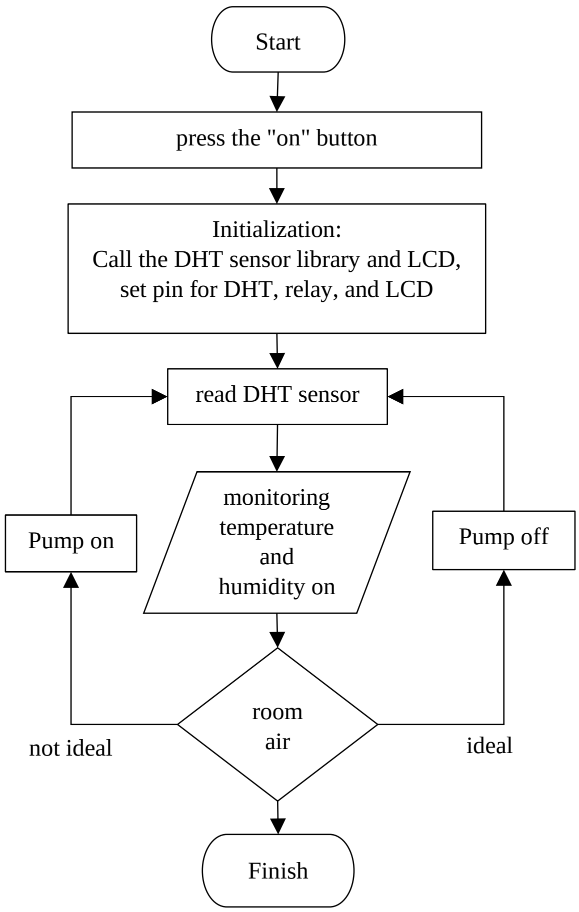


Figure 4. Control system *flowchart*

## RESULTS AND DISCUSSION

### Description of Products Produced

The automatic-based mushroom house that has been made has a total dimension of 150 cm x 90 cm x 100 cm. The working principle of this automatic- based mushroom house is that if the DHT22 sensor detects temperature and humidity exceeding the *setpoint* limit, the pump will automatically turn on and the *nozzle fitting* will spray water into the barn until the temperature and humidity in the barn become ideal. If the room is ideal, the air conditioner and pump will automatically turn *off*. The ideal conditions for oyster mushroom growth are at a temperature of 28-30°C, air humidity of 80-90%.

Figure 5. The designed mushroom house

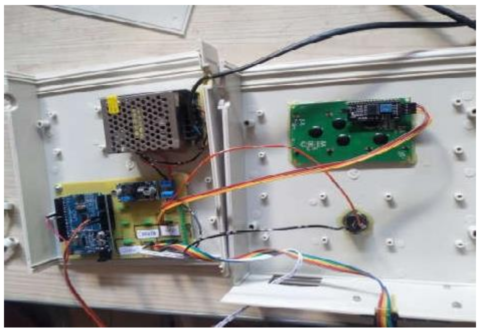

Figure 6. Mushroom house control circuit

### Functional Testing

***DHT22 Sensor***

Functional testing of the DHT22 sensor is carried out to determine the sensor error rate. In this test, a comparison is made between the temperature and humidity measured using a hygrometer measuring instrument and the temperature and humidity data displayed on the LCD. The test method was carried out with 4 times with 3 replicates. The results of testing the DHT22 sensor and measuring instrument can be seen in table 1 below.

Table 1 Average data of sensor calibration test results

| No. | Time (UTC+ 08:00 ) | Temperature (°C) | | Humidity (%) | |
|---|---|---|---|---|---|
| | | Sensor | Thermometer | Sensor | Hygrometer |
| 1. | 07:00 | 28 | 29 | 89 | 77 |
| 2. | 12:00 | 31 | 32 | 78 | 69 |
| 3. | 16:00 | 30 | 31 | 78 | 68 |
| 4. | 20:00 | 28 | 29 | 86 | 77 |

Error testing is the difference in value read by the sensor with a thermometer and hygrometer measuring instrument. Below can be seen table 2 anda table 3 error data on sensor calibration (temperature and humidity).

Based on the data in tables 2 and 3, calibration is carried out several times in order to obtain accurate sensor data which can be seen from the low error value. Calibration is done by comparing the sensor value and thermometer or hygrometer value. The two values are compared by forming a calibration equation that is entered into the system code.

**Temperature and Humidity**

A comparison diagram of the temperature values of the sensor and measuring instrument can be seen in Figure 7 below.

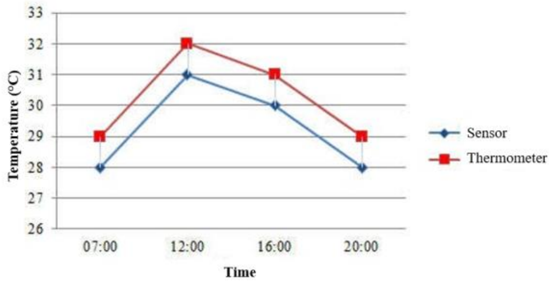


Figure 7 Sensor measurement performance graph

Based on the sensor performance measurement data, it shows that there are

Table 2. *Error* data on sensor calibration (temperature)

| No. | Time (UTC+08:00 ) | Testing | Thermometer (°C) | Sensor (°C) | Value difference | Error (%) |
|---|---|---|---|---|---|---|
| 1 | 07.00 | 1 | 29.0 | 28.2 | 0.8 | 2.75 |
| | | 2 | 29.0 | 28.3 | 0.7 | 2.41 |
| | | 3 | 29.0 | 28.6 | 0.4 | 1.37 |
| 2 | 12.00 | 1 | 32.3 | 31.6 | 0.7 | 2.16 |
| | | 2 | 32.3 | 31.8 | 0.5 | 1.54 |
| | | 3 | 32.3 | 31.9 | 0.4 | 1.23 |
| 3 | 16.00 | 1 | 31.3 | 30.5 | 0.8 | 2.55 |
| | | 2 | 31.3 | 30.7 | 0.6 | 1.91 |
| | | 3 | 31.3 | 30.9 | 0.4 | 1.27 |
| 4 | 20.00 | 1 | 29.0 | 28.6 | 0.4 | 1.37 |
| | | 2 | 29.0 | 28.9 | 0.1 | 0.34 |
| | | 3 | 29.0 | 29.0 | 0.0 | 0.00 |
| **Average Error** | | | | | | **1.58** |

Table 3. *Error* Data on Sensor Calibration (humidity)

| No. | Time (UTC+08:00 ) | Testing | Hygrometer (%) | Sensor (%) | Value difference | Error (%) |
|---|---|---|---|---|---|---|
| 1 | 07.00 | 1 | 77 | 90 | 13 | 16.88 |
| | | 2 | 77 | 89 | 12 | 15.58 |
| | | 3 | 77 | 89 | 12 | 15.58 |
| 2 | 12.00 | 1 | 68 | 81 | 13 | 19.11 |
| | | 2 | 68 | 77 | 9 | 13.23 |
| | | 3 | 68 | 76 | 8 | 11.76 |
| 3 | 16.00 | 1 | 69 | 81 | 12 | 17.39 |
| | | 2 | 69 | 77 | 8 | 11.59 |
| | | 3 | 69 | 77 | 8 | 11.59 |
| 4 | 20.00 | 1 | 77 | 89 | 12 | 15.58 |
| | | 2 | 77 | 89 | 12 | 15.58 |
| | | 3 | 77 | 81 | 4 | 5.19 |
| **Average Error** | | | | | | **14.08** |

differences in temperature at the time of observation. Sensor measurement data shows that the lowest average temperature value in the observation at 07:00 is 29$^{O}$ C for the sensor and the average value of the hygrometer measuring instrument is 28$^{O}$ C. This is due to the low temperature in the morning because there is no sunlight yet. This is due to the low temperature in the morning because sunlight has not yet appeared, while the highest temperature was observed at 12:00, 31$^{O}$ C for the sensor and 32$^{O}$ C for the hygrometer (comparison measuring instrument). This high temperature is caused by a spike above the *setpoint* limit between 12:00-16:00 this is in line with the opinion of Widyastuti & Tjokrokusumo (2008) that the intensity of sunlight and high temperatures, coupled with the heat from the respiration of cultivated oyster mushrooms causes the temperature to soar high in the mushroom barn. Efforts to reduce the high temperature and humidity are made by spraying water into the barn automatically.

From the comparison of the output temperature value of the sensor and the hygrometer measuring instrument, the *error* rate will be calculated. Seen in Figure 7 the sensor performance graph (temperature) at 12:00 shows that there is an increase in temperature. At the time of measurement, the difference in results in the output value of the sensor and hygrometer measuring instrument is quite small, causing a small *error*. The increase in temperature was followed by an increase in sunlight. The accuracy of the DHT22 sensor is fairly good, with an average measurement difference value of 1.58%. This is in accordance with the opinion of Sindung et al. (2020), namely the smaller the tolerance value of the sensor, the higher the percentage value of its accuracy.

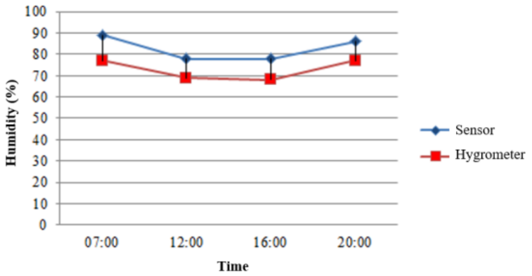


Figure 8: Sensor performance graph (humidity)

The graph in Figure 8 is the performance data of the DHT22 sensor and hygrometer (humidity) measuring instrument. The sensor performance data shows that the highest humidity is with an average temperature at 07:00 observations, which is 89% on the sensor and 77% on the hygrometer. This is due to low temperatures, where if the temperature is low then the humidity is high. This is in line with Ari & Sri's (2016) research which explains that when the air humidity is high, the air temperature is low. At 12:00 observation, the humidity was low with an average result on the sensor of 78% and the hygrometer measuring instrument of 67%. This is due to the high temperature, where if the temperature is high then the humidity is low. This condition is in line with Kanginan's research (2000), which explains that the relative humidity of the air changes inversely with changes in air temperature, namely when the air is cold, the humidity increases and when the air is hot, the humidity decreases.

**White Oyster Mushroom Growth**

The growth of white oyster mushrooms is one of the indicators used as a benchmark in collecting research data. Observation of the length and diameter of white oyster mushrooms is done visually by looking directly at the white oyster mushroom growing media. The growth of white oyster mushrooms is characterized by the appearance of *pin heads* on the *baglog*. *Baglogs* that have been filled with mycelium are then moved into the barn for the growth stage of the fruiting body *(pin head)* with a temperature of 26-30$^{O}$ C and humidity of 80-90% (Mufarriha, 2009). The observation parameters measured were the growth of mushrooms in height and diameter (cm). from the results of observations regarding the growth of white oyster mushrooms in each *baglog* have differences. The graph of the average size of the height and diameter of white oyster mushrooms can be seen in Figure 9 below.

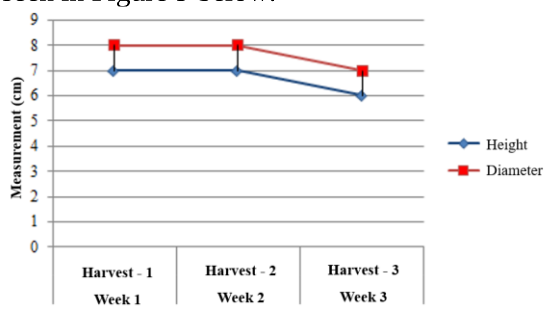


Figure 9. Graph of the average size of height and diameter of white oyster mushrooms

Figure 9 above shows a graph of the average size of white oyster mushrooms. The size of white oyster mushrooms is measured before harvesting every week. White oyster mushrooms are measured using a ruler attached vertically and horizontally to each treatment. Observation of mushroom growth from mycelium until the mushrooms are ready to be harvested takes ± 1 week. From graph 3 shows that the longer the age of the baglog, it will produce a decreasing height and diameter, this is because the nutritional needs needed by white oyster mushrooms for mycelium growth are also decreasing.

Observations in graph 3 of week 1 mushrooms with an average mushroom height of 7 cm and a diameter of 8 cm, show a difference in height and diameter every week in mushroom growth. This shows that the nutritional needs needed by mushrooms for mycelium growth are sufficiently met in the growing media so that mushroom growth grows quickly within ± 1 week. This is reinforced by the explanation of Rohmah (2005) that the faster the growth of mushrooms and the fewer fruiting bodies that grow, the larger the diameter of the mushroom hood.

Mycelial growth is rather slow in 3 weeks 3 mushrooms so that the height of the mushrooms reaches an average of 6 cm and a diameter of 7 cm, this is because mycelial growth in mushrooms is influenced by several factors, including physical, chemical and biological factors. Physical factors consist of temperature, pH, humidity, light intensity and air circulation *(aeration)*. The growth of mushroom hoods that are many and crowded together causes mushroom hoods to not grow optimally. This is in accordance with the opinion of Tutik (2004) which explains that mushrooms grow to form clumps where if in a clump the number of hoods is large, it will affect the diameter of the hood, namely the mushroom hood is getting smaller.

Another factor that causes fungal growth is one of them is nutrition if the more nutrients contained in the *baglog*, the growth of the fungus will quickly experience mycelial extension, whereas if the nutrients contained are only a few, it will slow down the extension of the mycelium. This is in line with the opinion of Suharnowo & Budipraman (2012) which explains that fungal growth is highly dependent on the nutrients contained in the substrate.

## CONCLUSION

Based on the results of research on the development of an automatic-based mushroom house to optimize the growth and production of white oyster mushrooms *(Pleurotus ostreatus), it is* concluded that this tool was successfully designed in accordance with the targeted plan. With the process of making mushroom houses starting from mechanical components, *control* systems and the finalization stage. Based on the results of functional tests, all have met the criteria of being able to produce mushroom houses that can regulate temperature and humidity automatically with physical conditions that are in accordance with the cultivation of white oyster mushrooms.

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