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The Moisture Content of Robusta Coffee Beans is dried in the Sun and the Room Temperature is measured with a Microcontroller-based Moisture Content Analyzer

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Abstract: The water content of coffee beans plays an important role in the coffee industry. The water content of fresh coffee beans is still high so it needs to be reduced to meet the SNI standard or around 11-12%. Reducing the water content of coffee beans can be done by drying them in the sun and at room temperature. There is no tool made to measure the water content of coffee beans. This study created a microcontroller-based coffee bean water content measuring tool. Measurements were made on robusta coffee beans. Water content measurements were carried out on coffee beans that were dried in the sun for three days and at room temperature for seven days. Water content measurements were also carried out using the AR991 water content measuring tool as a comparison. From the results of measurements using a microcontroller-based water content measuring tool, it was found that the water content of coffee beans dried in the sun decreased day by day starting from 23% on the first day and 10% on the third day. From the AR991 water content measuring tool, it was found that the water content of coffee beans was 23.3% on the first day and 11.9% on the last day. The moisture content of coffee beans dried at room temperature has a moisture content of 22% on the first day and 11% on the last day using a microcontroller-based moisture meter. While the results of measuring the moisture content of coffee beans using the AR991 moisture meter are 23.3% on the first day and 12% on the last day.

Keywords: moisture content, robusta, coffee bean, microcontroller, sun, room temperature

1. Introduction

Robusta coffee (Coffea canephora) is a coffee variety that is widely cultivated in various regions, especially in Indonesia. One factor that greatly influences the quality of coffee beans is water content. The right water content not only affects the taste and aroma of coffee, but also plays an important role in the storage and processing of coffee beans. Coffee beans with high water content tend to be more susceptible to damage and quality reduction, so measuring water content is a crucial step in the coffee industry [1].

One common method of drying coffee beans is by drying them in the sun. This method has advantages, such as low cost and simplicity, but also has disadvantages, such as the uncertainty of weather conditions which can affect the drying duration [2]. On the other hand, drying at room temperature also needs to be explored to determine its effect on the moisture content of coffee beans.

So far, farmers have measured the water content of coffee beans manually, namely with scales [3] and visual observation [4]. Both methods have advantages and disadvantages. The advantages of the weighing method are high accuracy [3], simple and easy to do. The weakness of this method is that it takes time [5] and there is the influence of other variables. Visual observation also has advantages such as fast, practical and low cost [6] and its weaknesses are inaccuracy [7] and does not provide quantitative data [8].

The impact of not using a water content detection tool on coffee beans is very significant. Without adequate tools, coffee farmers and entrepreneurs may have difficulty determining the optimal drying time. This can cause the coffee beans to over-dry or under-dry, which has a negative impact on the quality and taste of the coffee. Coffee beans that are too dry can lose important aromatic components, while beans that are still wet can cause mold growth and damage during storage [3]. Therefore, the use of a microcontroller-based water content measuring instrument provides a modern solution for measuring water content accurately and efficiently. By utilizing this technology, it is hoped that better monitoring of the water content of coffee beans can be carried out during the drying process [7]. Arduino microcontroller is used as a data processor [8] who can communicate command to sensor [9]. Microcontrollers are known to have small and compact sizes [9], low prices, low power consumption [10], ease of programming [11], flexibility and easy component integration [12]. This research is entitled "The water content of coffee beans dried in the sun and at room temperature is measured using a microcontroller-based water content measuring instrument"

2. Method

2.1. Material and Time

The material used is robusta coffee beans.

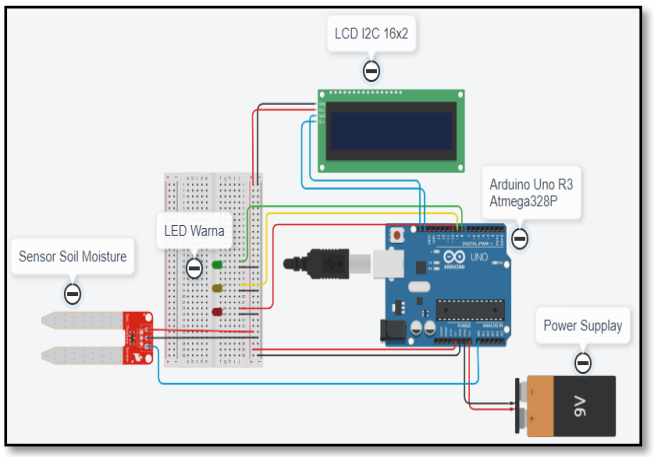
This research was carried out by drying coffee beans under sunlight and room temperature. Sun-dried coffee beans were measured for water content every day for seven days. Every day, drying is carried out for 7 hours per day under sunlight and 24 hours per day at room temperature.

2.2. Tools

Tool used in a series of water content measuring devices are

1. Arduino Uno R3 (Arduino. CC., Itali)
2. Soil moisture capacitive sensor (DFRobot, China)
3. I2C 16x2 LCD (DFRobot, China)
4. Red, Yellow, Green LED
5. Mini Breadboard
6. Jumper Cables
7. Power Supply Adapter

2.3. Design of Device



The schematic diagram for detecting water content in Robusta coffee beans can be seen in Figure 2.1.

2.4. Ways of Working

The capacitive soil moisture sensor works by detecting the intensity of water contained in robusta coffee beans. This sensor functions by measuring changes in humidity in coffee beans. The measurement results from the sensor are then processed into digital data which is sent to the microcontroller.

The microcontroller is tasked with processing data received from the capacitive soil moisture sensor. After processing the data, the microcontroller sends data output to two output components, namely the 16x2 I2C LCD and the LED. In any research 16x2 I2C LCD commonly used to display result of the system [13]. The device 16x2 I2C LCD can be used to displays the percentage of water content in numerical form, so users can know the water content of Robusta coffee beans accurately. Meanwhile, the LED provides a visual indication with certain colors that represent the range of water content, namely, the green LED indicates low water content, the yellow LED indicates medium water content, and the red LED indicates high water content.

Thus, this tool allows users to determine the water content of

robusta coffee beans in two ways, namely, percentage display on the LCD and color indication on the LED. The resulting output is a percentage of water content data displayed in real-time, providing important information for users in the processing and storage of robusta coffee beans. This helps ensure that the quality of the coffee beans is maintained with the appropriate water content.

3. RESULT AND DISCUSSION

The process of drying coffee beans after harvest is an important step in coffee processing that functions to reduce the moisture content in coffee beans so that they can be stored properly and reduce the risk of spoilage.

3.1. Drying Test under the Sun on Robusta Coffee Beans

Figure 3.1 displays the results of the measurement of drying coffee beans after harvest using a capacitive soil moisture sensor. Sensor readings show that when the coffee beans have just been peeled, the moisture content contained in the coffee beans is 23%. The drying process for several days is required to achieve the desired level of dryness.

Figure 1. *Display of Coffee Bean Results Before Drying under the Sun*

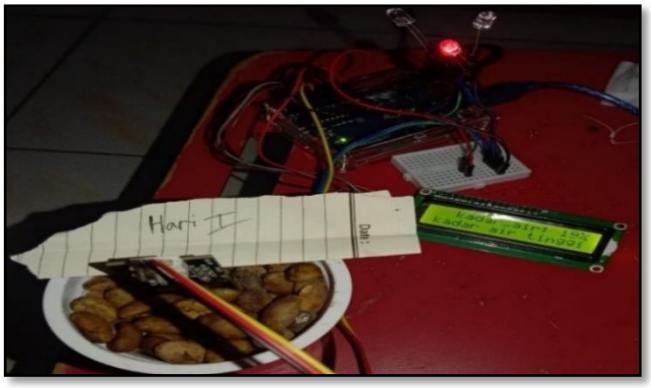


Figure 2. *Display of Drying Results in 1 day under thet sun*

In Figure 2, after 1 day of drying with a time span of 9 am to 4 pm with hot weather conditions, the moisture content in coffee beans decreased to 19% wet. This moisture content is still too high for long-term storage and further processing, so the coffee beans need to be dried in the sun longer to achieve lower moisture content.

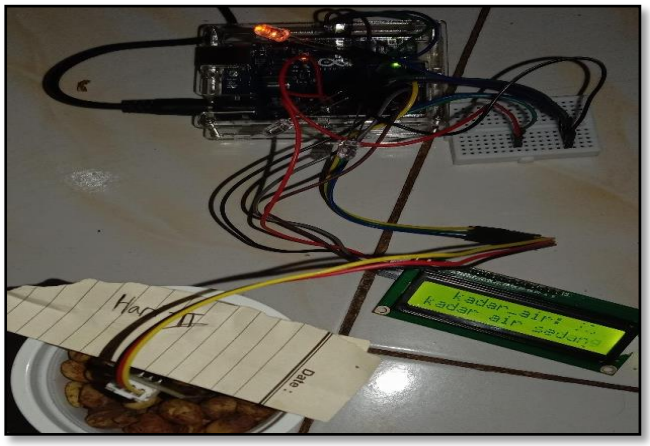


Figure 3. Display of Drying Results in 2 Days the Sun

In Figure 3, the moisture content of coffee beans after drying for 2 days with a time range of 9 am to 4 pm with hot weather conditions, decreased to 13% moderately. This is a drought level that has improved, but it still needs to be further reduced to achieve the desired selling point and moisture content standard.

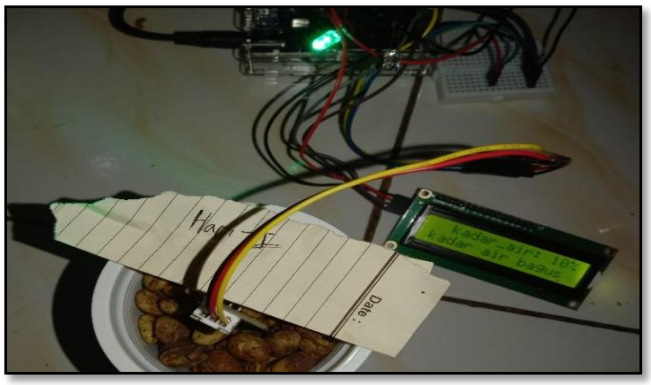


Figure 4. Display of Drying Results in 3 Days the Sun

In Figure 4, after being sun-dried for three days from 9 a.m. to 4 p.m. under hot weather conditions, the moisture content in the coffee beans shrank to 10% dry. This is the desired level of dryness for long-term storage and further processing, ensuring that the coffee beans remain durable and ready for the next stage of processing.

Research on the moisture content of coffee beans dried at room temperature takes 5 to 10 days to reach a moisture content of 10-12% depending on the weather and drying technique [14]. Proper drying in the sun can increase the complexity of coffee bean flavours, although there is a risk of damage from unexpected moisture [15]. Higher temperatures speed up the drying of coffee beans, but they can damage aroma compounds if they overheat [16].

Table 1. Results of Drying Test under the Sun

No	Date	Drying Time	Moisture content (Sensor *Soil Moisture Capacitive*)	Moisture content (*Grain Moisture Meter AR991)*	Error %
1	7 June 2024	-	23%	23,3%	0,3%
2	7 June 2024	7 hours	19%	19,5%	0,5%
3	8 June 2024	7 hours	13%	14,1%	1,1%
4	9 June 2024	7 hours	10%	11,9%	1,9%
Average of error					0,95%

In the table 1, on day zero, the wet moisture content measured using the soil moisture capacitive sensor was 23%, while the AR991 grain moisture meter showed 23.3%, with a difference of 0.3%. On the first day, the wet moisture content measured using the soil moisture capacitive sensor was 19%, while the AR991 grain moisture meter showed 19.5%, with a difference of 0.5%. On the second day, the medium moisture content measured using the soil moisture capacitive sensor was 13%, while the AR991 grain moisture meter showed 14.1%, with a difference of 1.1%. On the third day, the dry moisture content measured using the soil moisture capacitive sensor was 10%, while the AR991 grain moisture meter showed 11.9%, with a difference of 1.9%. From the results of the test, it can be concluded that there is a difference in the measurement of wet moisture content between the two devices. The largest difference occurred on the third day with a difference of 1.9%, while the smallest difference occurred on the first day with a difference of 0.3%.

3.2. Room Temperature Drying Test on Robusta Coffee Beans

Figure 5. displays the results of the measurement of drying coffee beans after harvest using a capacitive soil moisture sensor. Sensor readings show that when the coffee beans have just been peeled, the moisture content contained in the coffee beans is 22%. The drying process for several days at room temperature is required to achieve the desired level of dryness. Drying at room temperature allows for natural evaporation of water from coffee beans, so that the quality of coffee beans is maintained without the risk of drying too quickly or unevenly.

Figure 5. Display of Coffee Bean Results Before Room Temperature Drying

Figure 6. Display of 1-day drying results in room temperature

In Figure 6, after 1 day of drying at room temperature, the moisture content in the coffee beans shrinks to 20% wet. This moisture content is still too high for long-term storage and further processing, so the coffee beans need to be dried in the sun longer to achieve a lower moisture content. Drying at room temperature gradually reduces the moisture content in the coffee beans without damaging the quality of the beans, as drying occurs naturally and under control. With proper drying at room temperature, coffee beans can achieve optimal levels of dryness for storage and subsequent processing.

Figure 7. Display of 2-day drying results in room temperature

In Figure 7, after 2 days of drying at room temperature, the moisture content in the coffee beans shrinks to 18% wet. This moisture content is still too high for long-term storage and further processing, so the coffee beans need to be dried in the sun longer to achieve a lower moisture content.

Figure 8. Display of 3-day drying results in room temperature

In Figure 8, after 3 days of drying at room temperature, the moisture content in the coffee beans shrinks to 16% wet. This moisture content is still too high for long-term storage and further processing, so the coffee beans need to be dried in the sun longer to achieve a lower moisture content.

Figure 9. Display of 4-day drying results in room temperature

In Figure 9, after 4 days of drying at room temperature, the moisture content in the coffee beans shrinks to a moderate 14%. This is a drought level that has improved, but it still needs to be further reduced to achieve the desired selling point and moisture content standard.

Figure 10. Display of 5-day drying results in room temperature

In Figure 10, after 5 days of drying at room temperature, the moisture content in the coffee beans shrinks to a moderate 12%. This is a drought level that has improved, but it still needs to be further reduced to achieve the desired selling point and moisture content standard.

Figure 11. Display of 6-day drying results in room temperature

In Figure 11, after 6 days of drying at room temperature, the moisture content in the coffee beans shrinks to a moderate 11%. This is the desired level of dryness for long-term storage and further processing, ensuring that the coffee beans remain durable and ready for the next stage of processing.

Research on the moisture content of coffee beans dried at room temperature takes 10 to 14 days to reach a moisture content of 10-12% depending on the temperature and ventilation conditions [17]. Drying at room temperature can preserve the aroma and taste of coffee beans, although the process is slower [18][19].

Table 2. Results of Drying Test at Room Temperature

No	Date	Drying Time	Moisture content (Sensor *Soil Moisture Capacitive*)	Moisture content (*Grain Moisture Meter AR991*)	Error %
1	27 June 2024	-	22%	23,3%	1,3%
2	28 June 2024	24 hours	20%	20,5%	0,5%
3	29 June 2024	24 hours	18%	18,9%	0,9%
4	30 June 2024	24 hours	16%	17,3%	1,3%
5	1 June 2024	24 hours	14%	15,1%	1,1%
6	2 June 2024	24 hours	12%	13%	1%
7	3 June 2024	24 hours	11%	12%	1%
	Average of error				1,01%

Table 2 shown that the test results using the soil moisture capacitive sensor and the AR991 grain moisture meter are as follows: Day zero, the wet moisture content measured using the soil moisture capacitive sensor is 22%, while the AR991 grain moisture meter shows 23.3%, with a difference of 1.3%. On the first day, the wet moisture content measured using the soil moisture capacitive sensor was 20%, while the AR991 grain moisture meter showed 20.5%, with a difference of 0.5%. On the second day, the moderate moisture content measured using the soil moisture capacitive

sensor was 18%, while the AR991 grain moisture meter showed 18.9%, with a difference of 0.9%. On the third day, the dry moisture content measured using the soil moisture capacitive sensor was 16%, while the AR991 grain moisture meter showed 17.3%, with a difference of 1.3%. On the fourth day, the dry moisture content measured using the soil moisture capacitive sensor was 14%, while the AR991 grain moisture meter showed 15.1%, with a difference of 1.1%. On the fifth day, the dry moisture content measured using the soil moisture capacitive sensor was 12%, while the AR991 grain moisture meter showed 13%, with a difference of 1.0%. On the sixth day, the dry moisture content measured using the soil moisture capacitive sensor was 11%, while the AR991 grain moisture meter showed 12%, with a difference of 1.0%. From the results of the test, it can be concluded that there is a difference in the measurement of wet moisture content between the two devices. The largest difference occurred on the third day with a difference of 1.3%, while the smallest difference occurred on the first day with a difference of 0.5%. This difference indicates that each tool has different measurement characteristics.

4. Conclusion

This study demonstrates the effectiveness of a microcontroller-based moisture content analyzer for monitoring the water content in robusta coffee beans. The tool provides accurate measurements comparable to the AR991 grain moisture meter, with an average error margin of ±1%. The device effectively tracks the reduction in moisture content during both sun drying and room temperature drying processes, ensuring that the beans achieve optimal dryness levels for long-term storage and processing.

The study highlights the practical advantages of integrating a microcontroller-based system, including real-time data display, ease of use, and cost-efficiency, making it a valuable tool for coffee farmers and processors. By leveraging this technology, the coffee industry can improve quality control and reduce the risks associated with over-drying or under-drying beans. Future research can explore further optimization of the tool to accommodate diverse drying conditions and different coffee varieties.

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