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Cocoa Bean Cleaner and Dryer Device: A Microcontroller Experiment

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Abstract – Cleaning and drying cocoa beans are generally done manually by farmers. The manual cleaning process takes a long time, and the pulp reduction is not optimal. In contrast, drying using sunlight takes a long time when it is done in the rainy season. This causes the cocoa beans to be moldy and have low sale value. In the equipment made by the factory, the two machines are made separately and are hardly affordable by the farmers. Based on these problems, a microcontroller-based cocoa bean dryer (de pulper) was designed with a single container so that both processes could be carried out using just one machine. To elaborate this system, cleaning is carried out on fermented cocoa beans that are pulp shed in a rotating cylinder. In comparison, the drying process is carried out by using a heat source, a soil moisture sensor to detect the moisture content of cocoa beans, a DS18B20 sensor to detect temperatures in the drying container, and a cylindrical container is rotated using an A.C. motor. Based on the experiment results, it takes 10 minutes to clean the cocoa beans from the pulp. The drying process takes 5 hours, 10 minutes, and 5 hours and 40 minutes to dry the cocoa beans to a maximum moisture content of 7%. A rotating drying container can speed up the drying process of cocoa beans compared to drying using sunlight in the rainy season. The proposed tool in this study can carry out more efficient capacity better than the conventional tool.

Keywords: *depulper*, cocoa dryer, cocoa beans, fermented cocoa

Introduction

Cocoa (*Theobroma cacao* L) is one of the plantation crops that possess superb economic value and massive market opportunity. The demand for cocoa has sharply inclined, along with the increasing demand for raw materials for dry cocoa beans (Daniel et al., 2015; Riskiawan et al., 2018). Based on International Coffee Organization (ICO), Indonesia produces the fourth largest coffee globally (ICO, 2018). Market opportunities for these commodities are also increasingly open in line with the decline of production experienced by other countries (Amran, 2009).

Before drying, the cocoa beans are cleaned from the mucus attached to the seeds. This process is called *depulper*. Drying is then carried out to reduce the water content of the seeds and affect the taste, especially the acidity of the chocolate generated (Karmawati, et al., 2010). Before the drying phase, the cocoa beans are cleaned of mucus attached to the seeds, called the cleaning or depulper process. Because the people process most Cocoa plantations in Indonesia, cleaning cocoa beans is still done conventionally, i.e., by hanging cocoa beans on nets or washing them with water.

The next essential step that must be passed in processing cocoa beans is drying using sunlight or using a dryer (artificial drying). While the cocoa bean drying process is carried out by drying the seeds directly under the sun. (J Veira et al., 2019). The problem with using this method is the time needed to dry cocoa beans directly under sunlight in the rainy season due to the intensity of erratic sunlight. At the same time, the use of tools costs a lot of money. In recent research, there is some improvisation by presented research developed in cocoa bean drying plant artificial for calculation Generalized Predictive Control (GPC), is the same as implemented using based embedded system microcontroller. Technique natural cocoa drying and synthetic specifications, detailed physical tools, and dynamics

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operations are determined through linear process identification. This scientific activity provided a conclusion in the analysis comparability of the GPC controller and implemented PID on drying (Rosero et al., 2015). A microcontroller as a control system is one of the technological developments increasingly used today to solve everyday problems in various fields. Development This technology is the background for applying Arduino in processing software post-harvest cocoa beans to produce the final product of cocoa beans with a maximum moisture content of 7% and a faster drying process (Arduino, 2017).

The dryer used by the factory has a sieve of aluminum that is used as a drying floor and heated at a temperature of 55^0C - 65^0 C. In comparison, the cleaning process is done separately. The two machines will be combined to clean and dry cocoa beans using the same container in this study. System control uses a microcontroller ATmega328, a temperature sensor to determine the drying temperature, two soil moisture sensors, and an A.C. motor to rotate the container.

Materials and Methods

Mechanism of Cocoa Cleaning and Drying

The research was conducted in 2018 in Bukitinggi, located in West Sumatra Province, during the rainy season and worked privately using a designed tool. In the tool's design to be built, a microcontroller-based dryer and cleaner for cocoa beans consist of a container that functions as a cleaner and dryer. In detail, hardware components such as Arduino Uno (ATmega328), A.C. motor to rotate the container during the cleaning process, drying cocoa beans, moisture sensor (soil moisture sensor), temperature sensor DS18B20, relay, heater, LCD, switch, and buzzer. (Instructable, 2018) The cleaning and drying container for cocoa beans will be made in a tube with a radius of 12 cm and a length of 40 cm. The container will be given small holes that function as air circulation channels and release the mucus attached to the cocoa beans during the cleaning process. The container will be rotated using an A.C. motor adjusted at a customizable speed for each operation. The container will turn faster in the drying process than in the cleaning process. Heat for drying comes from a heater heated a 55^0C – 60^0C. The moisture content of the dried cocoa beans was measured using two custom-positioned moisture sensors, and the temperature in the container was measured using the DS18B20 sensor.

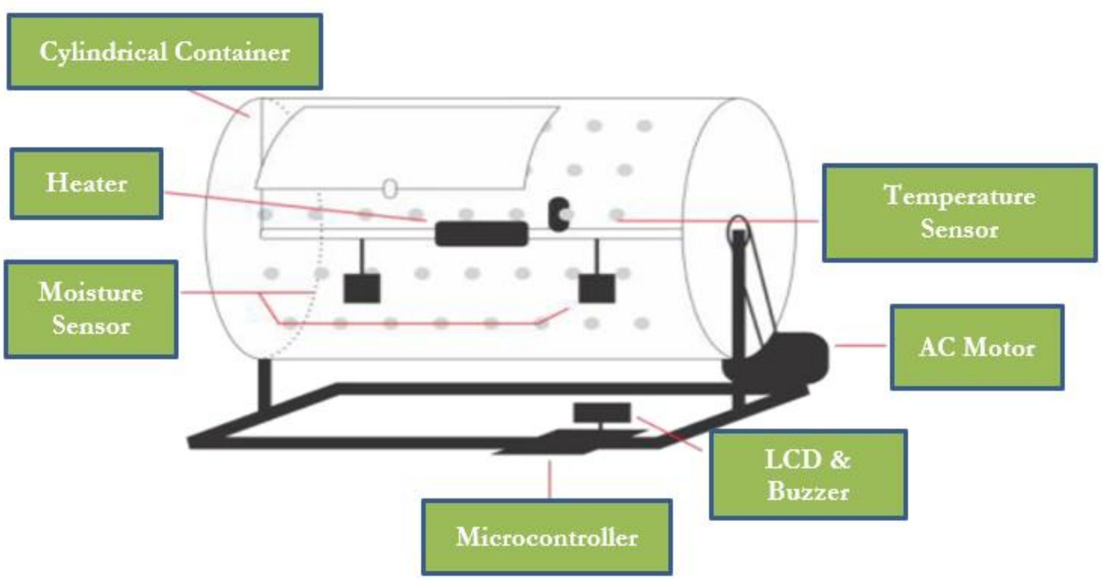

Figure 1. Proposed tool schema

Hardware Design

The hardware design provides an overview of the relationship of each component used in cocoa beans' cleaning and drying process. The cocoa bean cleaning process uses an A.C. motor rotated at an adjustable speed in the container. It uses an A.C. dimmer / A.C. motor rotation speed regulator and a container in the form of a tube with

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small holes on the side for the mucus attached to the cocoa beans to come out. Meanwhile, the cocoa bean drying process uses an A.C. motor to rotate the container slower than the motor during the cleaning process. It is heated using a heater at a specific temperature range. The moisture content of cocoa beans during the drying process was measured using a soil moisture sensor to ensure that the cocoa beans reached the desired moisture content.

Based on Figure 2, it can be s that several components are installed in the container. These components will only be active and used in the drying process by pressing the switch. The soil moisture sensor is used to detect the moisture content of dried cocoa beans. The heater serves as a heat source to dry the cocoa beans. The DS18B20 temperature sensor detects the temperature in the container during the drying process. While in the component box, there is a microcontroller, relay, power supply, buzzer, and switch, as shown in Figure 3.

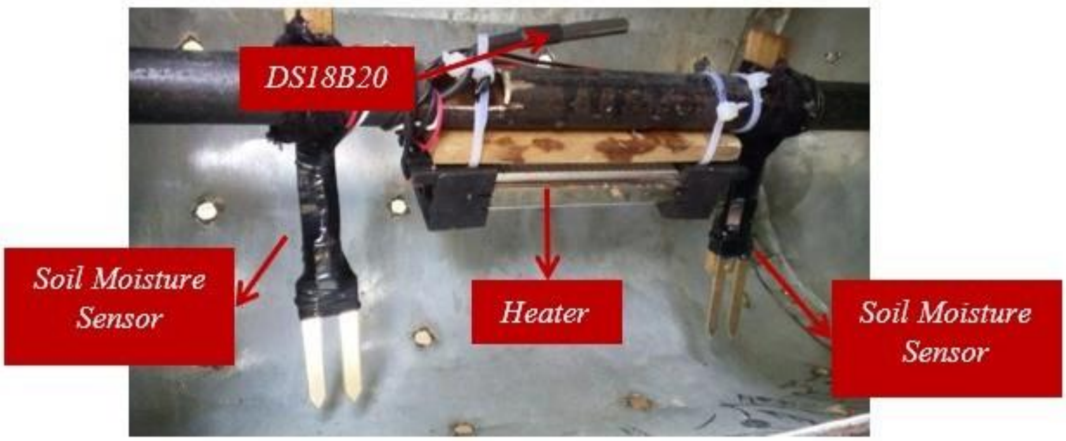

Figure 2. Sensors and Heater Components inside the tray

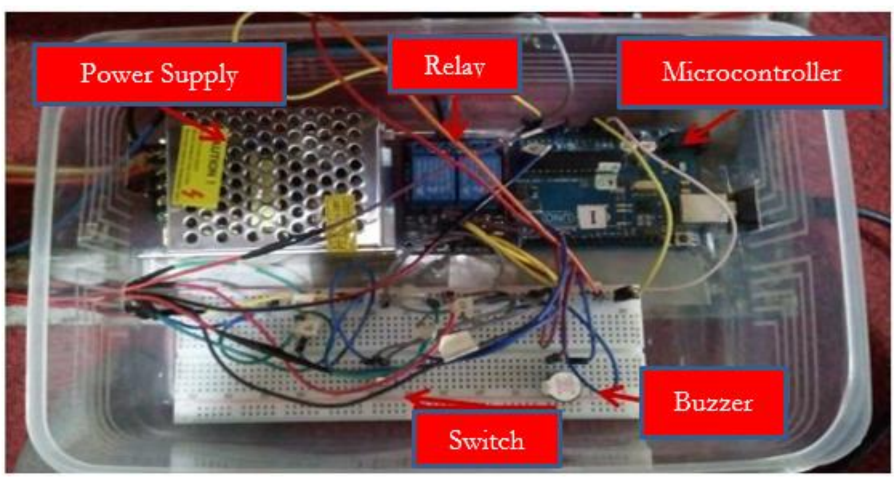

Figure 3. Schematic of Microcontroller, Relay, Power Supply, Buzzer, and Switch

Results

Cocoa beans cleansing

Cleaning testing is the sloughing off the mucus attached to the cocoa beans, which aims to reduce the amount of mucus attached to the cocoa beans. In the cleaning process, three samples of cocoa beans with the same weight were used. The tool's cleaning process is carried out by running the instrument within a specific period and then comparing the results to the length of time and samples with conventional processing methods. Traditional cocoa beans were cleaned in two ways: washing the cocoa beans using water and hanging the cocoa beans in a net for 1

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or 2 days.

Table 1. Cocoa beans cleansing techniques

No.	Methods	Result	Cleansing Duration	Final Weight
1.	Cocoa beans fermented and soaked (not cleaned)		-	1 kg
2.	Cleansing using water		3 minutes 31 seconds	6,2 ounce
3.	Cleansing by hanging the cocoa beans using nets		10 hours 12 minutes	7 ounce
4.	Cleansing by using the proposed device	(a) 	3 minutes	9 ounce
		 (b)	5 minutes	8,7 ounce
		 (c)	10 minutes	7 ounce

Cocoa Beans Drying Testing

Testing the effect of heater and container rotation using an A.C. motor is conducted to see the impact on drying time. Drying cocoa beans using a dryer will be compared with drying using sunlight. The test was carried out twice with the same wet weight of cocoa beans, 1 kilogram. In the tool, the moisture content of cocoa beans is checked every 10 minutes by turning off the A.C. motor. The graph of the effects of drying cocoa beans using a device can be seen in Figure 3 and Figure 4.

The moisture content in the cocoa bean drying process using the equipment in experiment 1 was more volatile than drying in experiment 2. The moisture content did not decrease constantly but increased when the moisture

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content test was carried out. During the drying process, the cocoa beans are inverted so that some beans are stacked on the sensor, while at other times, the beans are scattered. The measurement results are also influenced by the dryness of the cocoa beans attached to the sensor during the testing process due to the different sizes of cocoa beans. Some cocoa beans dry faster than larger beans. However, based on the test data, it can be observed that the increase in the moisture content of cocoa beans from the previous measurements is not too far away, and the results of even distribution of the drying phase.

Following the data from the cocoa bean test results, it was concluded that it took more than 5 hours to dry the cocoa beans to reach a maximum moisture content of 7%. The first experiment took 5 hours and 40 minutes to dry the cocoa beans with a final moisture content of 6.00% cocoa beans on sensor 1 and 6.07% on sensor 2. In the second experiment with the same wet weight of cocoa beans, it took 5 hours and 10 minutes to Dry cocoa beans with a final moisture content of 6.00% on sensor 1 and 6.80% on sensor 2. Meanwhile, drying cocoa beans using sunlight takes 10 hours and 9 minutes with a 6.23% cocoa beans moisture content.

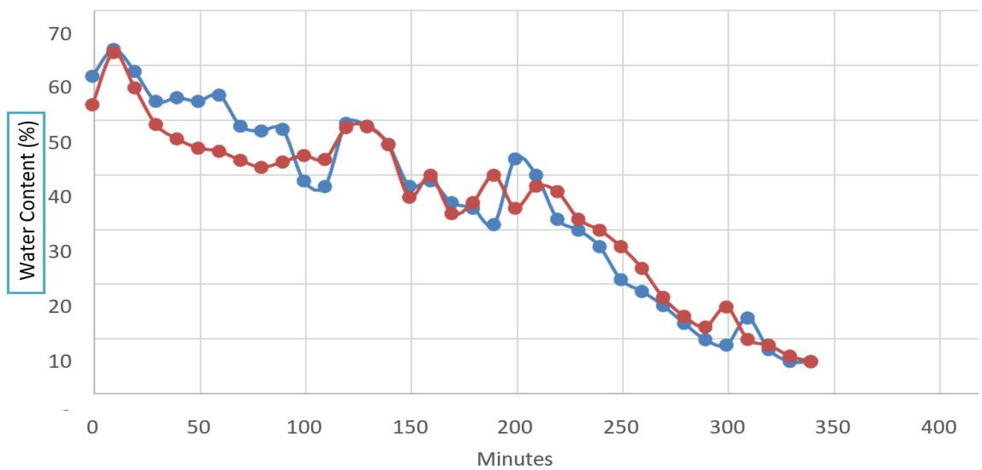

Figure 3. Graph of cocoa bean drying results using tools (1st Experiment)

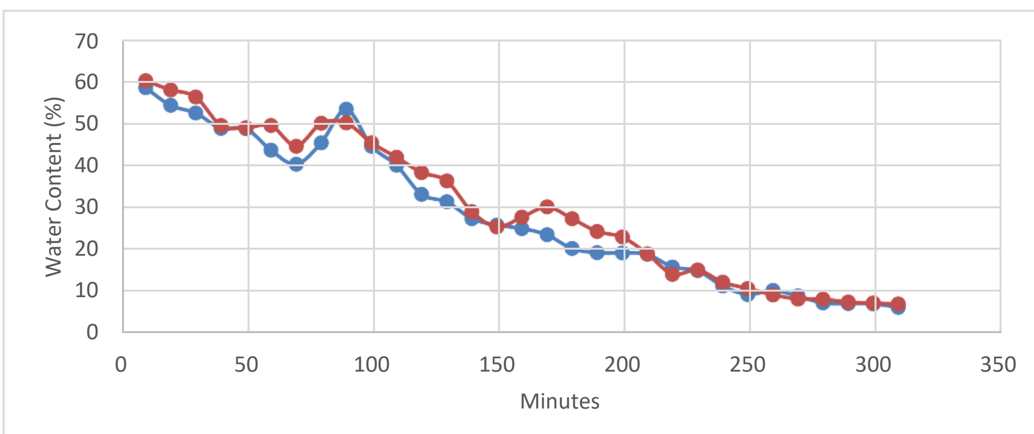

Figure 4. Graph of cocoa bean drying results using tools (2nd experiment)

The drying temperature influences the drying yield of cocoa beans. The drying temperature can be adjusted to the desired temperature range in the tool. Meanwhile, when using sunlight, especially in the rainy season, the drying temperature is often not as expected, so it takes a longer drying time. The temperature in the drying container is regulated by turning the heater off and on at a specific temperature limit. The effect of the heater setting on the temperature in the drying process can be seen in Table 2.

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Table 2. Effect of heater setting on the temperature in the drying process

Experiments	Water Content		Temp (^{0}C)	*Heater Condition*
	Moisture Sensor 1	Moisture Sensor 2		
1.	58.55	60.22	42.31	On
2.	62.91	61.00	47.13	On
3.	52.50	56.34	59.13	On
4.	48.81	49.52	60.08	Off
5.	40.20	44.56	63.23	Off
6.	48.75	48.94	44.19	On
7.	53.40	50.13	45.38	On
8.	33.00	38.25	52.50	On
9.	31.25	36.27	61.38	Off
10.	40.00	41.92	60.02	Off

Table 3. Comparison Between Proposed Tool and Conventional Method

Duration	Cleaning and Drying Activities	
	Proposed Tool	**Conventional**
1 (One) Day	2 Kg	-
1 (One) Week	10 Kg	1 Kg
2 (Two) Weeks	20 Kg	3 Kg
3 (Three) Weeks	30 Kg	7 Kg
4 (Four) Weeks	40 Kg	10 Kg

Discussion

Comparison Between the Proposed Tool and Conventional Method

The drying process of cocoa beans in the rainy season depends on sunlight intensity (Veira, 2019). The cocoa beans can get moldy and dry longer when the sunlight gets less. Table 3 describes the cleaning and drying of cocoa beans using the conventional method in one day not exist because the cocoa beans are dried only half dry and have not reached the desired moisture content.

While processing with tools in one day can produce as much as two kilograms of dry cocoa beans with two processing times. Processed cocoa beans weigh one kg according to the ability of the motor used. In calculating the estimated capacity of cocoa beans that can be cleaned and dried using the designed system, the tool only operated for five days in 1 week. The remaining day was used for machine maintenance. Based on the estimated cleaning capacity table and drying cocoa beans, the system is designed to effectively clean and dry cocoa seeds without the help of sunlight in the rainy season.

Conclusion

The microcontroller can read the water content value from the soil moisture sensor and the temperature value from the DS18B20 sensor. The moisture content value is used for the complete drying system, while the temperature value regulates the heater's heating. A heater with a 55^{0}C - 60^{0}C can dry cocoa beans in 5-6 hours. A rotating drying container can speed up the drying process of cocoa beans compared to drying using sunlight in the rainy season. Furthermore, based on the actual comparison, the proposed tool can carry out more efficient capacity better than the conventional. It is better to figure out how to simplify the maintenance activities for further work since the proposed tool can only operate for 5 (five) days.

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