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Design of Gelugur Acid (Garnicia Antroviridis) Dryer Using ESP32 Based on Internet of Things (IoT)

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Abstract

This research aims to design a system for gelugur tamarind dryer and test gelugur tamarind dryer using ESP32 microcontroller. This research uses an experimental method by using ESP32 as a data processing tool given by the DHT22 temperature sensor, then designing temperature and time controls, as well as designing mechanical and electronic devices for the gelugur tamarind dryer. Gelugur acid is dried to be used as a mixture of food or spices. In this tool, the temperature for drying can be adjusted as desired, each temperature set then gets different results. In this drying process is done for hours, in order to get optimal results. The results showed that the original weight of 500 grams of gelugur acid had been dried and sampled within 4 hours with a temperature of 60ºC that had been programmed, and when dry the weight of the acid was reduced to 140 grams if the percentage was 28%. The conclusion that the longer the drying, the less the weight of the acid that was originally wet. The presence of a temperature and time control system shows that this dryer can dry various raw materials, not limited to gelugur acid.

Keywords: *Gelugur Acid, ESP32, DHT22, Internet of Things (IoT), Prototype*

1. Introduction

Asam gelugur, or Garcinia atroviridis, is a type of Garcinia that has long been used by the community. There are gelugur tamarinds all over Indonesia, from Aceh to South Sumatra. The plant is beneficial in a variety of ways, such as being used as a spice, medicine, cosmetics, and even snacks. Gelugur acid, in its dried form, is often used as a cooking spice in North Sumatra, also known as asam potong. The thin, dry, clean and clear-looking cut tamarind of North Sumatra is imported to Malaysia. Once processed into a beverage, the gelugur tamarind content can be used as a fat burner [1].

For many years, gelugur tamarind has been used to add flavor and aroma, as well as a food preservative. Due to its highly acidic taste, gelugur tamarind should not be consumed directly. The asam gelugur plant grows easily, but with the advancement of science and technology, the pulp of the asam gelugur fruit can now be enjoyed in the form of wet sweets, fresh drinks, and jams. and does not require special care, so many people have started cultivating it [2].

In a previous study, "Gelugur Acid (Garcinia Atroviridis) Dryer Using Internet of Things (IoT)-based Atmega 328," it was found that the usual drying technique used by people in gelugur tamarind pieces are cut and dried in the sun to be processed. However, this method is ineffective because it depends on the weather and takes a long time. In addition, the resulting product is also easily contaminated by dust or other airborne impurities, making it unhealthy [3].

Although there have been studies that discuss research around gelugur tamarind drying using different microcontrollers, such as using the ATmega328 microcontroller. However, this research uses the ESP32 microcontroller which is better in terms of memory and processor.

Based on the above problems, the author wants to conduct research. This research is designed to be adjusted as desired, and can be controlled remotely. So the authors conducted research with the title Designing a Gelugur Acid Dryer (Garnicia Antroviridis) Using ESP32 Based on the Internet of Things (IOT).

2. Review the Library

2.1. Dryer or Drying

Food drying is the process of removing the water content in food by passing hot air through the food, which inhibits the growth of enzymes and bacteria. Food that has been dried has nutritional value, is lightweight, easy to process further, and easy to store and use. The drying process requires less energy than freezing, and requires less storage space when compared to canning or storing frozen foods [4].

Traditional drying methods usually involve the use of mats on which the materials to be dried are placed, and then dried in the sun in an open area. The bunded drying system, on the other hand, is more hygienic and does not require a large space. To increase the temperature inside the kebuk, hot air is introduced into it. This removes the water content from the material. This hot air can be obtained from electric heaters, solar energy collectors, or both [5].

2.2. Internet of Things (IOT)

In today's era of globalization, the Internet of Things (IoT) is not a trivial idea. The Indonesian government is also actively using and developing this advanced technology. Frequency bands have been established by the Acting Head of Public Relations of the Ministry of Communication and Information. radio and technical requirements relating to the use of telecommunications devices that support license access (LAA). There are two categories of frequency spectrum: licensed and unlicensed. Band 1 at 2,100 MHz, Band 3 at 1,800 MHz, Band 5 at 800 MHz, Band 8 at 900 MHz, Band 31 at 450 MHz, and Band 40 at 2,300 MHz fall into the licensed category. Bands 2.4 GHz, 5.8 GHz, and the 919-925 MHz range are still under investigation due to potential interference to mobile network operations [6].

2.3. Gelugur Acid

Gelugur fruit (Garcinia atroviridis) is one of the plants used for medicine. It is commonly used by Malays as a seasoning for cooking, but it also has benefits for lowering cholesterol. In addition, this fruit can help reduce weight and cholesterol due to its antioxidant properties. Gelugur fruit is known to contain many organic acids, including atroviridin, atrovirsidone, atrovirinone, gamma-lactone, vitamin C, pentadecanoate, octadecanoate, nonodecanoate, and dodecanoate acids [7]

The gelugur acid plant, also known as Garcinia atroviridis, has many active substances, including alkaloids, flavonoids, saponins, tannins, carbohydrates, proteins, and organic acids such as tartaric acid, citric acid, and malic acid. Asam gelugur leaves contain Hydroxycitric Acid (HCA), which can inhibit the formation of fat and cholesterol. Hydroxytric acid (HCA) is the main organic acid that has antilipidemic and anti-obesity benefits [8]

2.4. ESP 32

Espressif Systems developed the ESP32 as a successor to the ESP8266. It has an integrated WiFi module in the chip, which makes it ideal for the development of Internet of Things (IoT) applications. The pin-out of the ESP32 is seen in figure 2.2, and it can be used as an input or output for various functions, such as controlling lights, LCDs, or even DC motors [9].

The ESP32 microcontroller has many advantages over other microcontrollers, including larger memory capacity, more analog pins, and more pinout pins. In addition, the ESP32 is equipped with with Bluetooth 4.0 Low Energy and WiFi, the ESP32's WiFi feature makes it easy to use this microcontroller for Internet of Things (IoT) applications [10]

2.5. Temperature and Humidity Sensor (DHT22)

DHT22 is a digital sensor used to measure temperature and relative humidity using capacitors and thermistors. After detecting the surrounding air conditions, the sensor sends a signal through the data pin. When compared to other thermohygrometer tools, it has good reading quality, compact size, and affordable price [11].

2.6. Heater

A heater is a device used to increase the temperature of a material. The way a heating element works is quite simple. Unlike conductors, heating elements are made of metals with high electrical resistance, usually using a nickel-chrome alloy called nichrome. When an electric current flows through the element, this high resistance inhibits the flow of current, which generates heat. When the current is turned off, the element will slowly cool down [12].

2.7. Liquid Crystal Dsisplay (LCD)

A type of electronic display called LCD (Liquid Crystal Display) uses CMOS logic technology. Although it does not produce its own light, an LCD reflects light from its surroundings through front-lit or transmits light through back-lit. LCDs display data in the form of characters, numbers, letters, or graphics. LCDs consist of a layer of organic mixture between clear glass and transparent indium oxide electrodes located on the back glass, which form a seven-segment display. When the electrodes are applied voltage, the long, cylindrical organic molecules rotate towards the segment electrodes. In front of this sandwich layer is a vertical light polarizer and behind a horizontal light polarizer. A reflector layer then comes underneath. The reflected light cannot pass through the oriented molecules, so the active segments darken and form the desired data character [13].

2.8. Fan 12 Volt DC

The DC fan has a voltage of 12 Volts DC, a current of 0.25 A, and a speed of about 3200 rpm. It is an electromagnetic device that converts electrical energy into mechanical energy which is then used to drive the fan blades. rpm, and 3 Watts of power. An electric motor uses a DC fan to convert electrical energy into motion. This motor has a pair of stationary U magnets and a moving iron coil. The iron coil becomes magnetized when an electric current flows through it. The periodic rotating force on the coil is caused by the repulsive interaction between the U magnets and their poles. This method connects the fan blades to the shaft of the coil and makes it rotate. By increasing the electric voltage on the coil, the magnetic force of the fan increases. This increases the wind blowing from the fan [14].

2.9. Relay Module SPDT 2 Channel

One type of electrically operated switch is the relay. It consists of two main parts: the mechanical part (switch contacts) and the electromagnet part (coil). Relays work on electromagnetic principles to actuate the switch contacts, allowing a low power electric current to carry a higher voltage [15].

2.10. Buzzer

A buzzer is an electronic component that consists of a coil attached to a diaphragm and serves to convert electrical vibrations into sound. When the current goes through the coil, the transformer turns into an electromagnet. The coil will be pulled in or out, depending on the direction of the current and the polarity of the magnet. The vibration of the coil will make the diaphragm move back and forth, resulting in air vibrations, which produce sound [16].

2.11. LM2596 Step Down Module

The step-down module uses IC LM2596, an integrated circuit that functions as a DC step-down converter with a current rating of 3A. The adjustable version of the LM2596 IC allows for output voltage regulation, and a fixed output voltage version with a fixed output voltage. The above module uses a series adjustable IC, so that the output voltage can be adjusted as needed. One of the advantages of the LM2596 step down module compared to the step-down method using a resistor or potentiometer is that the output voltage remains stable even if the input voltage changes [17].

2.12. Adapter 12 VDC

An adapter is an electronic device that is often used instead of a direct voltage (DC) source, such as a battery, to convert alternating current (AC) with a high voltage into direct current (DC) with a low voltage. or battery. Adapters are usually used to reduce the AC voltage of 220 Volts to 12 Volts DC, having a current capacity of about 2 A. They can also convert AC voltage to DC with a voltage adjusted according to the electrical equipment or load used [18].

3. Analysis and Planning

3.1. Research Stages

The stages of this research serve as guidelines during the research, so that research activities can be carried out clearly and carried out properly and in accordance with the objectives of the research. Research is a method for looking carefully and thoroughly at a problem, so that the problem can be found a solution. Where these stages there is a process that is carried out in a structured, coherent, standardized, logical and systematic manner. The stages of this research consist of problem identification, problem analysis, literature study, prototype planning, prototype assembly, research implementation, research results and conclusions.

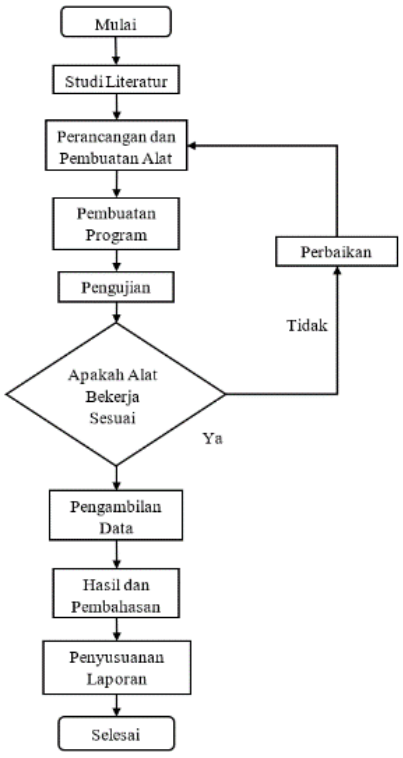


Fig. 1: Research flow chart

3.2. Design of Gelugur Acid Dryer Equipment

3.2.1. Mechanical Design

In the design of this Internet of Things-based gelugur acid dryer, it has a cube-like design that has a height of 39 cm, a width of 40 cm, and a length of 38 cm. as for the electronic parts that support this tool are: 12 volt DC adapter, sensor, ESP32, relay, fan, Heater, and Buzzer. For mechanical design can be seen in Figure 3.2 below.

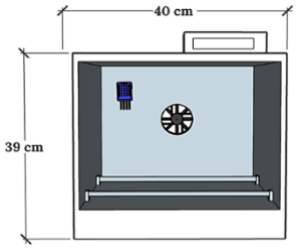


Fig. 2: Gelugur acid dryer

3.2.2. Block Diagram

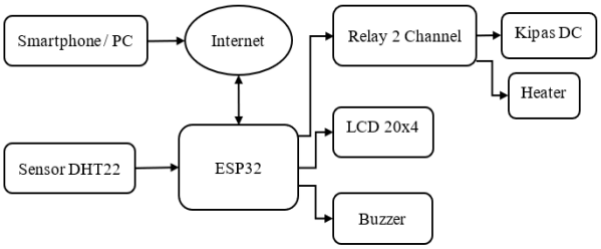


Fig. 3: Block diagram

3.2.3. Electrical Design

Furthermore, this electrical system drawing will show the overall system design, starting from the input, process, and output of the system used. For electrical design can be seen in Figure 4 below.

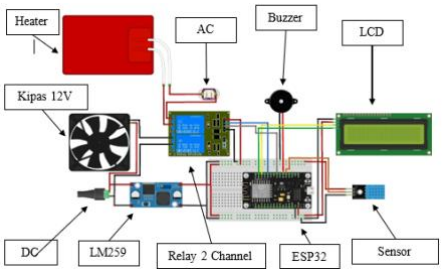


Fig. 4: Wiring diagram

3.2.4. Programming design

Programming design of monitoring and control system using Software
a. Arduino IDE functions as a command access that runs all control components in the tool system.

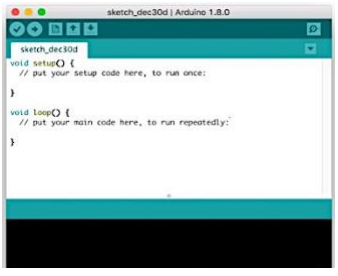


Fig. 5: Arduino IDE software display

b. Verify the program aims to check for errors contained in the program.
c. The IoT website has the main function that includes monitoring and controlling IoT devices remotely.

3.3. Programming Language Used

The programming language used in this research is the C++ and HTML programming languages, where the C++ language is used to program the tool as a whole so that the tool runs in accordance with the objectives of this study, while HTML is used to create an IoT Web which is a place of control and monitoring.

3.3.1. C++ Program Language

The purpose of the programming language is to ensure that the device functions in accordance with the desired specifications, is reliable under the expected operational conditions, is safe to use by the user, is well integrated with other systems, is easy to use, is efficient in energy use and has optimal performance. By conducting comprehensive testing, users can have confidence in the reliability and performance of the controller.

3.3.2. HTML Programming Language

The HTML programming language is used to create an IoT Web which can monitor and control temperature automatically, the software used in creating the HTML programming language is Visual Studio Code software.

4. Results and Discussion

"Design of Gelugur Acid Dryer (Garnicia Antroviridis) Using ESP32 Based on Internet of Things (IOT)", on the system that has been designed and tested. The testing phase begins by testing the system as a whole to determine the level of success and accuracy of the system, trials must be carried out on each component. After all components work well, the system can be operated. Through this system, it can be used as a system that facilitates the drying process of gelugur acid and gets satisfactory results. Test data can be discussed to be used as a basis for making conclusions.

4.1. System Design Results

The design of the Gelugur Tamarind (Garnicia Antroviridis) Dryer using ESP32 based on the Internet of Things (IOT) is divided into mechanical design, electronic design and program design.

4.1.1. Mechanical Design

Mechanical design in this study is in the form of making the installation of the required component components using a dryer box measuring 39 cm high, 40 cm wide, and 38 cm long. Then using a project box measuring 6 cm high, 18 cm wide, and 11 cm long, the results of the mechanical design of the Gelugur Acid Dryer Using ESP32 can be seen in Figure 6 below.

Fig. 6: Mechanical Design

4.1.2. Electrical Design

The electrical design is specifically designed in accordance with the design of the Gelugur Tamarind (Garnicia Antroviridis) Dryer Using ESP32. The electrical design is divided into several parts, namely:

1. Design of a 2-channel SPDT relay on input 1 which functions to turn on and off the heater to regulate heating in the dryer.
2. 2 channel SPDT relay design on input 2 which functions to turn on and off the 12 volt DC fan to circulate hot air from the heater.
3. LM2596 Module design which functions to reduce the voltage from 12 Volts DC to 5 Volts DC to supply ESP32 and the sensors used.
4. Buzzer design which functions to provide information that the drying process is complete.
5. DHT22 design which functions to read the temperature and humidity in the drying box.
6. Design of 20x4 I2C LCD Module which functions to monitor the results of the module.

4.1.3. Acid Dryer Programming

The dryer program is made according to the way the gelugur acid dryer works. The commands used to run the components use two types of software, namely Arduino IDE software and Visual Studi Code software. Here is a display of both software.

1. Arduino IDE Software

Arduino IDE is software used to create programming sketches and is used to program microcontrollers, testing this arduino program is done to find out whether the program made has run as it should. The ESP32 program on the gelugur acid dryer (garnicia antroviridis) using ESP32 based on the Internet of Things (IoT) is as follows.

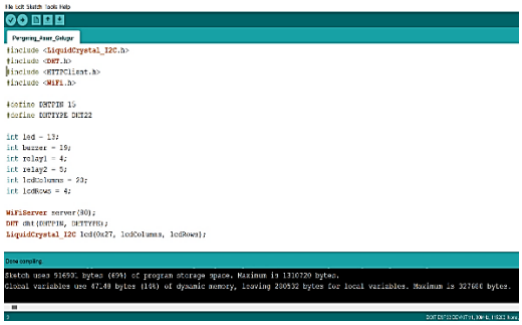


Fig. 7: ESP32 Program

2. Visual Studio Code
Visual Studio Code (VS Code) is a code editor that can be used for web application development.

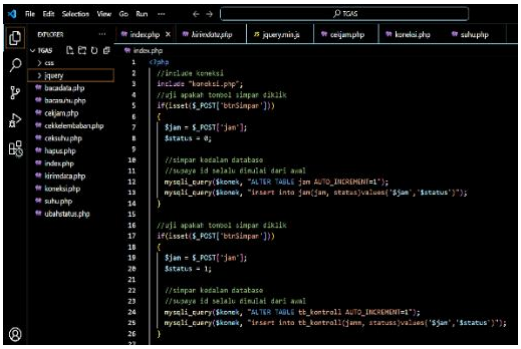


Fig. 8: IoT web programming

The following is a Web Iot display that can control and monitor the gelugur tamarind dryer via mobile phone.

Fig. 9: IoT web view

4.2. System Testing

4.2.1. 12 Volt DC Adapter Testing

To test this 12 Volt DC adapter, the author used a digital multimeter. This adapter requires a PLN voltage of 220 Volts AC as input, and the multimeter is set to voltage meter mode. DC. The output voltage of this adapter is 12 Volts DC, as shown in Figure 10 and Table 1 The resulting measurement result is 12.43 Volts DC.

Fig. 10: Measurement results on a 12 volt DC adapter

Tabel 1: Measurement results of 12 volt DC adapter

No	Component	Input	Output	Status
1.	12 Volt DC Adapter	AC 220 Volt	12,43 Volt DC	Good

In the measurement of the 12 Volt DC adapter, the result is 12.43 Volts DC, indicating that the 12 Volt DC adapter is in good condition so that the expected output voltage is appropriate.

4.2.2. LM2596 Module Testing

To test this LM2596 module, we used a digital multimeter. This adapter accepts a voltage of 12 Volts DC from its input, and the multimeter is set to DC voltage measuring mode. It outputs a voltage of 5 Volts DC, as shown in Figure 11 and Table 2.

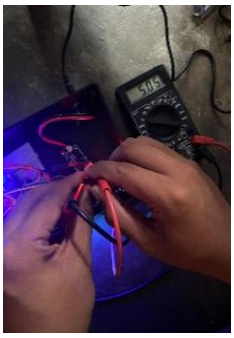


Fig. 11: Measurement results on the LM2596 module

Tabel 2: LM2596 module test results

No	Component	Input	Output	Status
1.	LM2596 module	DC 12 Volt	DC 5,05 Volt	Good

In the measurement of the LM2596 Module, the result is 5.05 Volts DC, this indicates that the LM2596 Module is in good condition so that the expected output voltage is appropriate.

4.2.3. Testing the I2C LCD Module

To ensure that the communication between I2C devices works properly, we tested this I2C LCD module. I2C is a serial communication protocol used to connect microcontrollers with devices such as LCDs. Here are the test results as shown in Figure 12 Table 3.

Fig. 12: Test results on 20x4 I2C LCD module

In testing the I2C LCD Module, the results are good so that it can be confirmed that the I2C module is functioning properly and can communicate with the microcontroller effectively.

4.2.4. DHT22 Sensor Testing

To test its performance in terms of temperature, the DHT22 sensor is installed under actual environmental conditions. Then, the results recorded by the DHT22 sensor are compared with the results of a digital thermometer. This data collection is from the dryer box that has been made as a place of testing and research. The following observation results are shown in Table 3.

Tabel 3: Test results of 20x4 I2C LCD module

No	**Temperature (ºC)**		**Error(%)**
	DHT22 Sensor	**Thermometer**	
1.	34	33	1
2.	33	33	0
3.	39	40	1
4.	40	41	1
5.	44	45	1
6.	46	48	2

The temperature observation from the DHT22 sensor results in a temperature of 34.30ºC, while the temperature observation from the thermometer results in a temperature of 33.0ºC. This indicates that the DHT22 sensor is still tolerable.

4.2.5. 12 Volt DC Fan Testing

In functional testing of the 12 Volt DC fan with ESP32, the first step is to assemble all the necessary devices, including ESP32, 12 Volt DC fan jumper cable and power source, according to the picture, the 12 Volt DC fan is connected to ESP32 using a jumper cable through a 2 channel relay, ensuring the connection between the two is in accordance with the pin configuration that has been previously set as can be seen in Figure 13 below.

Fig. 13: 12 Volt DC Fan test results

In the picture above, testing has been carried out on a 12v DC fan, where the dc fan can move or activate if the temperature of the gelugur acid dryer is above standard.

4.2.6. Buzzer Testing

In functional testing of the Buzzer with ESP32, the first step is to assemble all the necessary devices, including ESP32, Buzzer, jumper cables and power source, according to the picture, the Buzzer is connected to ESP32 using jumper cables, ensuring the connection between the two is in accordance with the pin configuration that has been previously set as can be seen in Figure 14 below.

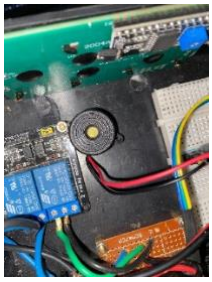


Fig. 14: Buzzer test results

In the picture above, testing has been carried out on the buzzer, where the buzzer can sound or be active if the gelugur acid drying is complete.

4.3. Drying Test Results

4.3.1. Drying Testing of Tamarind

The gelugur acid drying test was conducted at 60°C with a drying time of 2, and 4 hours, using a wet weight of 500 grams. After the drying process, the dry weight obtained got lighter as time increased, and reached 140 grams after 4 hours. Thus, the weight percentage of gelugur acid reached 28% of the wet weight, and has met the desired dryness level. The test results can be seen in Table 4.

Tabel 4: Weight test results of gelugur acid

Experiment	Temperature (ºC)	Time (hour)	Weight (gram)		Results
			Wet	Dry	
1.	60	2	500	250	No
2.	60	4	500	140	Good

Here are the wet gelugur tamarind fruits that have been cut into slices weighing 500 grams, as can be seen in Figure 15.

Fig. 15: Gelugur acid is cut into slices

After the drying process with a sample of 500 grams of wet gelugur acid taken within 2 hours at a programmed temperature of 60ºC, After the drying process, the gelugur acid reaches a semi-dry condition. However, in this semi-dry condition, there is potential for bacterial or microorganism growth. The test results shown in Figure 16 illustrate this condition.

Fig. 16: Half-dried tamarind

The figure below shows the results of wet gelugur acid whose original weight was 500 grams, which has been dried and taken within 4 hours with a temperature of 60ºC that has been programmed. The test results are as shown in Figure 17.

Fig. 17: Dry acid gelugur

4.3.2. Comparison of Drying Tests on Various Materials

Comparison drying tests were conducted on various materials, namely bananas, chili peppers, shallots, and rice. The results of the drying comparison show that this dryer can dry a variety of materials, not only gelugur tamarind fruit, but can also dry other materials. The drying time used also varies, depending on the type of material to be dried. When compared to conventional drying methods that rely on sunlight, drying using this tool is faster than drying with sunlight. The test results are shown in Table 5.

Tabel 5: Drying comparison

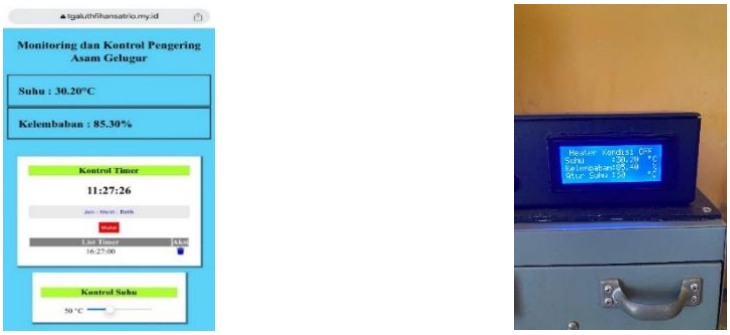
No	Material	Time (hour)	Temperature (℃)	Humidity		Weight		Water Content (%)
				Initial (%)	End (%)	Initial (g)	End (g)	
1.	Banana	5	50℃	85	26	500	230	54
2.	Chili	6	60℃	80	27	250	50	80
3.	Red Onion	7	60℃	85	28	250	40	84
4.	paddy	2,5	43℃	81	41	300	250	16

4.4. Monitoring and Control Observation Results Through IoT Web

In this research, controlling the time and temperature of the gelugur tamarind dryer using IoT web technology was carried out. Time control is done by activating the "Start" button on the IoT web page. After the button is activated, the gelugur tamarind dryer system will automatically activate. In addition, temperature control can also be done through the IoT web, allowing users to set the temperature as needed. With this temperature control, the temperature inside the dryer can be kept stable at a predetermined value, so that the drying process can run optimally.

Fig. 18: Time and temperature control menu

With this IoT web, users can easily monitor the gelugur tamarind drying process in real-time, utilizing technology to improve efficiency and accuracy. The system allows users to access temperature data displayed on the LCD and the IoT web directly, which is highly accurate and responsive to changing conditions. With more precise monitoring, users can ensure that the drying process is optimized, prevent damage to the product, and save time and energy. In addition, the system also allows users to make temperature settings or adjustments via the IoT web.



a.Temperature and humidity monitoring via IoT web b. Temperature and humidity monitoring via LCD

Fig. 19: Temperature and humidity monitoring

5. Conclusion

After testing and analyzing the above, it can be concluded as follows:

1. The dryer shows good performance because it is time efficient and can speed up the drying process of gelugur acid with a weight of 500 grams to 140 grams within 4 hours.
2. The effect of 60ºC temperature on the gelugur acid drying process can accelerate the gelugur acid drying process within 4 hours.
3. Drying using a gelugur tamarind dryer is more effective and practical than traditional drying which takes 2 days. With this tool, drying can still be done indoors during rainy weather.
4. This dryer offers flexibility and efficiency in the drying process of various types of raw materials, not limited to tamarind. It is able to optimally regulate temperature and humidity to ensure the quality and freshness of the dried ingredients.
5. With the control and monitoring system via smartphone, monitoring the gelugur drying process can be more effective and efficient.

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