Improving the quality and quantity of cinnamon drying process using art cave in Lambung Bukit West Sumatra

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Abstract. Cinnamon processing in Padang City constraints when processing cinnamon barks under direct sunlight due to its dependence on weather and vulnerability to dust and animals. Hence, a machine were introduced to a cinnamon drying device named Art-Cave (Smart Dryer System for Cassiavera). This machine can dry cinnamon barks with humidity below 14\% to prevent mushroom growth, while the heating temperature allowed is 60 °C to maintain the content of aetheric oil. The machine provides four shelves that are used as storage. The capacity of each shelf is 5 kg of moist cinnamon barks. After the cinnamon barks are evenly arranged, the stove at the bottom of the machine can be switched on. The heat will flow through the room on the side of the box, and the fan blows air into each shelf. On the top, a fan is installed to blow hot air out of the box — the fan functions to maintain the machine temperature on the limit of 60 °C. Therefore, the farmers can improve the drying process from 30 kg/day to about 80 kg/day as well as maintain the demanded ambient temperature by utilizing the machine.

1. Introduction
West Sumatra is one of the major cinnamon producers in Indonesia. One of the processes to obtain a good quality of cinnamon barks is the drying process [1]. Drying is the process of removing water content and removing moisture in the solution, suspension, or solid-liquid mixture to form dry solids. The process that is passed during drying is the process of energy transfer and mass transfer [2].

In general, this drying process is still carried out conventionally using sun [3]. This technique is still conducted traditionally by spreading the cinnamon barks outdoor under the sunlight [4] [5]. However, the drying process under direct sunlight yields some problems for the farmers. The first issue is the longer period it needs to reach the required moisture content [6]. Currently, it takes about three or four days to reach the moisture content which is complied with the sales standard of 14\% [7]. The second issue is the hygiene of cinnamon barks which are vulnerable to dust, soil, and dirt when drying outdoors [8]. The cinnamon barks are easily exposed to dirt in the process of rolling [9] [10]. Also, drying for agricultural products must also pay attention to the drying temperature used which is in the range of 45-60 degrees for safe drying [10]. An existing drying device is available with a quite high price that is approximately IDR 87 million which is used on the scale of the factory [11].

A field survey was conducted to a farmer processing cinnamon in Lambung Bukit village, Pauh, Padang. The findings showed that the price for each sale of 1 kg cinnamon barks is variable depends on...
the level of dryness. The way to determine the level of dryness of cinnamon barks used until this day is to split the cinnamon bark apart. The cinnamon bark is considered dry when it is hard to split; otherwise, it is imperfectly dry when the cinnamon bark is easily split. The farmer is solely dependent on sunlight to achieve the demanded level of dryness. When the rainy season comes, the cinnamon bark will suffer from mushroom vulnerability as the cinnamon barks are not dry enough. Another issue addressed by the partner is the abundance of dirt covering the cinnamon barks during the drying process. This occurs because the drying process takes on the side of the road or even half of the highway road due to the lack of land availability for the drying process. Farmers also revealed that the existing dryer in their area is available, but the device is not a specific one to dry cinnamon barks. Besides, the operational costs and machine maintenance are considered expensive for the cinnamon farmers.

Based on the problems faced by the cinnamon farmers and the literature review conducted, ART CAVE (Smart Dryer System for Cassia Vera) was generated as a solution to solve the problems of the cinnamon drying process. The machine promotes faster time, hygiene, portable, easy use and lower price. Also, the machine is equipped with a unique feature that is monitoring capability with a short message via mobile phone. The text contains information for users regarding moisture content of the cinnamon barks being drained by using GSM module [12]. The heat source used in drying device is gas stove installed with an MQ2 sensor on the side to detect any gas leaks during the drying process [13]. All communications of electronic components in the device are controlled by Arduino [14].

2. Methods

2.1. Study of Problems in Processing Cinnamon Barks
The first activity conducted is to learn the problems in processing cinnamon barks. The study of this issue was employed by observation and direct interview with the processor in Lambung Bukit, Lambung Bukit village, Pauh sub-district, Padang, West Sumatra. The processor has about 1000 kg of moist cinnamon barks in the storage every month. The drying process spends the maximum of 100 kg in one group by utilizing 50 m² large area consisting of a house yard and a little of the sidewalk. If one group takes three days to dry, then it takes 30 days to dry 1000 kg of moist cinnamon barks with only bright weather during the day. This condition emerges problems for the processors as the drying process is stopped before the cinnamon barks completely dry.

2.2. Cinnamon Dryer Design
After the problem was identified, a device was designed based on the needs of the cinnamon farmers, the standard of cinnamon moisture content is 14%, and the maximum drying temperature is 60°C. To monitor the cinnamon moisture content being drained, the information on water content is delivered directly to mobile phone users using GSM. Thus the dryer was designed using devices and main components such as fan, LCD, led, keypad, heat resistant glass, aluminum, temperature sensor, pressure sensor, Arduino, buzzer, gas stove, gas tube, and GSM module.

The dryer is made in the shape of a box with the display as shown in Figure 1. There is a single door that can be opened by pulling it. On the door, LCD is installed to display the information related to temperature, cinnamon barks mass and moisture content contained in cinnamon barks. There are four shelves to place the cinnamon barks. A weight sensor is placed in each shelf to identify the mass of cinnamon barks.
The stove as the source of fire is placed at the bottom. Hot air will flow on the side of the box and blow into each shelf with the support of the fan. At the top of the box, a fan is installed to blow away the water vapor out of the box. Figure 2 illustrates the positions of fire and airflow in the dryer.

**Figure 1.** Cinnamon dryer displayed from several positions (a) front (b) side (c) back

**Figure 2.** The position of the heater and airflow from the bottom flows out of the top.

### 2.3. Steps of Machine Evaluation

The first test is conducted to find out the temperature homogeneity inside the machine. The stove is heated slowly, and temperature changes are noted at three different positions, i.e., at the bottom of the inside, middle and top of the device. The device is considered good when no temperature difference from the three positions. Hence, the ANOVA test was conducted to figure out whether the temperature difference from the three positions employed.

The second test is to achieve the optimal temperature in controlling heat source. The temperature of the component is expected to be below 60°C. The heat source will be switched off when the temperature has reached almost 60°C. This temperature is defined as temperature control. The value of the temperature control is set for optimal performance.

The final test is to detect the time spent by the device in the process of converting the moist cinnamon barks becoming dried cinnamon barks with humidity 14%. Also, the capacity of the device is also taken into account to find out the drying capacity.

### 2.4. Analysis of Device Benefits for Cinnamon Processors

Based on the examination employed, it should be noted whether the device can solve the farmers’ problems in the context of land efficiency, processing capacity improvement and quality maintenance of dried cinnamon barks. All these will culminate in the profits gain for the cinnamon processors.

### 3. Results and Discussion

#### 3.1 Physical Specification of Cinnamon Dryer
The device was made of a box shape with the overall height is 120 cm, total wide of 120 cm and length of 50 cm. Each shelf size is 100 cm × 50 cm. There are holes on the left and right side to blow the hot air. The width of each hole is 10 cm. Figure 3 shows the dimensions of the dryer.

The cinnamon dryer is composed of two main parts, namely the outside and the inside. The outside parts are equipped with LCD, GSM module, gas sensors, buzzer. LCD is used as the display for showing information during the drying process. LCD used twenty columns and four rows supplied with 5 Volt battery. GSM module is used to transmit information using text message. The gas sensor is used to detect gas leaks. The buzzer is used to give a warning sign in case of gas leaks in the form of sound. Additionally, this device is also equipped with a gas stove as the heat-producing source during the drying process. Figure 4 shows the inside and the outside of the cinnamon dryer.

The inside parts are equipped with a thermocouple sensor, a weight sensor, DC fan, and dryer shelves. The thermocouple sensor is used as a temperature detector which enables to control the temperature needs. It detects the temperature from -270 °C to 1027 °C. This sensor is installed on three points; bottom, middle, and top of the inside of the device. The weight sensor is used to measure the water content contained in cinnamon barks during the drying process. DC fan is used to transmit heat evenly to the top, bottom, and middle of the dryer shelves. The dryer shelf is made of an iron plate which is resistant to heat. It is made in the form of nets to spread the heat to all directions. The dryer has four shelves.

3.2 Performance
3.2.1 Temperature inside the Machine
The device has three thermocouple sensors installed on the upper part (T1), the middle part (T2), and the lower part (T3) of the inside of the device. The examination was conducted on three sensors. Empty Artcave with an initial temperature of 35°C is heated to reach 60 °C. Table 1 shows the characteristics of the temperature increase on each thermocouple. With an initial temperature of 35°C, the three locations can reach 60 °C between the ninth minute and tenth minute. This shows that the hot airflow effectiveness supported by the utilization of the fan functions properly. Anova test is conducted to identify the average temperature differences at T1, T2, and T3 carrying 90% conviction level. Table 2 shows F count is 0.20138. The number is lesser compared to the F table that is 3.35 which means the temperature in each room is the same or has no significant difference. Based on findings, the heating process can be carried out in every shelf without any priority due to the difference in temperature.
### Table 1. Characteristic of temperature increase in T1, T2, and T3.

| No | Times to (minute) | Suhu (°C) |
|----|------------------|-----------|
|    |                  | Upper (T1) | Middle (T2) | Lower (T3) |
| 1  | 0                | 35        | 35          | 35         |
| 2  | 1                | 38        | 37          | 37         |
| 3  | 2                | 41        | 40          | 41         |
| 4  | 3                | 46        | 44          | 46         |
| 5  | 4                | 49        | 47          | 50         |
| 6  | 5                | 53        | 50          | 53         |
| 7  | 6                | 56        | 52          | 56         |
| 8  | 7                | 58        | 54          | 58         |
| 9  | 8                | 60        | 57          | 60         |
| 10 | 9                | 63        | 60          | 63         |

### Table 2. The Anova Test Table

|                  | SS     | df | MS     | F      |
|------------------|--------|----|--------|--------|
| Between-treatments | 35,2667 | 2  | 17,6333 | 0.20138 |
| Within-treatments    | 2364.2  | 27 | 87,563  |        |
| Total               | 2399,4667 | 29 |        |        |

In maintaining the room temperature in to remain within the range of 50° – 60° Celsius, the stove requires an automatic switch on and off on the set room temperature. A test was conducted by switching on the stove in certain temperature and looking at the pattern of temperature from raising until reaching the three sensors (T1, T2, and T3). This way, the period needed can be seen to achieve the set temperature. The test was conducted at four temperature; condition 1 (50°C), condition 2 (52°C), condition 3 (55°C) and condition 4 (58°C). When the temperature reaches the temperature control, the heat source is switched off, and the temperature characteristics can be seen after that.

Based on the results shown in Figure 4, it can be seen that the room temperature is still rising a few moments at each position of the sensor after being switched off. Later, the temperature will be down simultaneously. The average temperature rise after being switched off at each temperature control is about 1°C. Hence, the control point selected is 58°C assuming that the maximum temperature rise after the stove goes out is 1°C. Thus the highest temperature reached is 59°C. Nonetheless, the temperature is still good for the content of aetheric oil and also the most efficient in energy use because the energy is not disposed of as much.
Figure 4. Temperature response for condition 1, 2, 3, and 4

3.2.2 Humidity Level
Cinnamon barks drying is operated in a closed room. The moist cinnamon barks are compiled in line on the shelves provided. The recommended humidity of cinnamon complies with the standard sales is approximately 14%. Figure 5 shows that the humidity of dried cinnamon barks changes. After the test was examined to the moisture content of each variation of time, the finding shows that the moisture content of the cinnamon is influenced by the period taken during the drying process. The longer time in the drying process, the lesser the water content in cinnamon barks. As a result, it needs about 2 hours and 15 minutes to dry the cinnamon barks until it reaches the appropriate moisture content with the sale standard.

Figure 5. The moisture content of the cinnamon being drained

3.2.3 Profit Estimation for the Farmer
Land area for drying the cinnamon at one time by manual drying process requires an area of 50 m². A group of moist cinnamon barks takes 3-4 days of the drying process, in which an approximately 1000
Kg of moist cinnamon barks requires a month of the drying process. Meanwhile using the machine, it takes only 0.5 m² land area for a one-time drying process with a one-time drying capacity of 20 kg moist cinnamon barks. Effective time for the machine to operate is 10 hours in a day which means it can dry 80 kg moist cinnamon barks.

The weight of dried cinnamon barks will be reduced by as much as 59% of initial weight. The manual cinnamon drying process will produce 442.5 kg of dried cinnamon barks out of 1000 kg moist cinnamon barks per month. Whereas using the machine, it yields about 1416 kg of dried cinnamon barks monthly. If the price of cinnamon barks is IDR 37,000/kg, the processor will only benefit IDR. 21,830,000 per month using manual drying process. While using the machine, the revenue will reach up to IDR 52,392,000 per month. After spending additional funding such as purchasing of the machine IDR 4 million and IDR 16,000 for fuel (per day), the income of the processor would be IDR 47,912,000 per month. The revenue may increase up to 290% per month compared to the manual drying process.

4. Conclusion
Based on the results, it is concluded that the time spent to reach the average room temperature of 50°C-60°C is 5 minutes. The temperature sensor is installed on the top of the drying room (T3), which is capable of reaching the set temperature until the stove is switched off. The temperature rises from 0.25°C to 2.75 °C at each temperature sensor which is installed at the lower, middle, and upper parts of the room after the stove is switched off. The temperature is not dropped drastically when the stove switched off. The time it takes for the temperature to decrease is longer than the time it takes to rise until it reaches the setpoint value. The higher the temperature set as setpoint value the greater the possibility of the sensor to detect the temperature above 60°C. Based on the experiment to determine the condition of the temperature for drying processes, condition 3 is established as a reference to switch the gas stove on and off. This is to ensure that temperature in the drying room remains safe for cinnamon drying process after the stove is switched off and on. The time required to dry cinnamon using Art Cave that is about 2.5 hours with the moisture content of 14% complies with the trade standard. Thus, the drying process takes lesser time, requires less land area, and is more hygienic and not dependent on the weather in the drying process.

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