

IoT Applications in Fermented Tempe Production

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Abstract—Tempe is made from fermented soybeans with the fungus *Rhizopus Oligosporus*. In the manufacture of tempe producers often experience failure. The main cause is the temperature and humidity of the room where the tempe production is not maintained. The absence of supporting devices for detecting temperature and humidity in the factory is an obstacle in the tempe fermentation process. Manufacturers can only estimate the temperature and humidity in the fermentation chamber. If the temperature is considered too hot, tempe producers will come to the factory and open the air vents so that the room temperature returns to normal. To increase tempe production and reduce the risk of production failure, it is necessary to design an automatic control and monitoring tool through the use of the Internet of Things (IoT). The tools used in this research are ESP8266, DHT22, Relay, Power Bank as a power source, fans, and lights. The results obtained from the test are that if the temperature and humidity are above or below the normal temperature (250C-320C), a notification will appear on the user's smartphone via the Blynk application. If the temperature is too hot, the fan will turn on automatically. If the temperature is too cold, the light will turn on. Monitoring data can also be viewed on the things peak website in graphic form.

Keywords—controlling, fermented tempe, IoT, monitoring, humidity, temperature.

I. INTRODUCTION

One of the most popular traditional foods of Indonesian society is tempe. Tempe is made from fermented soybeans with the help of the *Rhizopus oligosporus* mold. Besides having a cheap, affordable price and good taste, tempe also has high nutritional content needed by the body such as protein, fat, carbohydrates, and minerals. Several studies have shown that the nutrients contained in tempe are easier to digest and absorb by the body compared to soybeans [1]. The main factors that affect the fermentation process are temperature

and humidity. A good temperature for tempe fermentation is 25-32^o C and 70 - 80% humidity.

Unpredictable weather causes the *Rhizopus oligosporus* mold to not develop properly and even the mold will die. This causes tempe not to be formed on time and its quality is also reduced and even production fails. Tempe producers often experience production failure. One of them is the Harber tempe factory which is located on Jalan Pelita, West Sidomulyo, Tampan District, Pekanbaru City. The cause of the failure was weather conditions that tended to change and were erratic. In addition to weather factors, the absence of supporting tools for monitoring temperatures and humidity in the factory is also an obstacle in the tempe fermentation process.

Tempe producers do not know for sure the temperature and humidity that must be maintained for the fermentation process. Manufacturers can only estimate the temperature and humidity conditions in the fermentation room. If the temperature is considered too hot, the tempe producers will come to the factory to open the air ventilation so that the room temperature returns to normal.

Based on the above problems, an application with an IoT platform was created to remotely control and monitor the temperature and humidity in the tempe fermentation room. This system will make it easier for tempe producers to control the temperature and humidity in the fermentation room without having to come to the factory. Internet of Things (IoT) is a concept where objects in physical form can be connected and transfer data through the internet network by sensors. The IoT concept describes every object that can be connected to the internet and can be controlled remotely without having to be in place. With the support of IoT, work will become faster and easier.

If the temperature and humidity exceed normal limits, tempe producers will get a smartphone notification via the Blynk application. Then if the temperature is too hot the fan will automatically turn on and if the temperature is too cold then the lights will turn on.

II. LITERATURE REVIEW

A. Tempe Fermentation

Fermentation is the process of converting glucose into alcohol which produces secondary and primary metabolites with the ability to be carried out by microbes [2]. Tempe has health benefits and contains 5% fat, 25% protein, 4% carbohydrates, and is rich in vitamin B12 and minerals. Tempe derived from soybeans is easily digested and beneficial for the body rather than consuming soybeans directly [3]. First, confirm that you have the correct template for your paper size. This template has been tailored for output on the A4 paper size. If you are using US letter-sized paper, please close this file and download the Microsoft Word, Letter file.

B. Temperature and humidity

Temperature is a quantity that states the level of hot or cold an object or room. The instrument used to measure temperature is called a thermometer. In people's lives, people usually measure temperature using the sense of touch. However, along with the rapid development of technology, a thermometer was made as a tool to measure temperature. Air humidity is the content of water vapor or states whether something is dry or wet (humid) [2].

C. Internet of Things(IoT)

IoT is widely used by humans to facilitate work that can be controlled, controlled, and monitored with access to internet services that are connected continuously, such as tracking lost objects, tracking human movements, controlling smart homes, and others [4].

The Internet of Things has a working system by utilizing a program that has been created on a machine that has the conditions to produce something desired without human intervention and control it remotely. The internet is used as a liaison between the system and the machine. Humans act as a control, direct control [5].

D. DHT22 sensor

DHT22 is a temperature and humidity sensor specially designed for 1 package. The power consumption used by the sensor is very low so it is suitable for monitoring indoor temperature. DHT22 has a temperature measurement range on the sensor of 0% to 100% while humidity has a measurement of around 40oC to 125oC. This sensor has 3 pins, namely, pin 1 Vcc as a voltage source, pin 2 data as input /output, pin 3 as the ground which can be connected to other microcontrollers [6].

E. ESP8266 Module

ESP8266 is a module that has a WiFi access chip where in this module has memory, processor, GPIO and has access speeds of up to 160 Mhz. This GPIO will later connect the sensor with the ESP8266 or Arduino microcontroller. Along with the development of technology, ESP8266 released many versions starting from ESP8266-01 to the latest version, namely nodeMCU. NodeMCU is a board that has a shape similar to Arduino, but the advantages of this nodeMCU besides being able to be programmed using the Arduino IDE

can also be programmed using the Lua language, besides that it also has 16 GPIO pins and a USB port. The following is Figure 1 of the types of ESP8266 modules and Figure 1 the shape of the ESP8266 nodeMCU [7].

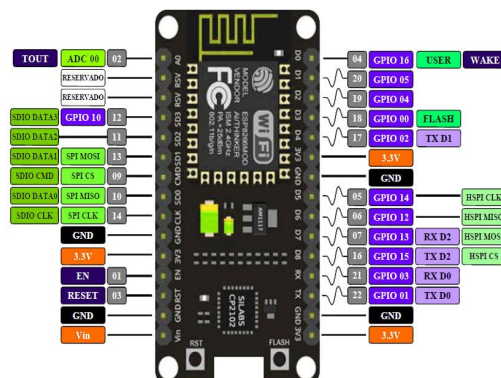


Fig. 1. NodeMCU form [8]

F. Relay

The relay function is used to control high voltages through the help of low voltage current signals, provide delay delays, and can carry out logic functions given during programming. Relays are used to connect and disconnect high electric currents by replacing them with small electric currents where the relay consists of a coil and contacts. The coil serves to get current from electricity from the coil of wire while the contact serves to determine whether the switch is energized by the electric current provided by the coil. Figure 2.8 the shape of the relay and the symbols contained in the relay [9].

G. Blynk App

Blynk is software used for IoT communication with an interface to monitor and control hardware from android devices that can be controlled remotely. The blynk application can be accessed via Android and IoS. Blynk is perfect for tracking home security movements, monitoring temperatures, turning on fans, and turning off lights remotely.

H. Thingspeak Website

The thingspeak website is a service that is used to store data, visualize data and retrieve data sent by the chip. Thingspeak has a unique identifier used which has API keys. These API keys will be used as identity numbers to be able to receive data sent by the microcontroller via Hypertext Transfer Protocol (HTTP) or Local Area Network (LAN).

I. Previous Research

Research by Alfannizar [11] designs tools for the manufacture and control of home electricity using the Internet of Things concept. The tools used in this research are Arduino, ESP8266, relay, LED. This design is made to control the existing equipment at home. Where control uses network access that can be controlled remotely. The control carried out is in the form of controlling household appliances, such as lights, televisions, air conditioners, and others where the control data is sent to things peak to see if the home devices are successfully controlled or not. From the results of the research above, it was found that the test with data transmission time was around 1.93 seconds and the longest data transmission was about 8.51 seconds. This time factor is influenced by the distance between the router and the device to be controlled.

Research by Wijanarko [2] monitoring temperature and humidity with an SMS gateway through a microcontroller-based tempe fermentation that can be controlled automatically. The research was conducted using Arduino Uno, LCD, SHT11 sensor, relay, and lamp. The microcontroller is used to read the input generated by the sensor, where this sensor will be used to read the temperature on the tempe incubator then the data from the sensor is displayed on the LCD and can be monitored via a smartphone. The function of this incubator is to regulate heat, temperature, and humidity.

Research by Rizaldi [11] designs for humidity and temperature control in the manufacture of tempe using the Arduino Uno microcontroller. This research uses tools including Arduino Uno, SHT11 sensor, fan, and lamp, nozzle, relay. Arduino is used to reading temperature and humidity inputs generated by the SHT11 sensor, drive fans, and relays on lights and nozzles. The fan functions to regulate the temperature in the tempe room so that the temperature is maintained properly according to the set point. The lamp serves to regulate the temperature of the incubator. The function of the nozzle is to adjust the humidity as needed. The results obtained function according to the purpose, where humidity can be controlled by pressing the on or off button. With this design, it is easier and faster to ferment tempe compared to not using a temperature incubator with an error of 2%.

Vandra [12] has done monitoring humidity and temperature using ATmega328 on decomposition in the compost fertilizer process. This research is designed to overcome the effect of maturity on compost fertilizer at temperature and humidity to overcome farmers in the decomposition process which has been done manually which causes cultivation to be inefficient. Which has a good temperature value for fertilizer around 38°C with 60% of humidity. The results obtained are when the sensor is inserted into the compost pile, the sensor will detect the humidity and temperature in the fertilizer. The data that has been obtained from the sensor will be converted into a microcontroller-controlled ADC. With these results, it is hoped that automatic monitoring of information regarding humidity and temperature from mixing the ingredients to the decomposition into mature fertilizer is expected. With the characteristics of brown fertilizer, smelly and loose. The time it takes to make is about 45 to 60 days.

III. RESEARCH METHODOLOGY

The research method describes the stages carried out in the research. Starting from identifying problems that occur during the tempe fermentation process than conducting a literature study that supports research, problem-solving, identification of system requirements, application design to the system testing stage.

A. Software Design

Software design starts from installing the Arduino idea software which is used to program by writing source code. Before writing the program, first prepare the library that will be used. Then create a field on thingspeak that has been registered for temperature and humidity monitoring data storage. In the blynk application, create a widget as a notification that will be sent to the smartphone if the

temperature and humidity in the tempe fermentation room are above or below normal temperature. Figure 2 shows the system flowchart.

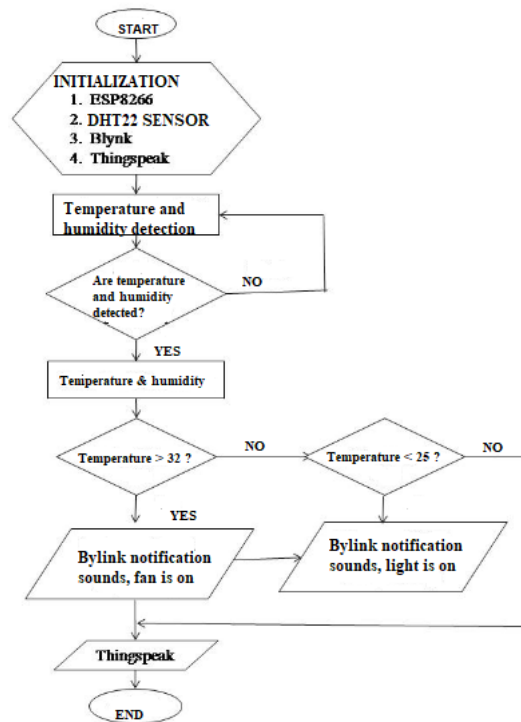


Fig. 2. System Flowchart

B. Hardware Design

At this stage, the researchers carried out hardware design such as the design on the ESP8266 with a DHT22 sensor, the design of the ESP8266 with relays, lights, and fans. This design uses Fritzing software to design the circuit to make it easier for users who need design tools and documentation on systems that use breadboards. Figure 3 shows a block diagram of the system.

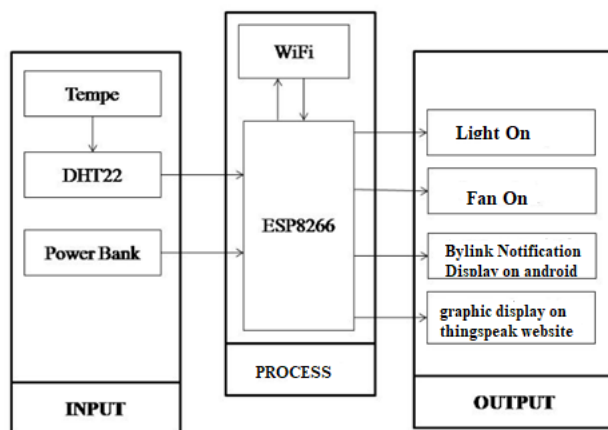


Fig. 3. Block diagram of the system

C. Electronic Schematic Design

Fritzing is software used to design electronic circuits (hardware). Table 1 is the relationship between the DHT22 sensor pins and the ESP8266.

TABLE 1. DHT22 SENSOR PIN CONNECTION WITH ESP8266

DHT22	ESP8266
Vcc	3,3V
Data	D7
GND	GND

TABLE 2. RELAY MODULE PIN CONNECTION WITH ESP8266

Relay Module	ESP8266
GND	GND
IN 1	D5
IN 2	D6
VCC	VU

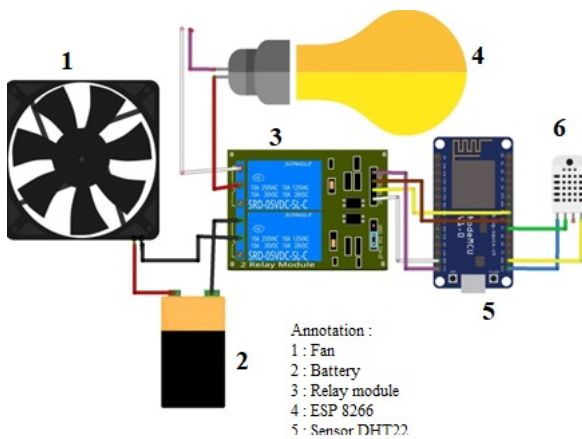


Fig. 4. Schematic design of the whole hardware

In Figure 3, the DHT22 sensor will detect the temperature and humidity of the air in the fermentation room, then if the temperature and humidity exceed or is less than the normal limit, a notification will be sent to the user's smartphone via the blynk application. If the temperature is too hot, the fan will automatically turn on, and if the temperature is too cold, the light will turn on to normalize the room temperature. All monitoring data can be seen on the thing's peak website. To work electronic circuits and software must be connected to the internet.

IV. RESULT AND DISCUSSION

The results of the test of the DHT22 sensor, fan, lamp, and blynk. If the temperature is too hot, i.e. $> 32^{\circ}\text{C}$, the fan will automatically turn on to cool the temperature in the tempe fermentation room while the lights remain off. In the blynk application notification of the current temperature state will appear and the message "WARNING...Temperature is too hot" on the user's smartphone. If the fermentation room is too humid, namely at a temperature of $< 25^{\circ}\text{C}$, the lights will automatically turn on to heat the room, so that the temperature and humidity of the air become normal during fermentation. In this condition, the fan turns off automatically and on the blynk application, a notification will appear with the message "WARNING...The temperature is too humid. However, the

fans and lights on the system can be controlled by pressing the on or off button on the blynk application via a smartphone if the temperature is normally at $25 - 32^{\circ}\text{C}$.

System testing was carried out for three days until the soybeans became the whole tempe. This is done by placing the hardware and tempe bars that have been yeasted into a prototype made of plywood with a length of 50 cm, a width of 45 cm, and a height of 30 cm. According to the size of the prototype box, the number of tempeh bar that can be put into the box is approximately 27 pieces with a tempe size of 30 cm long, 8 cm wide and 3 cm thick. Temperature and humidity monitoring data during tempe fermentation can be viewed on the Things peak website in graphic form. Figure 5 and 6 shows the Graphical Display on the Things peak Website.

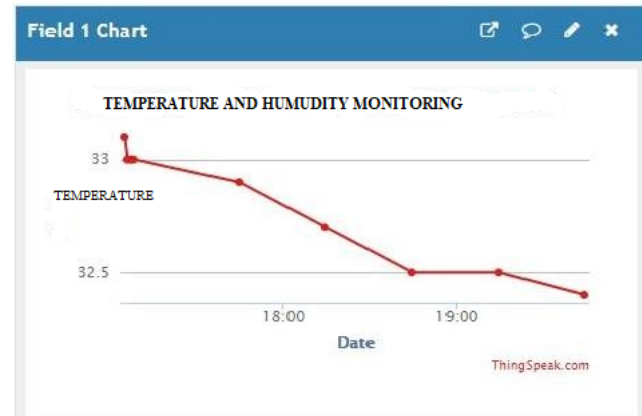


Fig. 5. Temperature Display on think speak website

Figure 5 shows the temperature in the test box when testing was carried out on February 26, 2020 for measurements at 18.00 - 19.00 PM at a temperature of 33°C to 32.5°C .

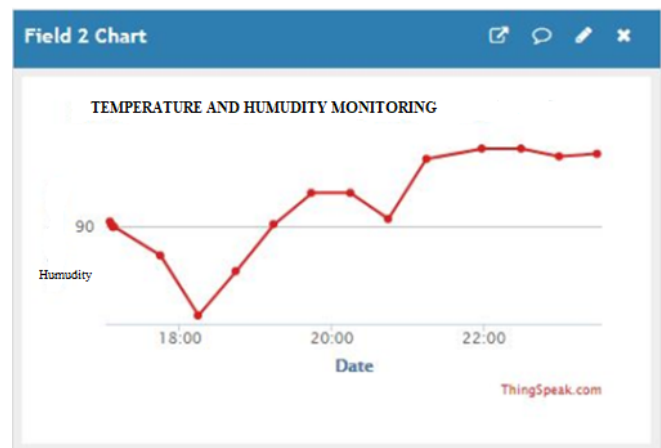


Fig. 6. Humidity Display on thinks peak website

Figure 6 shows the results of humidity monitoring in a prototype box at the same date and time as described above. The measurement results show that the humidity level is in the range of 90 g/m^3 . Based on the results of experiments in the field at the Tempe Harber Factory in Pekanbaru, tempe using this control system will accelerate the growth of molds. Within 23 hours the mold has started to appear and the tempe has started to form, so the time for the tempe fermentation process is shorter than the fermentation without using this system. Thus, the production of tempe will be more optimal and more effective so that its production can be increased. By using this control system, the time used for fermentation is only about 2 days and the tempe mold is fully formed. While

the normal fermentation time for tempe without a system can reach 4 days and sometimes production fails if the temperature and humidity are not normal

V. CONCLUSION

The system that has been designed can function properly according to the purpose, the system can read the temperature and humidity conditions in the tempe fermentation room and send the monitoring data to the thingspeak website. When temperature and humidity are detected by the DHT22 sensor, then the DHT22 sensor will send the temperature and humidity data that has been obtained to the ESP8266. The ESP8266 will forward the data to the blynk app and the thingspeak website. The blynk application serves to provide notifications. If the temperature and humidity in the fermentation room are too hot or humid, a notification in the blynk will appear on the user's smartphone. The fan will turn on automatically if the temperature and humidity of the air in the fermentation room is too hot, namely at a temperature of $> 32^{\circ}\text{C}$ to normalize the indoor temperature. The lamp will turn on automatically if the temperature and humidity of the air in the fermentation room is too humid, namely at a temperature of $< 25^{\circ}\text{C}$. The lamp functions as a heater so that the temperature of the fermentation room becomes normal. The internet connection greatly affects notifications on blynk and data transmission on things peak. If the internet connection is bad then the notification on blynk appears slow as well as data that goes to things peak and even data is not sent.

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