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Design an Automatic System to Control and Monitor the Process of Straw Mushrooms Indoors Cultivation

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Abstract

Current straw mushroom farming in countries with large rice growing areas has great development potential, and was once considered a way to generate additional income and reduce poverty in rural areas. However, currently most people still grow mushrooms using traditional processes, leading to low productivity and unguaranteed output quality. Currently, due to climate change and unusual weather changes, people tend to switch to growing straw mushrooms indoors. In the process of growing straw mushrooms indoors, the design of an automatic control and monitoring system is very important to ensure the growing process is carried out effectively and achieves high yields. In this paper, we propose a system that can automatically control and monitor the humidity and temperature of the indoor straw mushroom growing process and other parameters that can be monitored through a network system using Internet of Things. The control algorithm automatically adjusts the grow house equipment based on feedback from sensors to maintain an optimal environment for growing straw mushrooms. Experimental results show that the straw mushroom growing system with automatically controlled and monitored environmental parameters helps improve efficiency, reduce costs and increase the sustainability of the current straw mushroom growing industry..

Keywords: *Internet of Things, Straw Mushroom, Automation, Monitoring, Control.*

1. Introduction

Straw mushroom (SM) is known as a healthy food and has high protein, potassium, and phosphorus contents while being salt-free and low in alkalinity, fat, and cholesterol [1]. Therefore, SM are a popular food and consumers choose and demand is increasing. Tropical regions have great potential for producing edible and medicinal mushrooms due to its rich source of raw materials for growing mushrooms, abundant rural labor, and favorable weather conditions for the development of many types of mushrooms that can be grown all year round. However, growing SM is difficult in these regions where relative temperature and humidity varies between day and night. Cultivation of mushroom is done by farmers in greenhouse plant where they can control and maintain the specific temperature and moisture condition which suits to growing of mushroom. Currently,

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Vietnam has basically mastered mushroom breeding and production technology for key mushroom species, and the mushroom consumption market is increasingly expanding. However, today's traditional mushroom production process in Vietnam is still subject to many impacts from the environment and climate change. Since then, mushroom production has not been high, there has been a lot of loss, and the quality of mushrooms has not been high due to being often affected by diseases. SM can be used and processed into many different products but it is easily damaged during harvesting and primary processing. The choose of suitable technology for product storage and processing on a scale that is compatible with production conditions will promote the cultivation of mushrooms and keep stabilize consumption. As environmental factors such as temperature and humidity play a significant role in the growth and development of mushrooms, precise control of these variables is essential. Because the optimal temperature is from 30 to 35 °C for the SM's mycelial growth and from 28 to 30 °C for its fruiting body production [2]. And the suitable temperature for growing mushrooms is between 25 and 40 °C with the optimum being 35 °C [3]. Relative humidity in the range of from 70% to 90% is best for SM growth [4]. So maintaining the required condition is difficult with convectional system as in dry season it requires extra energy to sustain the required temperature and humidity level. This need required exploration of smart intelligent control system to increase the cultivation of mushroom with sufficient energy requirement. Based on actual needs, the increasing demands of the market, plus the strong development of science and technology, especially information technology, electrical and electronic engineering, Internet of Things (IoT) technology, automation.... The proclivity towards cultivating SM within the confines of agricultural practice delineates a pathway laden with the potential for both quirky innovations in the domain of agriculture as well as an astute economic ascension. By adopting technologies related to the IoT, like those used in controlling environmental factors for straw mushroom farming purposes, agricultural methodologies are significantly improved through the direct observation and meticulous adjustment of critical elements such as warmth and moisture levels. These strategies yield important knowledge regarding vegetation development and permit timely interventions to maintain an environment conducive to achieving peak productivity and quality standards. Furthermore, applying these monitoring approaches within agriculture, as demonstrated through advances in overseeing environments tailored for mushroom cultivation areas, holds promise for overhauling farm operations by introducing automated management abilities that champion intelligent agriculture leading towards better outputs and eco-friendly crop production methods. Currently, the application of IoT technology plays an increasingly important role in the agricultural production process and is becoming a strong development trend. And applying IoT technology in growing SM does not depend on the weather and grower's experience to monitor and control the parameters of temperature, air humidity, light and CO2 concentration in the mushroom house ensuring that mushrooms are grown in the most suitable conditions without human impact is the current development trend.

Many of the researchers developed the environment monitoring system based on Internet of thing for mushroom cultivation [4, 5]. An IoT based monitoring system for indoor SM cultivation at a minimal cost in terms of hardware resources and practicality was developed by [6]. Furthermore, a monitoring system was presented for mushroom house to monitor humidity, temperature, and light intensity with android device and real live data platform [7]. Beside, Application of IoT for monitoring and environment control for indoor cultivation of oyster mushroom was addressed by [8]. The approach utilized fuzzy controller to monitor humidity in the cultivation of oyster mushroom [9, 10]. Although these research articles have solved the problem of monitoring environmental parameters for mushroom growing, the automatic adjustment of parameters to optimal values has not been completely solved. Therefore, this paper proposes an automatic system to control and monitoring for indoor SM cultivation at minimal cost and suitable to the conditions of Vietnam.

2. Method

2.1 Control Diagram Design

The illustrated diagram for the research methodology is shown in Fig. 1. Sensor system which placed in SM house include humidity sensor and temperature sensor so that they control the humidity and temperature indoor. The Cooling Pad system combines with the Heater and the Pump to control the humidity and temperature inside the mushroom house.

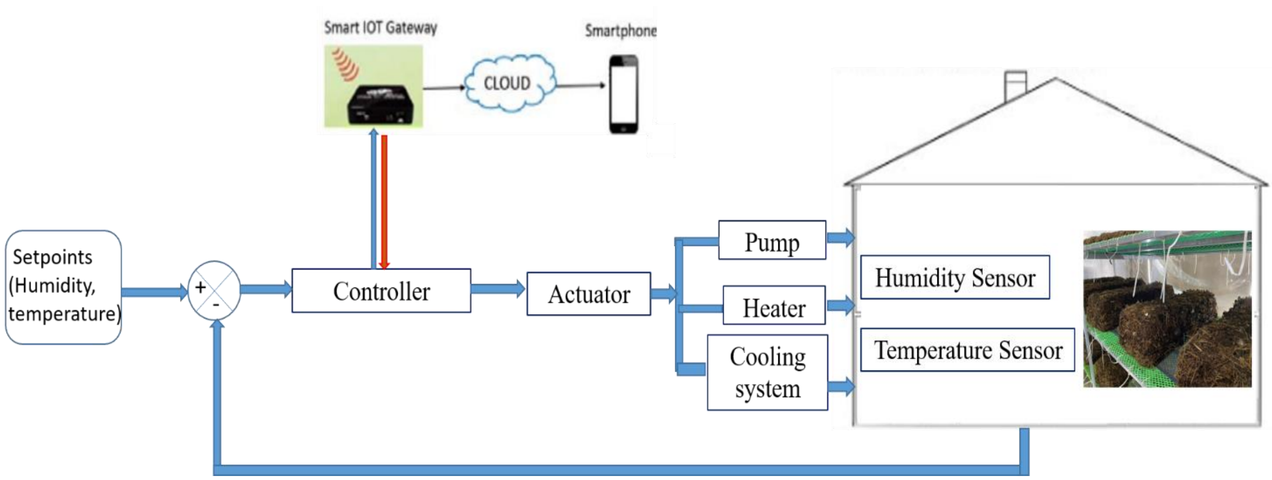

Figure. 1. An illustrated Block Diagram of Automatic Control and Monitor System for indoor SM cultivation

Set point is the optimal value of a system desired to achieve is shown in Table.1 [1, 2].

Table 1. Environmental parameter requirements for SM growth with 2 period: Mycelium and Fruiting

	Mycelium		Fruiting	
Parameter	Range	Optimal	Range	Optimal
Temperature, °C	15–42	35 ± 2	25–30	28 ± 2
Relative humidity, %	50–70	60 ± 5	80–100	90 ± 5
pH	6–7	6.5	6–7	6.5

In this study, set point of mycelium period is the most optimal humidity and temperature value to grow maximal. So the most optimum temperature value is 35±2^{0}C and the most optimum humidity value is 60±5 %, respectively. And set point of fruiting period with the most optimum temperature value is 28±2^{0}C and the most optimum humidity value is 90±5 %, respectively. Sensor in the control system serves to get the controlled variable value so the system can correct if there is a non-conformity of the controlled variable with the set point. In this study, the controlled variable is humidity and temperature. The humidity sensor and temperature sensor play a role in reading the humidity and temperature change which will then be compared with the set point.

2.2 Hardware Design

The experimental hardware system is shown in Fig. 2. The control system consists of Arduino Uno Rev3, Node MCU ESP32 and DHT 22 [11,12]. This component can detect the changing of temperature and humidity of the mushroom house. Node MCU ESP 8266 serve as a Wi-Fi to upload the data into the cloud sever that act as IoT platform.

Based on the proposed system design and operations, an automatic control system was installed in an indoor mushroom house. The interfacing of the whole system was done by the Blynk app [13].

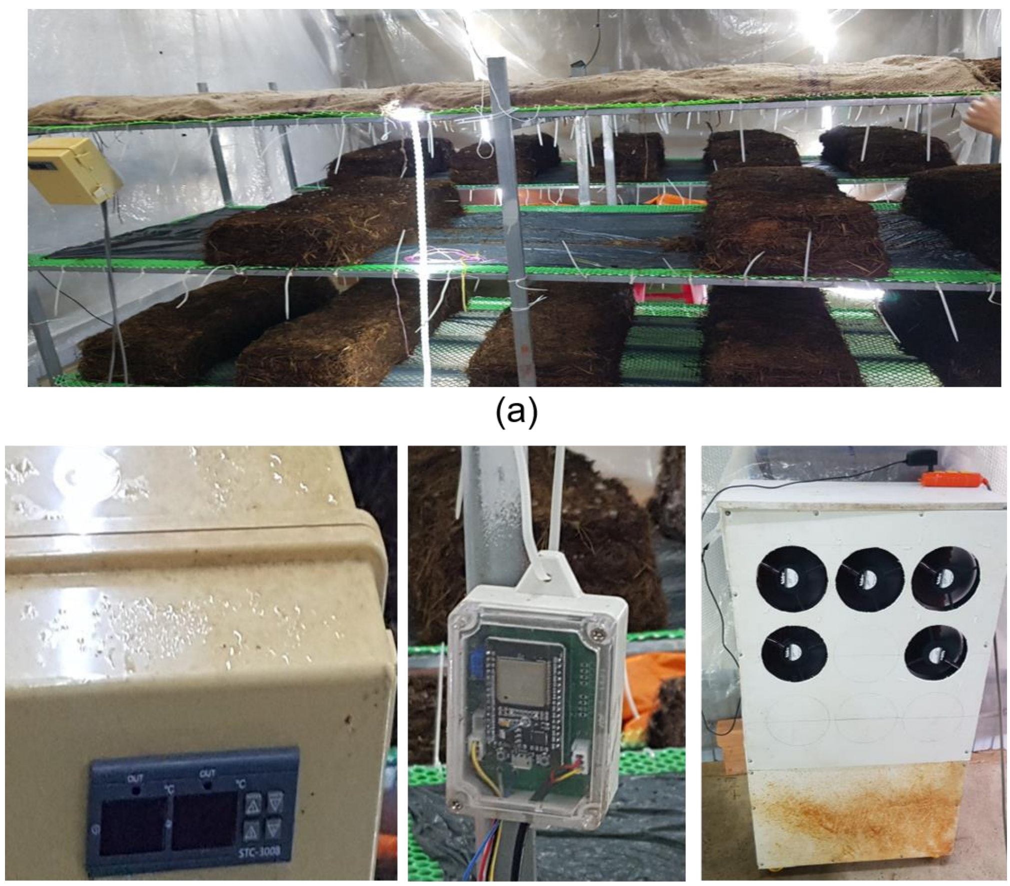

Figure. 2. Components of Control system (a) SM Cultivation indoor, (b) Temperature controller, (c) Controller and (d) Humidity control system

3. Results and Discussion

The temperature values in the mushroom house change in 1 day for the mycelium stage (Fig.3) and the fruiting stage (Fig.4). The results show that the temperature value is always controlled and maintained within the optimal set value when the ambient temperature changes.

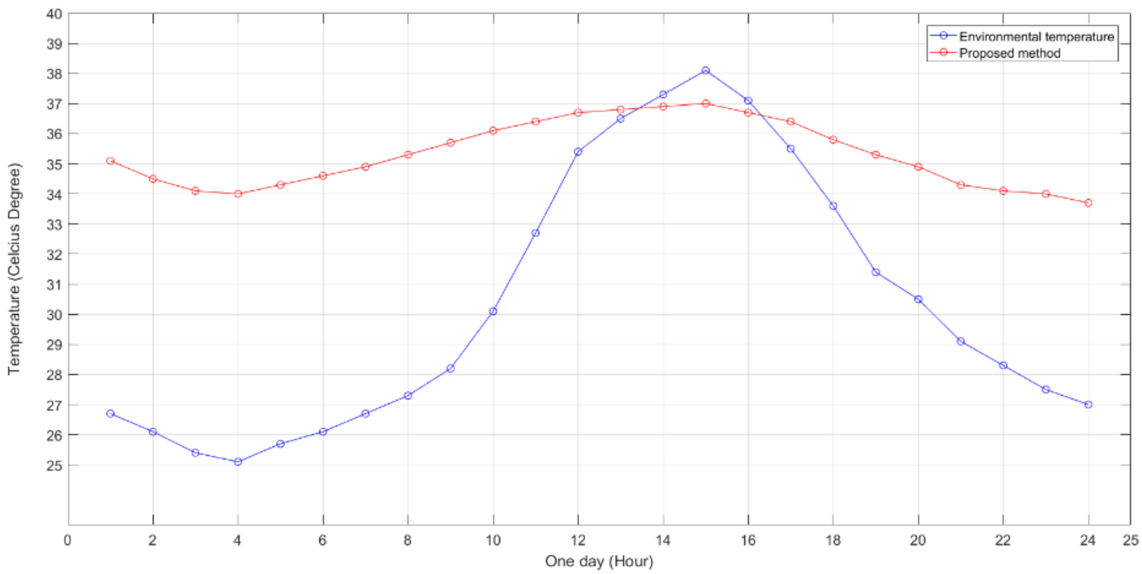

Figure 3. Temperature monitor in SM cultivation indoor in one day in Mycelium period

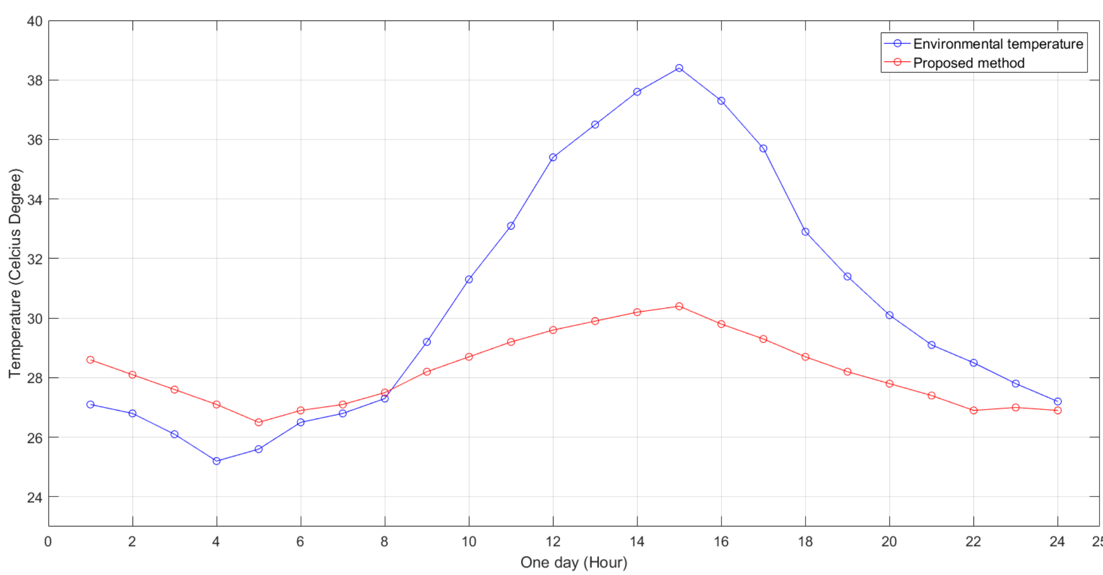

Figure 4. Temperature monitor in SM cultivation indoor in one day in fruiting period

Similarly, the humidity values in the mushroom house changes in 1 day for the mycelium stage (Fig.5) and the fruiting stage (Fig.6). The results show that the humidity value is always controlled and maintained within the optimal set value when the ambient humidity changes.

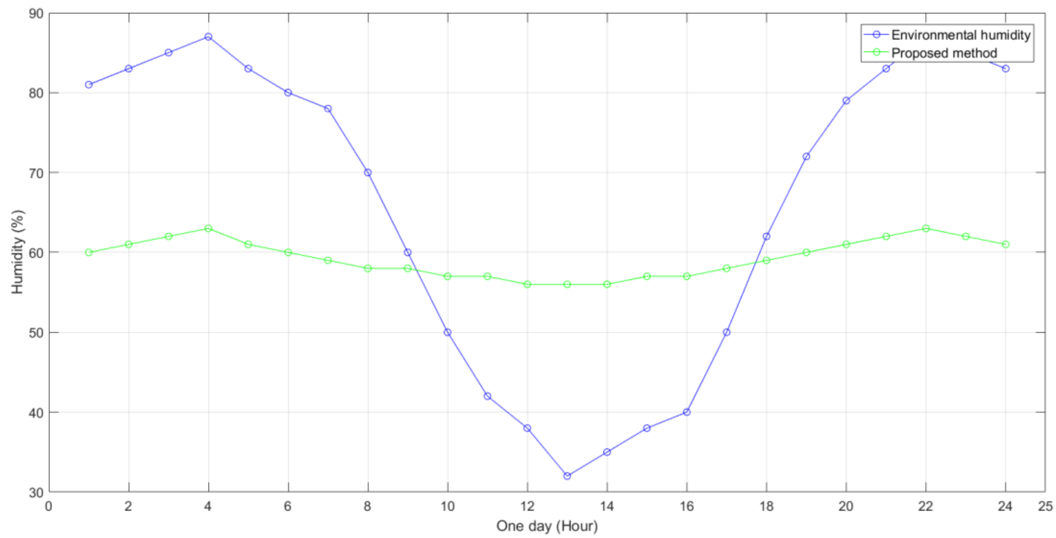

Figure 5. Humidity monitor in SM cultivation indoor in one day in Mycelium period

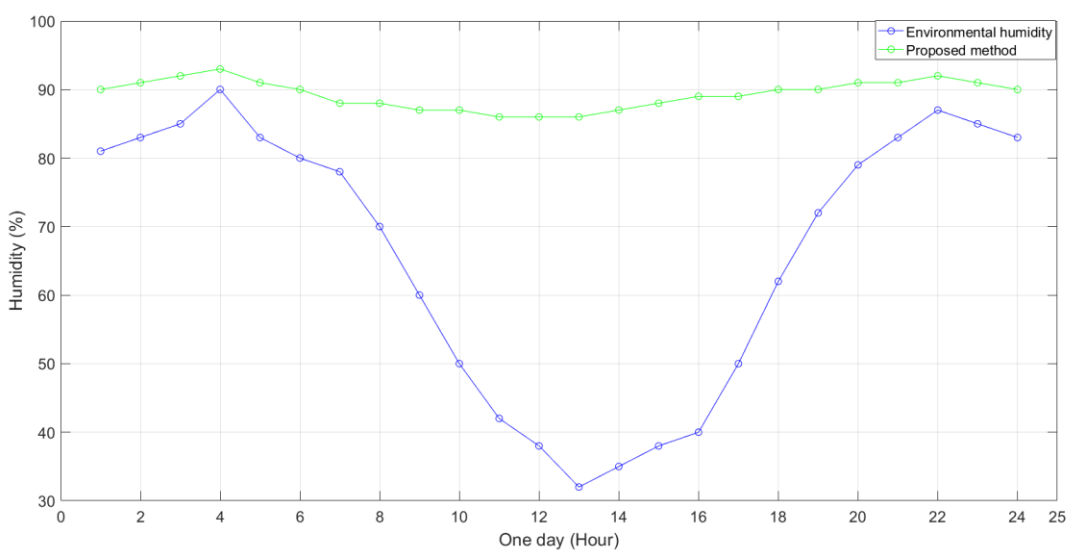

Figure 6. Humidity monitor in SM cultivation indoor in one day in Mycelium period

To monitor the parameters installed inside the mushroom grow house through the IoT system, we designed the apps which runs on the Android and IOS operating system as shown in Fig.7. The push button turns on/off the actuator devices (Fan, Pump,). The chart is used to monitor humidity and temperature inside the SM house in real time with monitoring cycles of 1h, 6h, 1 day, 1 week, 1 month and 3 months.

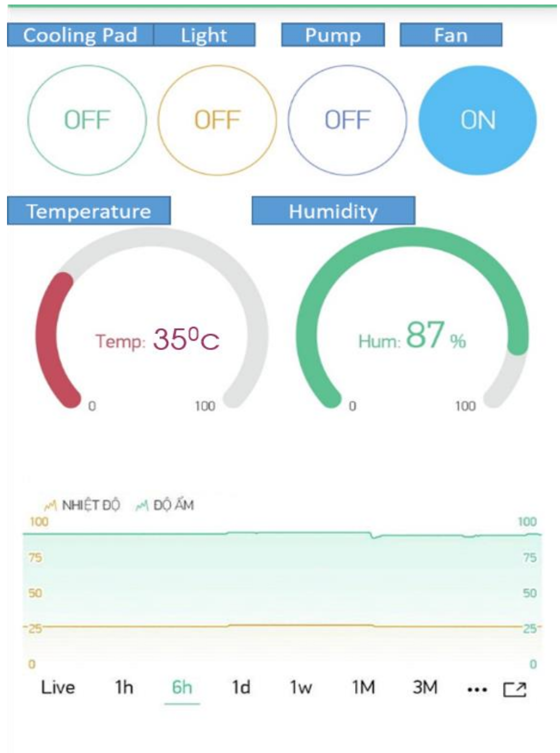

Figure. 7. Apps dashboard for data monitoring in the SM house

The results of growing process of indoor SM cultivation are shown in Fig. 8. After 5days, the SM grows in Fig.8 (a) and after 8 days the SM grows in Fig. 8(b) and after 12 days the SM grows in Fig.8 (c).

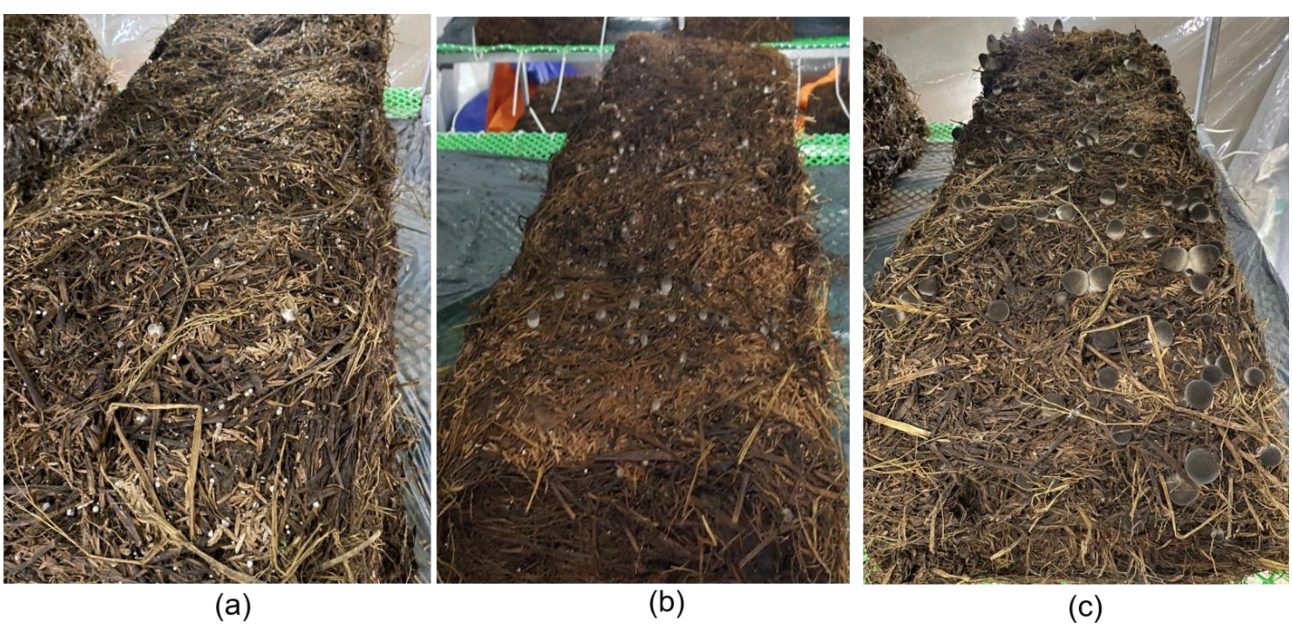

Figure. 8. The growing process of the indoor SM cultivation (a) after 5 day; (b) after 8 days and (d) after 12 days

4. Conclusion

Straw mushroom farming in tropical countries is currently an agricultural industry with potential for development and high profits. However, growing high-quality straw mushrooms is still difficult because of uncontrollable environmental factors. In this paper, we designed and implemented an automatic control and monitoring system to grow SM in indoor spaces. A hardware system designed simply at low cost, suitable for production and replication. Initial research and experimental results show that the temperature and humidity values in the mushroom growing space are controlled and maintained depending on the surrounding environmental conditions. The success of this straw mushroom growing system helps improve productivity, increase quality, reduce dependence on changing environmental factors and especially reduce the labor required in controlling and maintaining requires a mushroom house environment using traditional manual methods.

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