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AUTOMATED DRYING OF MORINGA LEAVES USING AN ARDUINO UNO MICROCONTROLLER

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Abstract

The nutritional and health benefits of Moringa leaves highlight the importance of employing proper drying methods to preserve nutrients and extend shelf life, as ineffective drying may lead to quality deterioration. Effective temperature management during the drying process is crucial for maintaining the nutritional integrity of Moringa leaves and preventing the degradation of heat-sensitive components. The purpose of this study is to determine the best way to build and apply an Arduino-powered DHT11 sensor for temperature and humidity control in a Moringa leaf dryer. In order to display the results on the LCD screen, this code connects the Arduino Uno, DHT11 sensor, LCD screen, relay, and fan using jumper cables. Over the course of seven hours, temperature and humidity were recorded every fifteen minutes. If temperature variations occurred during the drying process, the fan was automatically turned on. The study's findings demonstrate that the hardware for the device design system consists of fans, LCD panels, DHT11 and Arduino Uno sensors, and LCD screens. Aside from that, the software for the monitoring system has been successfully built and is operating efficiently. It was started using the Arduino IDE. The Moringa leaf dryer can effectively regulate temperature and humidity, according to the testing results of the equipment design and application of the DHT11 sensor with Arduino. Moringa leaves have an average water content of 7.2% as opposed to their initial water content of 73%. These outcomes highlight how well the system that was built was able to achieve the intended drying outcomes.

Keywords: moringa leaves, arduino uno, dht11 sensor, lcd, emperature, humidity

Introduction

Moringa leaves (Moringa oleifera) are recognised as a highly nutritious plant with significant potential for promoting human health. Rich in vitamins, minerals and other bioactive compounds, Moringa leaves have become an integral part of various food products and dietary supplements. These products could play a pivotal role in treating various lifestyle-related ailments and combating malnutrition (Islam et al., 2021). The drying process of Moringa leaves is a crucial step in preserving their nutritional content and extending their shelf life.

Moringa has been widely adopted as a beneficial dietary supplement to promote health (Kashyap et al., 2022). The leaves contain a wealth of minerals, vitamins and vital phytochemicals. Derivatives from the leaves are used to treat malnutrition and to increase breast milk production in nursing mothers. They hold promise as potential antioxidants, anti-cancer agents, anti-inflammatory substances, anti-diabetic solutions and antimicrobial entities (Gopalakrishnan et al., 2016). However, improper drying can lead to a reduction in the quality of these nutrients.

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However, this process became non-linear once the moisture content reached around 60-70% on a dry basis. The drying process took place mainly during the constant rate phase at lower temperatures and transitioned to the falling rate phase at higher temperatures. The drying characteristics of Moringa leaves were best described using the Page model (Hasizah et al., 2022).

Elevated temperatures during drying can result in the degradation of heat sensitive nutrients. Proper temperature control can reduce this risk. Convective drying at lower temperatures should be used to preserve phytochemicals (ElGamal et al., 2023). Significant changes in dried meat have sensory, microbiological and safety implications. These changes are influenced by consumer preferences and health considerations, with a focus on the effectiveness of drying in eliminating or reducing harmful bacteria (Mediani et al., 2022)

High temperatures cause direct damage such as protein denaturation, lipid membrane fluidity and enzyme inactivation. Indirectly, they inhibit protein synthesis and break down membranes. Low temperatures during propagation lead to problems such as abscission, sterility and reduced yield. It's important to mitigate the effects of temperature stress within acceptable limits to protect plants (Waraich et al., 2012).

Higher drying temperatures are observed to result in a decrease in moisture, ash, protein, carbohydrate, phenol, vitamin C and ß-carotene while increasing fat and the ideal temperature for drying Moringa leaves is 60°C as it results in the least amount of nutrient loss between 70°C and 80°C (Razzak et al., 2021). The protein content of Moringa leaves dried in the shade at 30°C was 28.44 g/100 g, while that of leaves dried at 70°C was 19.89 g/100 g. Beta-carotene, a precursor of vitamin A, decreased significantly from 5,220.20 mg/100 g in leaves dried in the shade at 30°C to 4,946.20 mg/100 g in leaves dried in the oven at 70°C. When dried at 70°C, the vitamin C content decreased slightly from 27.39 mg/100 g in the shade to 25.70 mg/100 g (Clement et al., 2017). At 35°C and 5 hours of drying, the ideal Moringa leaf powder composition was discovered after analysing the vitamin C and moisture content. The texture, flavour and aroma were preferred after the 7 hour treatment at 65°C. Meanwhile, the colour treatment of 5 hours at 35°C was chosen (Zainuddin & Hajriani, 2021).

Traditional drying methods often rely on weather and environmental conditions that can be unstable and difficult to regulate. Analysing the strategies, challenges, risks and recommendations for improving solar drying has implications for product quality, economics and the environment. Solar drying with natural heat storage sustainably extends shelf life (Suresh et al., 2023). A transformative approach to resilient, productive and sustainable agriculture and food systems is essential.

This system eliminates the need for constant farmer presence for morning and evening spraying. A larger temperature gap results in increased fan duty cycles and faster speed. When the room temperature falls within the set range, all consumers are deactivated, maintaining a normal temperature (Akbar et al., 2020). It enhances safety through autonomous, cost-effective and reliable operation, resulting in reduced energy consumption. The main benefits of the system include comfort, safety and security (Jabbar et al., 2019).

Variants such as the DHT22 exist, and for precise measurements in professional applications, alternatives such as the DHT11 are available (Mouser Electronics, 2011).The single-wire serial interface facilitates integration, while the compact size, low power consumption and up to 20 metres of signal transmission suit various demanding applications. Available in a 4-pin single-row package, customisable options are available on request (D-robotics, 2010). The device is designed to use more than one fan as a motor, uses a DHT11 sensor as a room temperature detector, and produces a high and low temperature output which is displayed in real time on a 16 x 2 LCD (liquid crystal display) (Aulia et al., 2021).

This research introduces an innovative automated Moringa leaf drying system utilizing an Arduino Uno microcontroller and a DHT11 sensor, ensuring precise temperature and humidity control to preserve nutritional content. Overcoming the limitations of traditional drying methods, which rely on unstable environmental conditions, this research offers a dependable solution for consistent drying, crucial for maintaining leaf quality. By enhancing efficiency, this approach enhances the availability of Moringa for food products and supplements, accessible even to small-scale farmers, thereby contributing to sustainable agriculture and food security initiatives.

Research Methods

The drying system uses an Arduino Uno microcontroller for temperature sensing. The DHT11 sensor is used as a digital temperature sensor with a temperature sensing range of 0°C to 50°C. The heating elements consist of four 5 watt bulbs and a relay is used for control. A 16x2 LCD display is incorporated to provide temperature information and system operating status. An AC fan motor is used to circulate air into the heating area.

The control system is primarily based on temperature, with this parameter serving as the input to the designed drying system. The output of the system consists of actuators, including heating elements, a fan, an exhaust and a 16x2 LCD display, which shows the status of the drying system based on the parameter conditions.

Implementation of the research

This research involves designing and carrying out experiments using the DHT11 sensor to control the temperature and humidity within a drying chamber. Drying occurs as a result of water evaporation from the Moringa leaves into the atmosphere. Evaporation is achieved by lowering the humidity in the drying chamber by circulating hot air around the material, creating a pressure differential that causes water vapour to leave the moringa leaves. The drying control system receives input parameters for temperature and humidity, which are programmed using the Arduino IDE.

Drying control is achieved by monitoring the room temperature using a temperature sensor connected to an Arduino installed in the drying chamber. The temperature control is set at 35°C according to (Paramita et al., 2021). The system operates on the basis of the room temperature; if the room temperature falls below 35°C, the fan is activated, and if the temperature exceeds 35°C, the fan is switched off.

The dryer is 80 cm long, 80 cm wide and 60 cm high, with four shelves at 15 cm intervals. Four 5 watt light bulbs are used as heating elements and four 12 V DC exhaust fans are used. Drying is carried out for a period of 7 hours, with 100 grams of Moringa leaves placed on each shelf.

Observations

Observations include monitoring changes in the drying chamber temperature displayed on the LCD and serial monitor. The Moringa leaves will be weighed every hour during the drying process.

Results and Discussion

The hardware installation is a process of setting up or assembling the devices used to build an automated temperature monitoring system for the moringa leaf dryer using the Arduino Uno microcontroller. The hardware components of the system are shown in Figure 1.

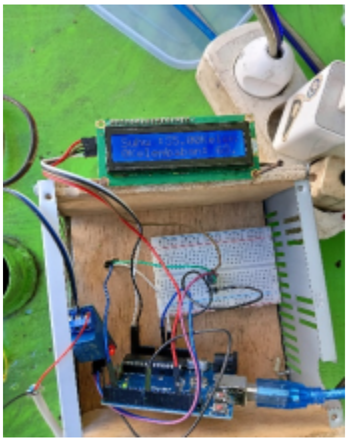

Figure 1. Hardware component

The Equipment Components

Connection to the DHT11 sensor: The Arduino Uno R3 board is connected to the DHT11 sensor as follows: The ground pin of the DHT11 is wired to the ground pin of the Arduino. The VCC on the breadboard is wired to the VCC pin on the DHT11. The digital pin 2 of the Arduino Uno board is wired to the input/output pin of the DHT11 sensor.

The Arduino Uno R3 board is connected to the relay as shown in the following diagram: The Arduino Uno board's ground pin is connected to the relay's ground pin. The VCC pin of the breadboard is connected to the VCC pin of the relay. Pin 8 of the Arduino Uno R3 board is connected to the analogue input and output pins of the relay. After connecting the Arduino and the relay, connect four 5V fans to the relay. The fans are connected from the Arduino board to VCC on the breadboard. Use electrical wires and a power supply that acts as a current divider to connect the relay and fans.

LCD 16x2 with Arduino Uno R3 connection: The LCD 16x2 is connected to the Arduino Uno R3 board as follows: The ground pin of the Arduino is connected to the ground pin of the LCD. The VCC pin on the breadboard is connected to the VCC pin on the LCD. The analogue pin (pin A4) on the Arduino is connected to the SDA pin on the LCD. The Arduino's analogue pin (pin A5) is connected to the LCD's SCL pin (pin). Use male-to-female jumper cables to connect all the pins.

USB connection: For programming and control, the USB connector of the Arduino Uno R3 board is connected to the USB port of a laptop. This allows the many components to work.

Software Implementation

The software implementation uses the Arduino IDE programming language and driver preparation.

The program initialisation process begins with the integration of essential libraries into the Arduino sketch. Specifically, the DHT11 library is included to allow the system to interact with the DHT11 sensor, which measures temperature and humidity. In addition, the liquidcrystal_I2c library is included to facilitate communication with the LCD 16x2 display. These libraries act as critical building blocks, providing the system with the necessary tools to read sensor data and display it on the LCD screen. Figure 2 shows that the initialisation step forms the basis for the subsequent execution of the program, ensuring that the system is prepared to perform its intended tasks efficiently and accurately.

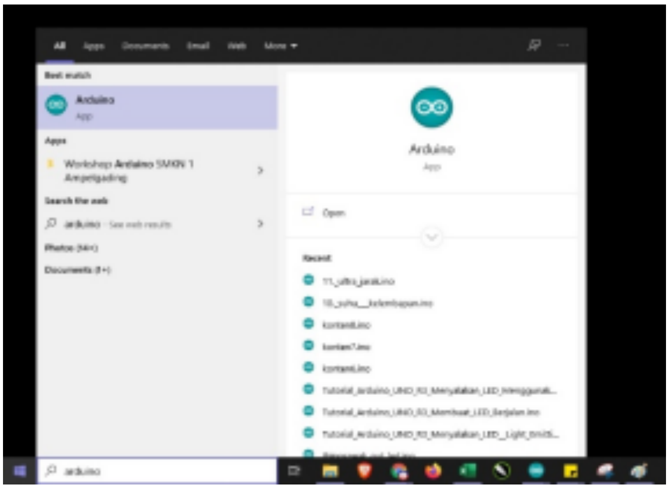

Figure 2: Driver Installation

This code essentially reads the temperature and humidity from the DHT11 sensor, controls a fan based on the temperature threshold, and displays the readings on both the serial monitor and the LCD screen. Make sure you have the necessary libraries installed and the hardware connections set up correctly for this code to work as intended.

```
#Include <LiquidCrystal_I2C.h>.
LiquidCrystal_I2C lcd(0x27,14,2);
int kipas=8;
#include <DHT.h> DHTPIN 2
#define DHTPIN 2
#define DHTTYPE DHT11
DHT dht (DHTPIN, DHTTYPE);

void setup() {
  pinMode(kipas, OUTPUT);
  lcd.begin();
  Serial.begin(9600);
Serial.println(Tes suhu & kelembapan")
  dht.begin();
}

void loop() {
  delay(2000);
float t = dht.readTemperature();
```

```
float h = dht.readHumidity();
if(isnan(t) || isnan(h)){ Serial.println(Perikratos)
Serial.println(Periksa Konfigurasi Pin/kabelnya")
Serial.println(Sensor Tidak Terbaca")
    Return;
  }

if (t>35){
    digitalWrite(kipas, HIGH);
  }
  else {
    digitalWrite(kipas, LOW);
  }
 ");
  Serial.print(t);
  lcd.print("Suhu :");
  lcd.print(t);
  Serial.print("kelembapan: ");
  Serial.print(h);
  Serial.println(" %");
  lcd.print("Kelembapan: ");
  lcd.print(h);
  lcd.print(" %");
}
```

Based on the research, temperature data inside the drying chamber was obtained using Arduino, resulting in 7 data points. The DHT sensor was placed at the top of the drying cabinet. There are 4 shelves inside the drying chamber. Temperature and humidity data were collected every 15 minutes and the weight of the moringa leaves was measured every 30 minutes. The test was carried out for 7 hours. The average temperature data in the drying chamber was found to be 35°C, with a decrease in humidity from the initial 81%.

(a)  (b) 

Figure 3. (a) Fresh moringa leaves; (b) Drying process of moringa leaves

Figure 3 shows that the Moringa leaves started drying at a temperature of 35°C with an initial humidity of 48%. Each drying rack contained 100 grams of fresh green moringa leaves. Weighing was essential to determine changes in mass and water content. The material was weighed every 30 minutes and during the last 2 hours of drying. A Kern

ABJ 220-4 Pioneer TM digital scale was used for weighing. Weighing was carried out 18 times over 11 hours, resulting in a water content of 7.2%.

The temperature and humidity readings obtained from the monitoring system showed that the air temperature in the drying cabinet gradually increased over the drying time and stabilised at the set temperature of 35°C. When the temperature exceeded 35°C, the fan control was activated. As the drying process continued, the humidity inside the kiln increased.

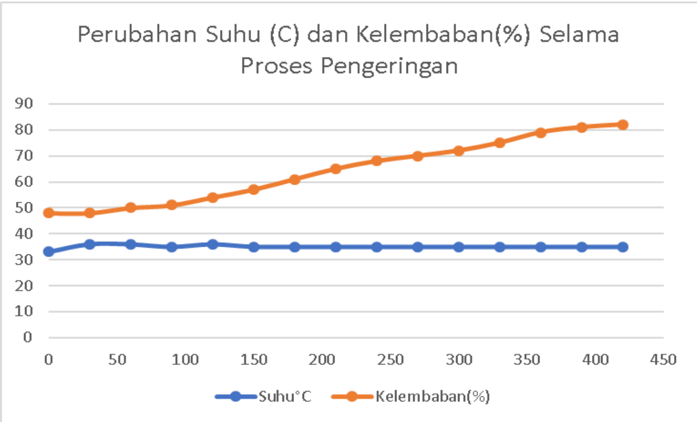

Figure 4. Temperature data graph during drying

The temperature information during the drying process is shown visually in Figure 4. The graph shows that the temperature in the cabinet was maintained at the required 35°C and that the humidity readings varied from 48% to 80%. This pattern developed because more water evaporated from the dried moringa leaves than from the drying cabinet. As the Arduino controlled the fan to automatically turn on when the maximum temperature was reached and turn off when the temperature dropped below the minimum, the graph also shows temperature variations. The temperature range chosen was 35°C maximum and 34°C minimum. During the drying process inside the cabinet, there was a correlation between temperature and humidity. During the initial test period, the humidity increased from 49% to approximately 81%, and during 450 minutes (7 hours) the water content decreased from an initial 73% to 7.2%.

Conclusion

The following conclusions can be drawn from the research results: The device design system consists of hardware elements such as an Arduino, DHT11 sensor, LCD 16x2, relay and fan. The Moringa leaf dryer can effectively regulate temperature and humidity, according to the testing results of the equipment design and application of the DHT11 sensor with Arduino. Moringa leaves have an average water content of 7.2% as opposed to their initial water content of 73%. These outcomes highlight how well the system that was built was able to achieve the intended drying outcomes.

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