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Research Article

IoT-based system for monitoring the drying time of date seeds in the manufacturing of date coffee

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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. The research tries to reduce the waste of date palms using date palm fruit seeds to replace 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 has designed a prototype of an Internet of Things (IoT) based monitoring system tool inside the drying room that allows humidity and temperature sensors, heater, fan, and mixer to be monitored through a smartphone in real-time. Hence, the monitoring tools inside the drying room could be controlled easily, and the data could be saved as databases in smartphone applications.

1. INTRODUCTION

Date palm (*Phoenix dactylifera*) is a plant like a palm in which fruits are safe and healthy to be consumed by humans. Date palms grow to a height of between 15-25 meters and have pinnate leaves 3-5 meters long [1]. Dates are a fantastic food among Muslims and the Indonesian people, most of whom are Muslims. Date palm fruit also has many essential vitamins and minerals in the human body [2].

The peak demand for dates is generally during the month of Ramadan, which is the holy month for Muslims. The consumption rate of dates increases by around 50-100% during Ramadan. The sweet taste is the main attraction of this fruit as an opening menu for breaking the fast [3]. Dates can be eaten raw or processed into food preparations with the flesh as the main ingredient. Most of the seeds in dates become waste, and not many people use them.

In several studies [4-6], there was an innovation in which date fruit seed was refined and used as date coffee. This date coffee is one of the coffee beverage innovations. Like coffee beans, the date palm fruit seeds go through a drying process during the manufacturing processes of date coffee. Several researchers [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 and tarpaulin) outdoors or in a greenhouse. Hence, it is necessary to stir or turn the date palm fruit seeds every 30 minutes to ensure they dry evenly.

On the other hand, other studies have designed a coffee bean drying system that is 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 than conventional drying. Based on the drying systems' advantages, this study combines the two techniques (i.e., via a website or web server and an Android device or a Bluetooth connection) and creates an automated monitoring device for date palm seed drying using the Internet of Things (IoT). 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]. The 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 fans are utilised 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 designing the drying system, data obtained from sensors in the greenhouse is sent to the database before being received on the user's device. Thus, users can monitor the process of drying date seeds from different places, and it can be controlled remotely. This study builds and designs a drying system using sensors that aligns conventional drying methods with technology. Regardless of the quality of the date seeds after the drying process, this design is expected to produce dried date seeds that are ready to process IoT-based date coffee drinks [4]. The dispensing process involves a monitoring system connected with remote control capabilities using IoT. Robots completely replace the role of humans, and humans prepare programming according to business process requirements.

2. MATERIAL AND METHOD

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

Then, all the parameters that need to be monitored during the drying process are designed into the sensors and actuators. Sensors are applied to detect the conditions inside the drying room. In this research, DHT22 is used as a temperature and humidity sensor. A fan and heater are used to control the proper humidity and heat inside the drying room [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 maintain and process the whole drying system, Raspberry Pi 3B+ is used as a minicomputer [22] by using python language to program the 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.

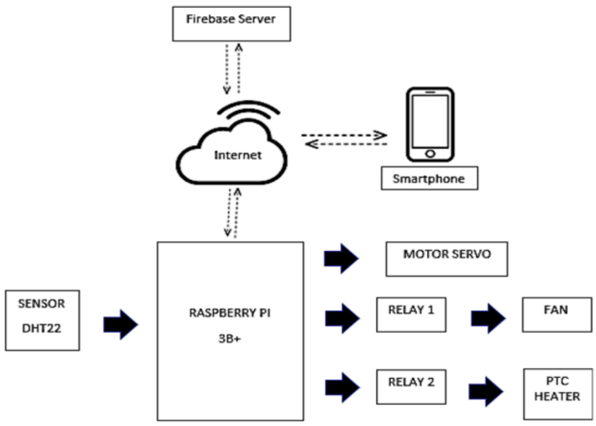

Figure 1. Overall design block diagram.

The input on the block diagram is a DHT22 sensor and 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 remote-control 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.

The Raspberry Pi 3B+ is a 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. 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 directed similarly on the breadboard, resulting in one row of holes on the breadboard and the ground.

The VCC pin in sensors, servo motors, and relays is a voltage supply pin. This pin is connected to one of the breadboard holes in line with the 5V Raspberry Pi pin. The GND pin is the ground pin and 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, the program's lower limit is 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 Meteorologi, Klimatologi, dan Geofisika) [26], the temperature in Depok City (where the drying room is installed) 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.

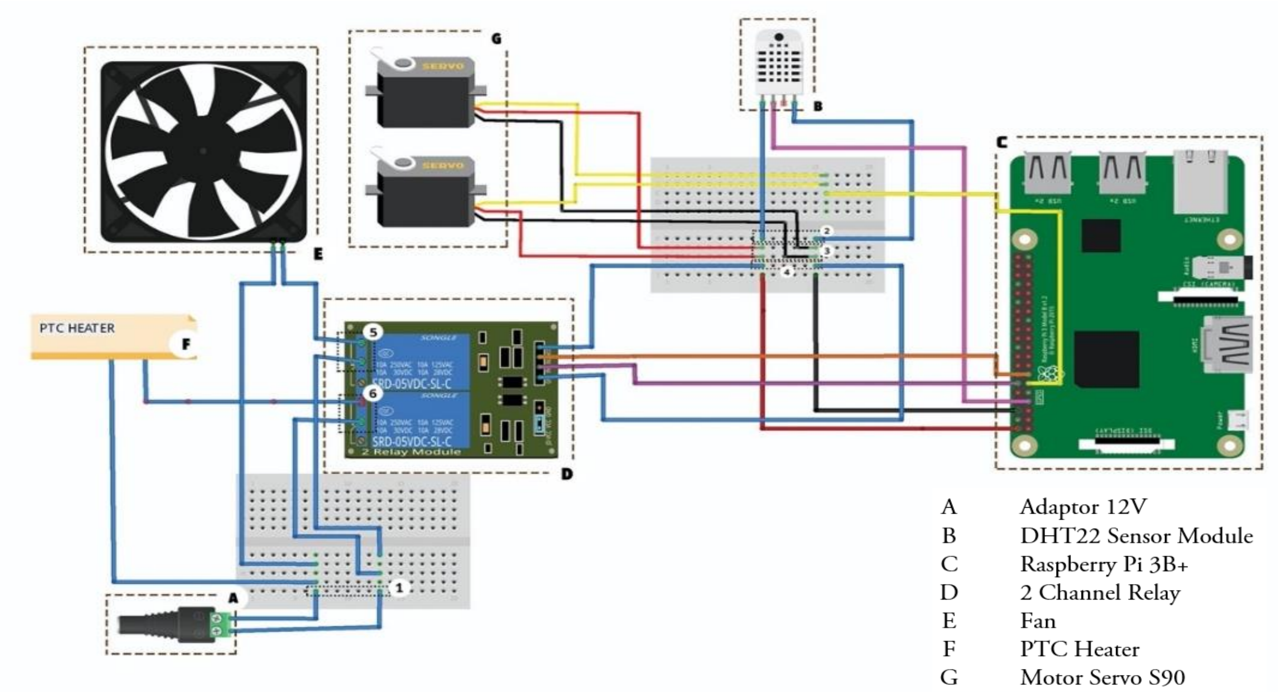

Figure 2. The schematic of prototype circuit.

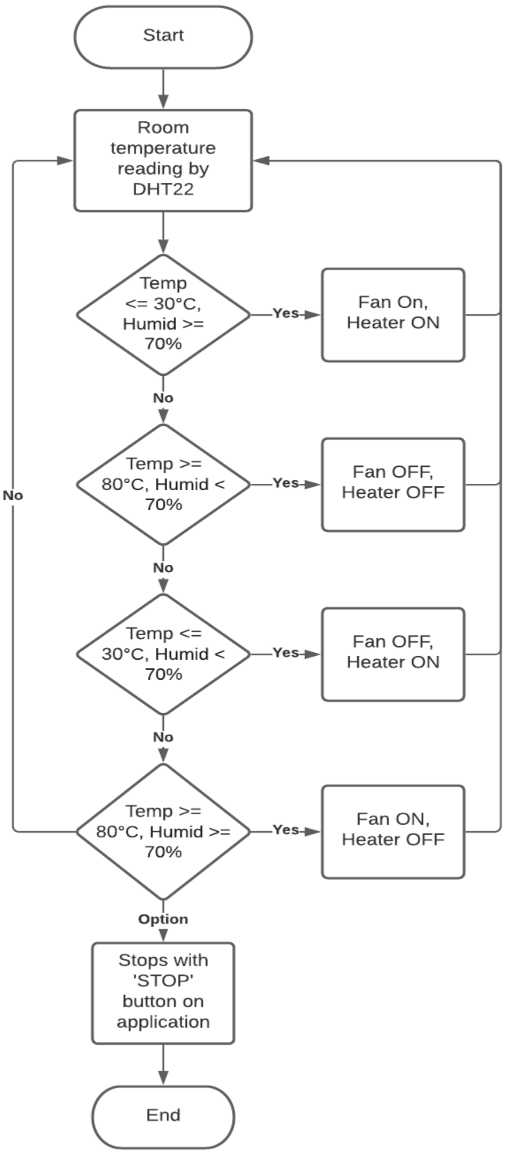

Figure 3. Programming flow chart.

Figure 4. Drying room with date seeds.

After all the conditions are met, the author includes the program instructions required to connect to Firebase Realtime. Then, the sensor will send the data, which the Raspberry Pi will process before being sent to Firebase. Accordingly, the status data will be passed to the application, showing the user what is happening in the drying room. The flowchart of the program can be seen in Figure 3.

According to the prototype design proposed in Figure 2, the prototype is made using the components listed in the design. The features 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 features are adopted from the previous design. The result of the arrangement of the elements inside the drying room can be seen in Figure 4, while the other components are stored in the box under the drying room.

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

3. RESULTS AND DISCUSSION

3.1. Voltage measurement on prototype components

Electrical quantities or voltage measurements are taken using the Avometer measurement tool to obtain 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 agree with the data or range in the component's datasheet, indicating 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 also agree with the data in the component datasheet with a slight discrepancy, i.e., about a 0.30V difference from the original measurement.

3.2. Software design result

Figure 5 displays the current temperature, humidity, fan, heater, and stirrer status on the application side. Temperature and humidity values constantly change 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 data acquisition, 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 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.

Table 1. The measurement at an electric voltage of 5V.

Label Number	Tested Pin	Voltage on Datasheet (Volt)	Measured Voltage (Volt)
2	VCC DHT22 Sensor	3.3 – 6V	5.01V
3	VCC Motor Servo	4.8 – 5V	5.03V
4	VCC Relay	3.75 – 6V	5.01V

Table 2. The measurement at an electric voltage of 12V.

Label Number	Tested Pin	Voltage on Datasheet (Volt)	Measured Voltage (Volt)
1	Adaptor Output	12V	12.30V
5	Relay Output to Fan	12V	12.30V
6	Relay Output to PTC Heater	12V	12.30V

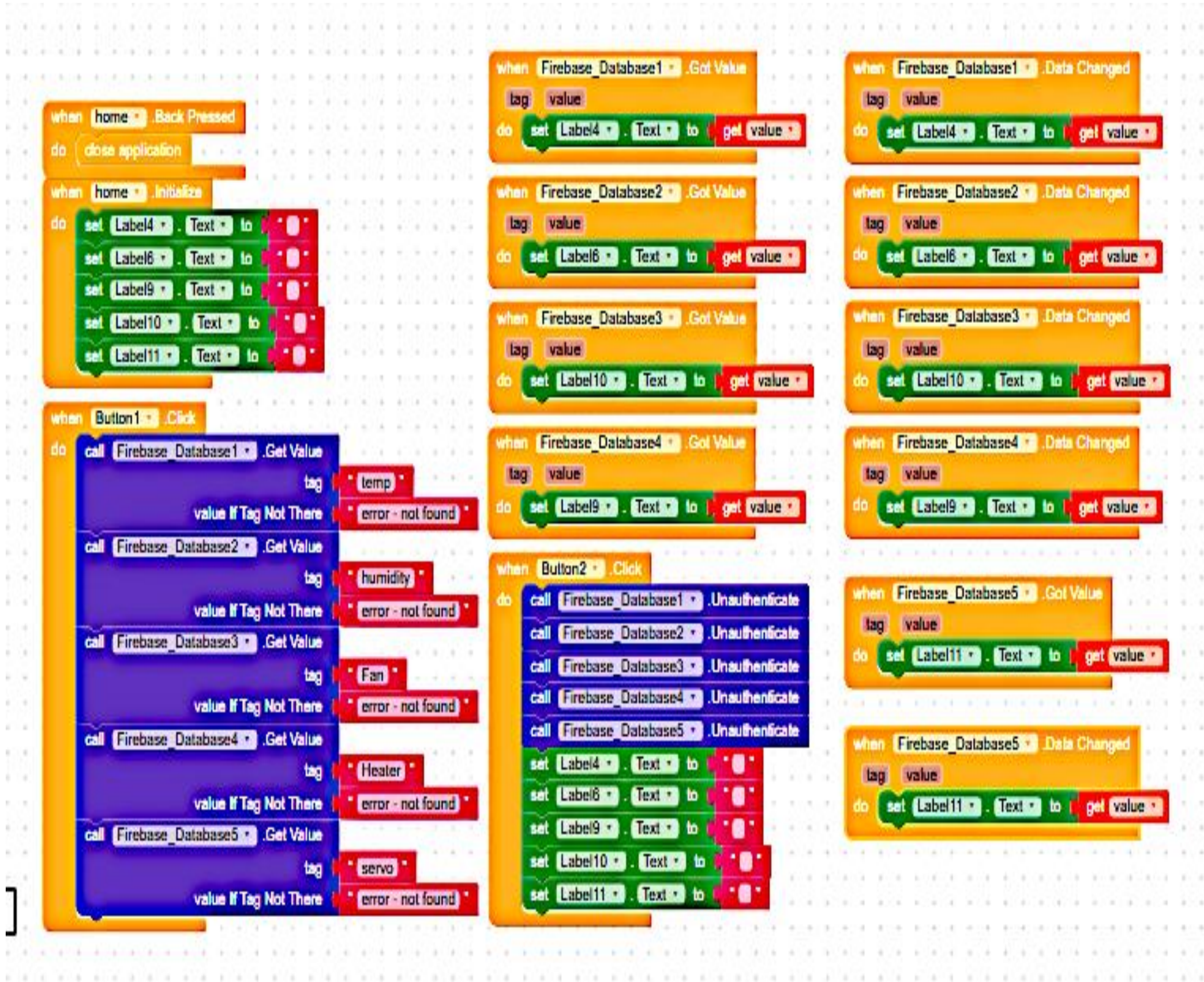

Figure 6. Application block system.

4. CONCLUSION

The idea of creating this drying room monitoring system design could 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 were 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 got a 0.30V difference between the datasheet and initial measurement, it could be concluded that the design is well made. The entire application system can run on any device with 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 OF INTEREST

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

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