Design of monitoring system prototype on drying time of date seeds in the making processes of date coffee based on internet of things

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ABSTRACT

Date palm (*Phoenix dactylifera*) is a plant of the Phoenix palms whose fruit tastes sweet and can be consumed by humans. These fruit seeds usually only become a waste and never be utilised by people. This research tries to reduce the waste of date palm by using the date palm fruit seeds to replace the coffee beans. One of the processes of changing date palm fruit seeds to coffee beans is drying the seeds. Instead of using a traditional drying method, this study designs a prototype of an Internet of Things (IoT) based on a drying room. The monitoring tools inside the drying room, such as humidity and temperature sensor, heater, fan, and mixer, are monitored through a smartphone in real-time. Hence, the monitoring tools inside the drying room can be controlled easily, and the data can be saved as databases in smartphone applications. Based on the voltage measurements results, the IoT prototype can measure the voltage accurately with only about 0.3 volt difference compared to manual measurement.

1. INTRODUCTION

Date palm (*Phoenix dactylifera*) is a plant like a palm in which fruits are safe and healthy to be consumed by human. Date palm tree can grow its height around 15-25 meters and has pinnate leaves that are 3-5 meters long [1]. Date palm fruit has a special place among Muslims and Indonesia, where most of its people are Muslims. Date palm fruit also has many important vitamins and minerals which needed in the human body [2].

The peak demand of this fruit is in the month of Ramadhan, a holy month for Muslims. Date palm fruit consumption rate rises about 50-100% during month of Ramadhan. The attractiveness of date fruit [3] is its sweet taste in the flesh. The date palm fruit can be eaten raw or can be processed into many kinds of processed food with its flesh as the main ingredient. Therefore, the seed inside the date palm fruit mostly become a waste and useless.
In previous research [4-6], there was an innovation in which date fruit seed was refined and used as date coffee. This date coffee is one of coffee beverage innovation. Similar to the coffee beans, the date palm fruit seeds go through a drying process during manufacturing processes of date coffee. Several researches [7-9] pointed out the ways of drying the date palm fruit seeds. The drying processes were usually done conventionally, i.e., drying the date palm fruit seeds under the sun over a mat (plastic, tarpaulin, etc.) outdoor or in a greenhouse. Hence, it is necessary to stir or turn the date palm fruits seeds every 30 minutes to ensure that they dry evenly.

On the other hand, other studies have designed coffee bean drying system that controlled via a website and a web server [10-11] or via an Android device and a Bluetooth connection [12-13]. These studies found that these systems are more effective compared to conventional drying method. Understanding the advantages of these drying system, the author in this study tries to combine the two systems (i.e., via website or web server and via an Android device or a Bluetooth connection) and the create an automated monitoring device for date palm seed drying using the Internet of Things (IoT) so the monitoring system of drying processes can be accessed via the internet from the communication device on the user’s side using a database [14-15]. It is knowingly that IoT is a scenario of a sensor or object that can transmit data/information over a network without human intervention [16-17].

In this study, the authors design the drying system inside a greenhouse, which has several components such as Raspberry Pi 3B+, DHT22 temperature and humidity sensor, servo motor, heater, and fan as tools which can optimise the drying time of date palm seeds based on IoT. Heaters and fan are utilized to get a stable temperature and humidity in the drying room regardless of the weather and ambient temperature. The servo motor is used as a stirrer or inverting date palm seeds so that the drying of the date seeds takes place evenly.

In the drying system design of the current study, the data obtained from the sensors inside the greenhouse will be sent to the database before being received on the user’s device. Therefore, users can monitor the drying process of date palm seeds remotely. This study builds and designs the drying system using sensors that harmonises the conventional drying method with technology. Despite the date seeds quality after the drying process, this design is expected to have the seeds are dried enough for the next processes of making date coffee [4] under a monitoring system connected with remote control ability using IoT.

2. METHOD

In this study, the drying system prototype is designed using the real situation of a drying room inside the greenhouse. As the situation inside the greenhouse needs to be monitored remotely, IoT (Internet of Things) and knowledge of basic conventional drying processes need to be identified. After identification process, the drying system prototype is designed and must be harmonised the drying process with technology.

Then, all of parameters that need to be monitoring during drying process is designed into the sensors and actuators. For knowing the conditions inside the drying room, sensors are used to detect the conditions. In this research, DHT22 is used as a temperature and humidity sensor. To control the right humidity and heat inside the drying room, fan and heater are used [18-19]. The rotation of the seeds is done with motors and controlled by a relay [20-21] to make the drying process done evenly. To control and process the whole drying system, Raspberry Pi 3B+ is used as a minicomputer [22] using python language to program this minicomputer [23-24]. The Raspberry Pi will connect the received data to the firebase database and send the received data to the user’s phone. The design of the whole system and process can be seen in Figure 1.

![Figure 1. Overall design block diagram.](image-url)
On the block diagram, the input is a DHT22 sensor, which is a temperature and humidity sensor. This temperature and humidity sensor is used in the drying room to measure temperature and humidity. The process block in the block diagram is the Raspberry Pi 3B+, which is in charge of processing the data from temperature and humidity sensor readings and controlling the telecontrol system subsystem. Lastly, the output of the block diagram is as follows:

1. The servo motor in the drying system rotates the date seeds until the dry side is evenly distributed across the entire surface of the date seeds. The Raspberry Pi is used to program the servo motor.
2. The fan is responsible for reducing the excessive moisture in the drying room. The fan is controlled by a Relay that is linked to the Raspberry Pi.
3. The PTC Heater acts as a heating element, delivering heat to the air in the drying room. A Relay connected to the Raspberry Pi controls the PTC Heater.

Noting that, the Raspberry Pi 3B+ serves as a data transmission device that transmits data generated by program processing wirelessly between system devices and Android applications via the internet network.

As can be seen in Figure 2, each sensor and actuator have pins for connecting components to the Raspberry Pi’s power supply, ground, and GPIO pins. Because the Raspberry Pi only has two 5V DC pins, the voltage must be distributed in parallel using a breadboard. To proceed, a cable is connected to one of the rows of holes on the breadboard, so that all cables connected to that row are channelled in parallel. Then, the ground pin is channelled in the same manner on the breadboard, resulting in one row of holes on the breadboard and the ground.

![Figure 2. Schematic of whole prototype circuit.](image)

The VCC pin in sensors, servo motors, and relays is a voltage supply pin. This pin is connected to one of the breadboard holes that are in line with the 5V Raspberry Pi pin. The GND pin is the ground pin, and it is also connected to the breadboard, which is in line with the Raspberry Pi ground. Data pins are the second pin on the sensor, the servo motor, and the IN1 and IN2 pins on the relay. Data is directly connected to the Raspberry Pi’s GPIO pins. GPIO4 for the DHT22 sensor, GPIO17 for the servo motor, GPIO18 to relay IN1 for the fan, and GPIO27 to relay IN2 for the PTC heater. Because the fan and PTC heater require 12V DC to operate, the VCC of these two components is connected to another power supply that provides 12V voltage with ground connected to the relay.
According to a previous study [25], if the relative humidity of the enclosed space is 70% or higher for an extended period, mould will be more likely to develop. As a result, in this study, the upper limit of humidity for fan conditions is set at 70%. A good humidity level is between 45 and 65%. Therefore, in the program, the lower limit is set between 45 and 65%, i.e., 55% humidity. Hence, the humidity range for the drying chamber in the system is determined to be 55-70%.

Moreover, according to the BMKG (Badan Meterologi, Klimatologi, dan Geofisika) [26], the temperature in Depok City (where the drying room is installed) as in November 2021 are 29-32°C during the day and 24-25°C at night. As a result, 30°C is chosen as the lower temperature limit for turning on the heater to ensure that the temperature remains stable throughout the day and night. According to a previous study [27], the ideal temperature in the greenhouse ranges from 80-85°C, but due to the limitations of the DHT22 sensor, which has a maximum temperature reading range of 80°C, 80°C is determined as the upper limit of the heater condition.

As a result, the obtained temperature range for use is 30-80°C.

After all the conditions are met, the author includes the program instructions requirement to connect to Firebase Realtime. Then, the sensor will send the data, which will be processed by the Raspberry Pi before being sent to Firebase. Accordingly, the status data will be passed to the application, which will show the user what is going on in the drying room.

According to the prototype design proposed in Figure 2, the prototype is made using the components listed in the design. The components are tested using voltage measurement to ensure that the prototype works well with the design. The voltage on the datasheet of the component is used as the reference for the optimal voltage used by the component. The shape and position of the components are adopted from the previous design. The result of the components arrangement inside the drying room can be seen in Figure 4, while the other components are stored in the box under the drying room.
Figure 4. Design result.

In Figure 4, there is a space at the bottom, i.e., the brown box, that serves as a location for supporting components such as Raspberry Pi, relays, etc. Then, directly above it, is the drying room. The outside is protected by a vinyl greenhouse. Except for the exhaust fan air outlet, this vinyl layer seals tightly on all sides to lock on the moisture and temperature inside the drying room.

3. RESULTS AND DISCUSSION

Voltage measurement on prototype components

Electrical quantities or voltage measurements are taken using the Avometer measurement tool, with the goal of obtaining the voltage value at each test point, as shown in Figure 2 (labelled with numbers). The test is conducted while the components are working and connected-controlled through the application. The test results are divided into two sections: 5V and 12V tests. Table 1 shows the results of the tests on 5V components. It shows that the voltage measurement results are in agreement with the data or range in the component’s datasheet. This shows that the component is working well with the design.

Furthermore, the results of the voltage measurements on 12V components are shown in Table 2. They are also in agreement with the data in the component datasheet with small discrepancy, i.e., about 0.30V difference from the original measurement.

<table>
<thead>
<tr>
<th>Label Number</th>
<th>Tested Pin</th>
<th>Voltage on Datasheet (Volt)</th>
<th>Measured Voltage (Volt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>VCC DHT22 Sensor</td>
<td>3.3 – 6V</td>
<td>5.01V</td>
</tr>
<tr>
<td>3</td>
<td>VCC Motor Servo</td>
<td>4.8 – 5V</td>
<td>5.03V</td>
</tr>
<tr>
<td>4</td>
<td>VCC Relay</td>
<td>3.75 – 6V</td>
<td>5.01V</td>
</tr>
</tbody>
</table>

Table 1. 5V electrical measurement results.

<table>
<thead>
<tr>
<th>Label Number</th>
<th>Tested Pin</th>
<th>Voltage on Datasheet (Volt)</th>
<th>Measured Voltage (Volt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Adaptor Output</td>
<td>12V</td>
<td>12.30V</td>
</tr>
<tr>
<td>5</td>
<td>Relay Output to Fan</td>
<td>12V</td>
<td>12.30V</td>
</tr>
<tr>
<td>6</td>
<td>Relay Output to PTC Heater</td>
<td>12V</td>
<td>12.30V</td>
</tr>
</tbody>
</table>

Table 2. 12V electrical measurement results.

Software design result

On the application side, Figure 5 displays the current status of the temperature, humidity, fan, heater, and stirrer. Temperature and humidity values are constantly changing and will be automatically updated as long as the user remains on the main page. Number 1 in Figure 6 shows the temperature and humidity logo, with the measurement numbers visible in Number 2 right next to it. The fan and heater can be seen in the second row, or at Number 3, where they will continue to update the status of the three components being on/off, and at Number 4, it says ‘rotating’ or ‘done’ for the servo stirrer, which says mixer. Finally, Number 5 is the button for initiating data reception to the application with the ‘START’ button and terminating the session with the ‘STOP’ button.

Blocks are executed on the application side, as shown in Figure 6, which describes the process in the application for receiving data from the database. The image depicts several orange blocks that describe the process calls that the application will make. During initialisation, the application will access the data from Firebase. Following
the acquisition of the data, the data will be displayed on the application with the label on the image. The application then waits for changes to the data in the database. When these changes are detected, the system immediately updates the data listed to reflect the current state of the database.

The application was tested on two different devices in this study, the Samsung type A31, and type S4. The application is declared valid and can be used properly after meeting the requirements for having a connection to the internet network and then testing the program on both devices.

![Figure 5: Application page.](image)

![Figure 6: Application block system.](image)

4. CONCLUSION

The idea of creating this drying room monitoring system design can be accomplished by assembling sensors, Raspberry Pi, and actuators into a tool that can communicate with the internet network, allowing IoT to be used. The components are tested through electrical measurement for their compatibility between components and to prove that the design works well. As the measured voltage compared to the datasheet for the 5V component corresponds with the data on the datasheet, and for the 12V component measurement, it gets a 0.30V difference between the datasheet and original measurement, it can be concluded that the design is well made. The entire application system can run on any device that has an internet connection and an Android system higher than Android 5.5. The android application can receive and display data in real-time based on what the sensor detects and what happens in the drying chamber.

CONFLICTS TO INTEREST

The author declares that there is no conflict of interest affecting this publication.
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