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APPLICATION OF MICROCONTROLLER TO CONTROL ROOM ENVIRONMENT OF A MUSHROOM HOUSE

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ABSTRACT

The objective of this research is how to control proper room temperature and humidity in a straw mushroom producing house with the targets of 28-33°C temperature, and 80-90% relative humidity. Research was conducted by building a mushroom house (4m wide x 6m long x4m high), steel framed, asbestos roofed with 3mm plywood ceiling, and 60% screen net wall layered with 14%UV transparent plastic. The mushroom house was equipped with a microcontroller to monitor and control the room temperature and relative humidity. Twenty units of SHT22 sensor were installed to monitor the temperature and humidity; eighteen in the room, one above the ceiling, and the last was placed outside the house (above the roof). The system was equipped with 4 units of water sprayer heads to elevate the room humidity and decrease the room temperature. Two units of vents were installed at the upper wall to exhaust the room air when the humidity and temperature were above the optimum ranges. A unit of heater was added at the middle of the room to elevate the room temperature when it went down bellow 28°C. Results showed that when the temperature and humidity were not controlled, they could fluctuate out of the optimum ranges; temperature increased above 33°C and went down to 25°C. Likewise; humidity was ranging between about 50% to saturation. However; when the control was activated, the temperature and humidity were in general close to the optimum ranges.

Keywords: mushroom, microcontroller, temperature, humidity, empty fruit bunch

I. INTRODUCTION

Cultivating of straw mushroom can be a potential alternative in the term of diversification of protein sources, because straw mushroom is one nutritious food with high content of protein. Some edible mushrooms grown in Indonesia are *Agaricus bisporus*, *Auricularia auricula*, *Lentinula edodes*, *Pleurotus ostreatus*, dan *Volvariella rolvacea* or straw mushroom. Straw mushroom dominates the portion by 55%—60% of domestic prouction (Iriana, 2007). However; Production and consumption of straw mushroom in Indonesia is still low, only limited people realize its good nutrition and consume mushroom. The world's production of edible mushroom is about 3,5 million tons/year, whilst Indonesian production is only 68 thousand tons or less than 2% of the world's production (Wakchaure, 2011). The fact showed that mushroom cultivation is very prospective to develop in Indonesia.

Straw mushroom (*Volvariella volvaceae L*) is more preferable to others because of its exceptional taste besides its high content of nutrition. Some researches showed that straw mushroom's protein content was about 25.9-28.5% (Sunandar, 2010). This protein content is higher if compared to rice's protein content which is only 8,4% (ParadiGma, 2014), or to wheat's content which is about 6-17% (Aptindo, 2012). Straw mushroom also contains 9 of 10 types of essential amino acids known. 72% of fat contained in straw mushroom is unsaturated fat. Some vitamins, such as B1 (thiamine), B2 (riboflavine), niacin and biotin are also contained in the straw mushroom. Straw mushroom is also known containing various minerals such as K, P, Ca, Na, Mg, dan Cu (Sunandar, 2010).

Straw mushroom is normally grown on rice straw media, which is firstly added with some fertilizers, limes, and carbohydrate-containing materials, and then composed after all. However; straw mushroom is in fact can be grown on media some cellulose materials other than rice straw especially for agricultural solid wastes such as EFB, dried banana leaf, coconut husk, sugar cane baggase, saw dusk (Mayun, et.al. 2007; Riduwan, et.al. 2013);Additional materials such as rice bran (as sources of carbohydrates), organic/inorganic fertilizers, chicken litters (sources of decomposers and nitrogen), lime (for controlling pH) are added to the main medium and mixed prior to composting (Arifestiananda, 2015; Zuyasna dkk., 2011; Farid, 2011; Ichsan dkk., 2011).

Utilization of EFB used as the growing medium for straw mushroom is prospective in that EFB is abundant waste from palm oil industries in Lampung and even in Indonesia. In addition, EFB is high content of cellulose which is needed for mushroom's growth. The spent medium then can be used for organic fertilizer. Therefore; there is some added value of the solid waste, as the mushroom growing medium and as organic fertilizers or compost.

Straw mushroom is grown in a mushroom house which is so called "kumbung". Proper environment (room temperature and relative humidity) is needed for straw mushroom to grow well. Growers know that the optimum temperature ranges from about 28^{o}C to 33^{o}C, and the optimum relative humidity (RH) ranges from 80% to 90 %. Traditionally growers control room temperature and RH by opening and closing ventilation. They spray the floor with water in order to increase RH. This traditionally method of controlling room temperature and relative humidity is neither accurate nor effective. When temperature sharply elevates, the opening ventilation is not effective enough to naturally deliver the warming air temperature from inside to the outside mushroom house. A mechanical exhaust is apparently required to solve this problem.

Automatically controlled room environment of the mushroom house might be the best solution to get the optimum temperature and humidity needed by mushroom. Researches on the use of microcontroller for controlling hydrophonic plant's environment have been done (Candra at.al, 2016). Other research works on the use of microcontroller to control the mushroom's environment have been found too (Sunarsa dkk., 2010; Akmaludin dan Luthfi, 2014; Karsid et.al., 2015). All of the researches; however, were done in smaller scale models of mushrooms. So we need further pictures of the application of microcontroller on true size of mushroom house in term of controlling the environment. This research aims to observe temperature and humidity profiles in a 4x6x4 m^3 mushroom house.

II. MATERIALS AND METHODS

Research was started by building a mushroom house with the size of 4x6 m^2 large and 4 m high. The structure was supported by steel frame, while the wall was sealed with woven plastic screen and doubled with plastic tarpaulin to get a better thermal insulation. The roof was made of waved asbestoses; ceiling was from 3 mm plywood. The wall was equipped with 2 units of exhaust vents to draw warm air in the inside to the outside of the mushroom house.

Four units of nozzle water sprayers were mounted at the ceiling, to elevate humidity and lower temperature. A mixing vent was also installed on the ceiling in order to make room air homogeneous. A set of heater was placed underneath of the mixing vent. These equipments were all automatically controlled by assembled microcontroller using processor of Arduino Mega 2560. Twenty units of DHT sensor were mounted; 18 units inside the room, one above the ceiling, the last one above the roof (outside the building). After all, the system was calibrated, validated, and then tested before the true mushroom production. Consistency of the temperature and humidity was assessed by using trial and error.

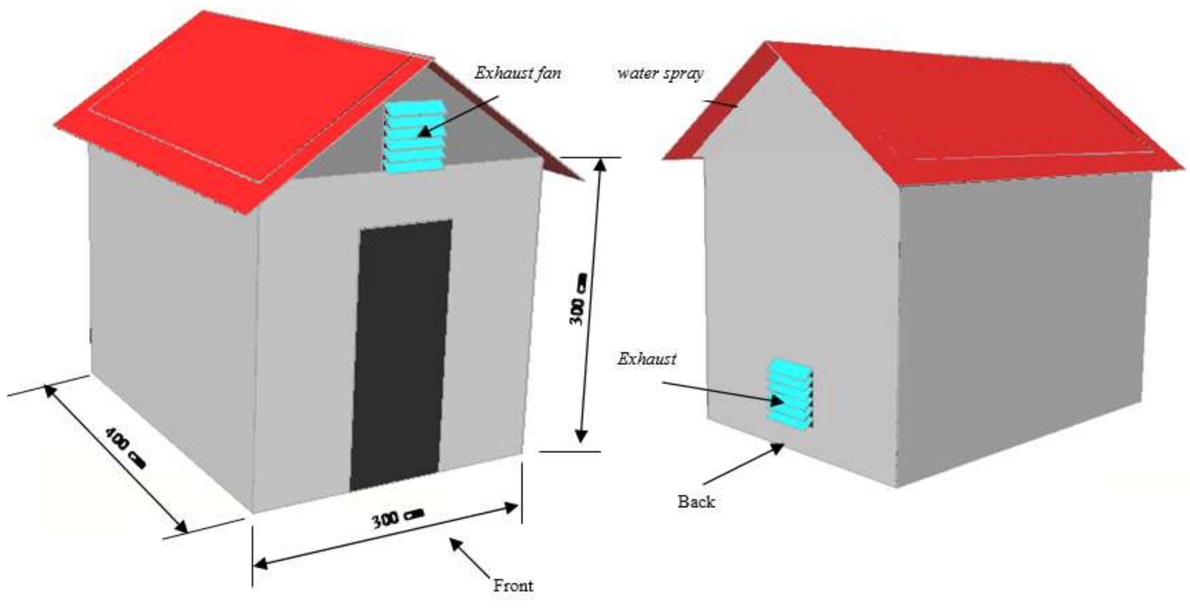

Fig. 1. "Kumbung" the mushroom house

III. RESULTS AND DISCUSSION

A set of microcontroller assembled using the Arduino mega 2560 processor was displayed on Fig. 2. This control monitored temperature and humidity outside the room (two sensors, above the ceiling and above the roof), and also control temperature and humidity inside the room through twenty units of DHT 22 sensor.

Fig. 2. Microcontroller set

Fig. 3 shows hourly temperature profile for one mount. Average outside (above the roof) temperature was 37.46°C, too high for mushroom to grow. Average ceiling (above the ceiling) temperature was 35.43°C, still high for mushroom to grow well. The temperature difference showed the sealing effect of the waved asbestoses roof. Average temperature inside the room was 37.22°C, still higher than the optimum temperature needed, showing that the room temperature needs to be controlled to around be optimum (max of 33°C). Especially just before and after noon, temperature was rising to pick points of almost 40°C which were dead points.

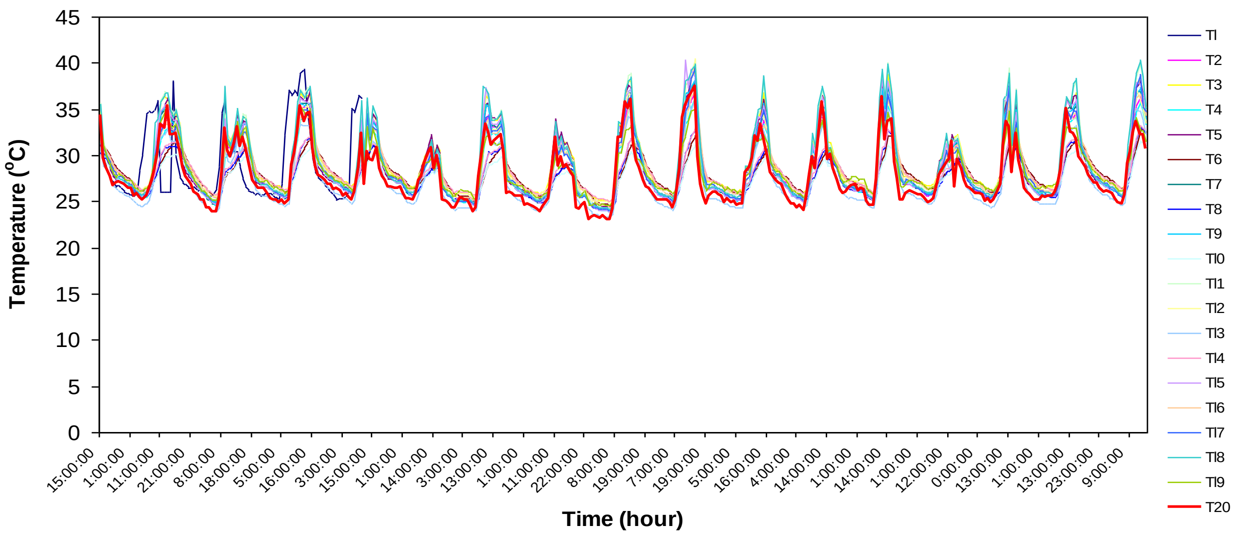

Fig. 3. Uncontrolled room, above ceiling, above roof temperatures

Fig. 4 shows humidity at room, above ceiling, and above roof of mushroom house. Humidity above roof of the mushroom was 98.9% almost saturation, minimum of 74.4%, and maximum of 99.9% just saturation. Above the ceiling, humidity was 92.7% on the average, minimum of 53.1%, and maximum of 99.9%. Inside the room of the mushroom house, humidity was 84.8% on the average, meaning that humidity met the optimum requirement. However, the minimum humidity of 63.5% was definitely too low, meaning that room humidity needs to be controlled. The maximum humidity of 94.1%; however, was fairly close to the optimum range.

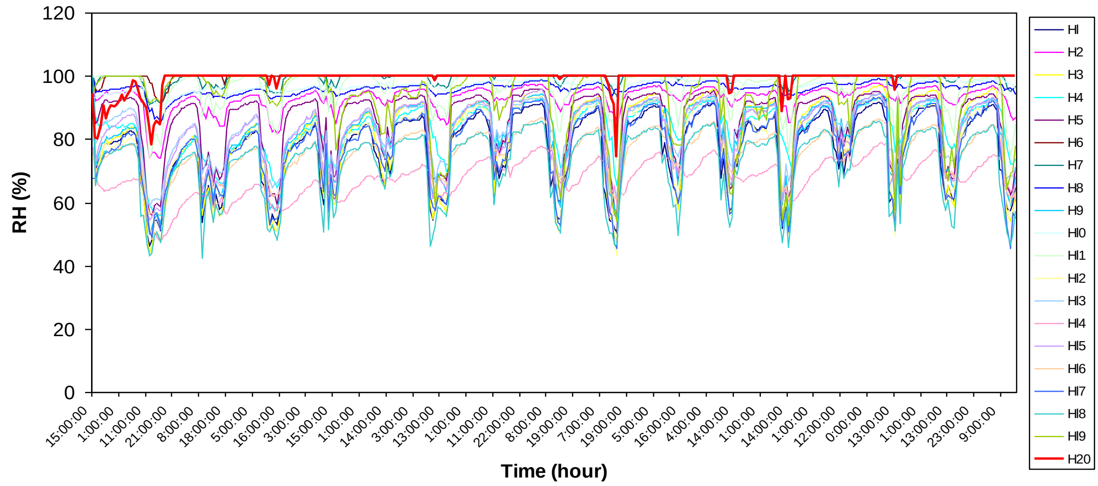

Fig. 4. Uncontrolled room, above ceiling, above roof humidity

Sensors were had to be validated to make sure that the sensor could read properly at saturated humidity. All sensors showed almost the same temperatures for average and minimum temperatures, meaning that all sensors had no problem in reading the saturated temperatures. For maximum temperatures, sensors showing the highest temperature at outside were just normal.

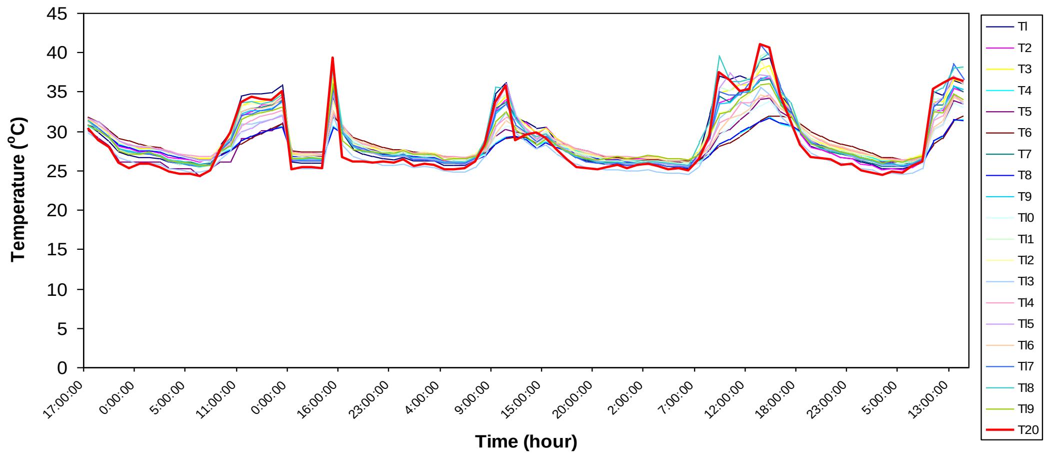

Fig. 5. Room, above ceiling, above roof temperatures at saturated humidity

For humidity validation at saturation, Fig. 6 showed just all sensors could reach saturated humidity, meaning that all sensors had no problem of reading at maximum ranges.

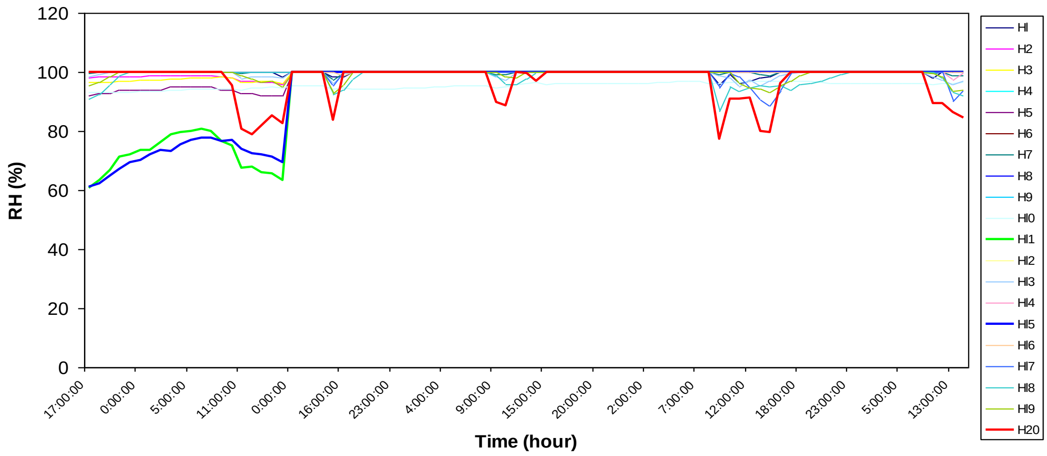

Fig. 6. Room, above ceiling, above roof humidity at saturated points

Fig. 7 showed controlled room temperature, above ceiling and above roof temperatures. Average room temperature of 28.64°C was good since it was in the optimum range. However; the minimum temperature of 25.81°C and the maximum temperature of 35.13°C were somewhat critical points. The minimum temperature of 25.81°C might not so bad, but the maximum temperature of 35.13°C might cause very serious effect on mushroom growth. These critical temperatures mostly happened just before and after noon. This problem implied that some modifications of coding of water spray and exhaust vent were needed to be done.

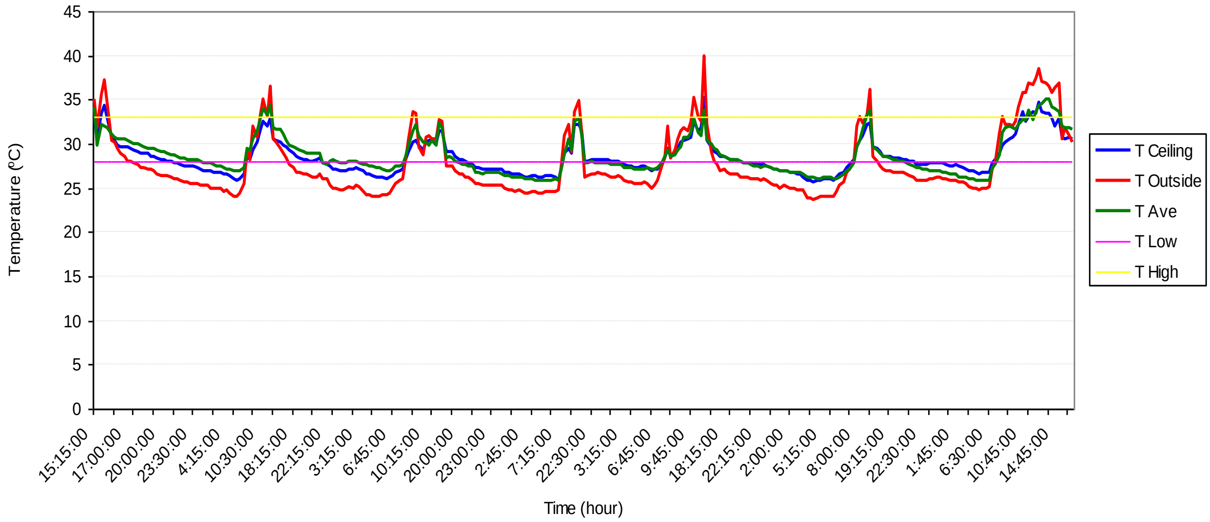

Fig. 7. Controlled room temperature, above ceiling and above roof temperatures

Fig. 8 showed controlled room humidity, above ceiling and above roof humidity. Average room temperature of 96.83 was above the designed range which is 80-90%. It suggested that some modification of exhaust vent operation modes and water sprayer were needed to be taken to get the best condition in the room in the mushroom house. However; the effect of high humidity on mushroom growth was not as critical as the effect of temperature.

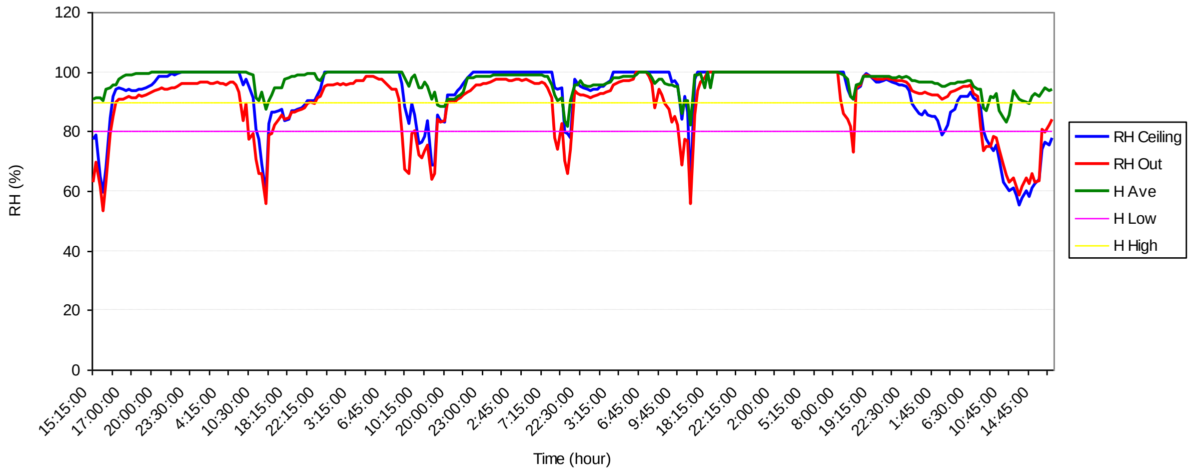

Fig. 8. Controlled room humidity, above ceiling and above roof humidity

IV. CONCLUSION

Based on the data showed, some conclusions that can be taken were:

1. Temperature and humidity Sensors (DHT 22) could work pretty well.
2. The control system designed worked very well. However, temperature was easier than controlling humidity. Average controlled inside room temperature of 28.64°C fell in the optimum range, while the average controlled humidity of 96.83% was still above the designed range, and therefore needed some adjustments of the operation modes.

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