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Article

The Effect of Varying Air Flow Solar Collector on the Quality of Arabica Coffee Beans

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Abstract: Different coffee drying technologies face complex task in ensuring an acceptable final seed moisture content. Drying technology of agricultural commodities aims to maintain and improve the quality of the agricultural products themselves. In addition to maintaining quality, especially from other bacterial attacks, it can last for a long time before further processing. Coffee commodities are promising for the welfare of coffee farmers. Drying technology plays a major role in determining the quality of coffee. Various drying models are applied including the traditional model that until now is still applied, direct drying under solar radiation. However, this drying process is less hygienic and requires a large area. Thus, one of the drying technologies that can accelerate drying time is to vary the air flow in the drying chamber so that the coffee can be determined to reduce the water content with a certain temperature. In this study, it was found that the moisture content of coffee beans dried using a dryer on air flow with variations of velocity in solar collector 1 (DB1) air velocity of 1.0m/s obtained the final mass = 732.249 gr, solar collector 2 (DB2) with air velocity 1.5 m/s obtained the final mass = 774.70 gr, solar collector 3 (DB3) with air velocity 2.0 m/s obtained the final mass = 855.10 gr, solar collector 4 (DB4) with air velocity 2.5 m/s obtained the final mass = 745.79 gr, and solar collector 5 (DB5) with air velocity 3.0 m/s obtained the final mass = 786.40 gr. Water Content DB1=12.0%, DB2=13.6%, DB3=18.5%, DB4=12.9% and DB5=15.2%. The time required for 25 hours with a maximum radiation of 586.9 w/m², total heat utilized from solar radiation in 3 days =16.663128 MJ/m². from the initial weight of 1500gr coffee bean samples and dried in five solar collectors with parallel simultaneously. The evaporated water content DB1=51.18%, DB2=48.35%, DB3=42.96%, DB4=50.28% and DB5=47.57%. Based on this research, it was found that the most optimum quality of coffee was by using solar collector 2 (DB2), namely with air flow of 1.5 m/s with average temperature in the drying box DB2=43.68°C, with the quality content of the coffee, Protein content=12.2%, Carbohydrate=22.8% and Free Fatty Acid (ALB) content=0.05%.

Keywords: coffee; air flow; forced convection; temperature; quality

1. Introduction

Based on the latest data from The International Coffee Organization (ICO) and coffee review, Indonesia ranks fourth largest in the world in terms of coffee production, after Brazil, Vietnam and Colombia. Indonesia is also the fifth largest coffee exporting country in the world [1],[2]. Based on data from the Central Statistics Agency (BPS), Indonesia's coffee exports were recorded at US\$ 1.14 billion with a volume of 433,780 tons in 2022. The export value increased by 35.71% compared to the previous year which amounted to US\$842.52 million with a volume of 380,173 tons [3]. The drying process is one of the required stages in the processing of crops that serves to reduce the water content to a level that is suitable for storage for a longer period of time but still maintains the quality of the final product [4].

Solar energy, the most main source of today's energy, is unsurpassed due to its large amount of energy, capable capacity, environmentally friendly, easily available, and clean power source [5].

Compared to non-renewable sources, solar energy is considered the most beneficial renewable energy resource for drying industrial and agricultural products. The utilization of solar power in food drying technology can reduce costs due to fossil fuels [6]. Solar energy in the food production process has a great impact in the development of food technology, although there is currently a movement towards renewable energy storage due to the impact of fossil fuel use on energy, climate change, and the demand to reduce post-harvest damage is growing. Drying farm products can maintain shelf life, save packaging costs, reduce packaging costs, increase transportability, and create a better appearance while maintaining flavor and nutritional content. By removing water from foodstuffs, bacteria, yeast, and mold cannot grow, leading to food spoilage [7]. This is accomplished by eliminating water from a substance and the result is a solid. However, it is a complicated procedure that combines mass and heat transfer simultaneously [8].

Drying in direct sunlight is a traditional method often used by farmers to preserve their agricultural produce. This technique is a method that has been used for a long time [9]. Open sun solar dryer (OSSD) is one way to dry foodstuffs. OSSD has many drawbacks, such as degradation of the quality of professional air ducts, rain, wind and production loss due to birds and dust [10]. Solar dryers can be considered to replace OSSD types if designed appropriately. SD offers advantages over OSSD if well designed [11]. Therefore, indirect dryers are widely researched to improve the quality of agricultural products and are a sustainable solution [12], [13].

The Indirect drying method consists of a drying chamber and a solar collector. The solar collector absorbs heat from the sun and delivers the heat to the drying chamber naturally. Lingayat and Chandramohan conducted a numerical investigation of an indirect solar dryer for drying banana chips [14]. Designed a solar dryer integrated with a solar collector for drying green tea [15]. Analyzed a solar dryer integrated with a double-sided solar collector for drying bananas. From the results of the study, the efficiency obtained was 21.9% [16]. Experimented a solar dryer integrated with a solar collector with the help of heat storage material to overcome the absence of sunlight at night. From their results, the highest drying efficiency was 41.66% [17]. Examined indirect solar stills integrated with solar collectors numerically, from the results of their research it was found that the optimum output position was in the northern part [18]. Analyzed indirect dryers using flat plate collectors and finned collectors [19]. Based on the literature studies conducted above, until now drying using plate collectors with forced convection systems is a fairly efficient and most widely used drying system for drying various commodity products.

Drying is a very complicated process of mass transfer phenomena, so that each commodity must have special drying conditions in order to obtain optimal quality drying results. For this reason, until now there is still a great need for research to determine the optimum forced convection drying conditions to obtain good drying quality results. Some research related to solar drying using forced convection system plate collectors, [20] in 2021 conducted research on performance Forced Convection solar Cabinet Dryers Under Different air Mass flow Rates for Dryer cluster number. In this study, several variations of air flow rates were carried out to dry cluster fig fruit. Based on this research, the optimum air flow rate for drying cluster fig fruit in order to obtain good drying quality was 3.72 kg/min. [21] in 2021 conducted research on analyzes drying system based on a solar collector for drying carob pulp. In this study, several variations of flow velocity and temperature were carried out to dry carob pulp. Based on this research, it was obtained that the drying temperature condition of 80°C and a drying air velocity of 0.18m/s was the optimal condition for drying carb pulp. [22] in 2021 conducted research on the effect of variations in the mass flow rate of drying air to dry pineapple using a mixed-mode solar dryer. In the study obtained, a drying air mass flow rate of 0.0015 kg/s can produce better exergy and drying efficiency. [23] in 2022 conducted research on variations in the mass flow rate of drying air on the V-groove double pass collector to dry pink lady apples. In the study, an air mass flow rate of 0.041 kg/s can remove the most optimal moister, however at an air mass flow rate of 0.051 kg/s is the maximum exergy efficiency.

Therefore, there is still no research that varies the air flow velocity on the solar coffee dryer. For this reason, this research has a novelty with the aim of analyzing the effect of variations in airflow velocity and temperature solar collector on coffee quality in a solar coffee dryer with speed variations

of 1 m/s, 1.5 m/s, 2 m/s, 2.5 m/s, 3 m/s. This research is expected to find the optimal speed in the solar coffee dryer process to get optimal coffee quality.

2. Materials and Methods

In this research, 5 solar coffee dryers are used which have the same size and components. The heat source used in drying coffee beans is from solar radiation heat obtained from solar collectors as heat collectors. The arrangement of the solar coffee dryer components can be seen in Figure 1.

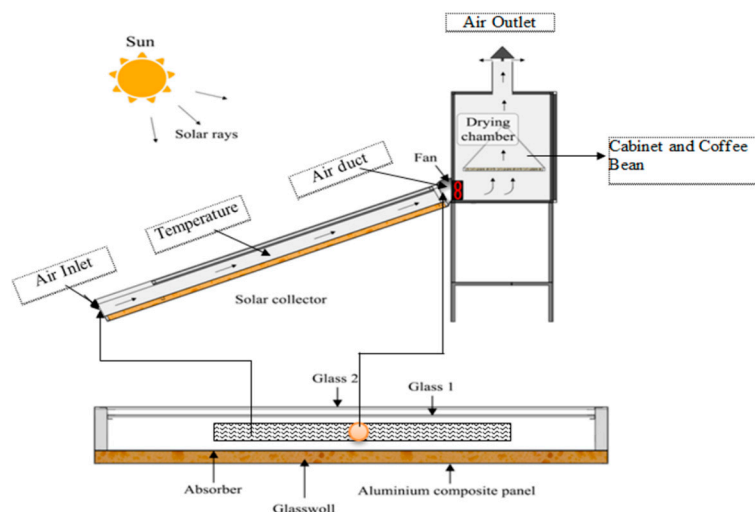


Figure 1. Component arrangement of solar coffee dryer equipment

Solar coffee dryer has components consisting of two pieces of glass with a thickness of 5 mm, a 3 mm flat type absorbent plate painted black which functions as a solar heat collector. To isolate the heat that has been trapped in the solar collector, 50 mm thick glass wool is used around the solar collector body. The cover of the lower solar collector is made of 3 mm thick ACP (Aluminum Composite Panel). On the sides of the two wide parts, air inlets and air outlets (dryer box direction) are made of flexible pipe material with a diameter of 120 mm and a length of 100 mm attached to the side of the dryer box wall. Dryer box with size 800 mm × 890 mm × 600 mm

The exterior of the drying box is made of 3 mm flat zinc plate and coated with 10 mm styrofoam and on the inside of the drying box is coated with aluminum foil to maintain the cleanliness of the dried coffee bean samples free from surrounding dirt. Another component in the drying box is a chimney that functions as an air outflow in the upper position with a diameter of 150 mm. Hot air from the solar collector is flowed using a 12 V and 0.14 A DC fan with a speed variation of 1 m/s, 1.5 m/s, 2 m/s, 2.5 m/s, and 3 m/s. Testing was carried out for 25 hours until the final moisture content of the coffee was 19% with an initial moisture content of 95%. In this experiment, the temperature data (measured by thermocouple type Agilent 34972A) and mass loss as well as solar radiation and ambient air velocity were measured by HOBO. Hobo Microstation data logger, the humidity value of the sample in the dryer box was measured using Data Logger GM1365 LE: 2511497 and recorded every 10 minutes with a device connected to the computer. Each solar coffee dryer is symbolized by DB1. It is a solar coffee dryer with an intake air speed of 1 m/s, DB2 is a solar coffee dryer with an intake air speed of 1.5 m/s, DB3 is a solar coffee dryer with an intake air speed of 2 m/s, DB4 is a solar coffee dryer with an intake air speed of 2.5 m/s, and DB5 is a solar coffee dryer with an intake air speed of 3 m/s. Each box of dried coffee beans contains a weight of 1500 grams and is hung on the available shelves made of aluminum with a size of 400 mm × 400 mm × 200 mm with holes at the bottom (wire mesh) which is directly connected to the load cell as a recorder of changes in coffee mass reduction. The design of the dryer can be seen in Figure 2

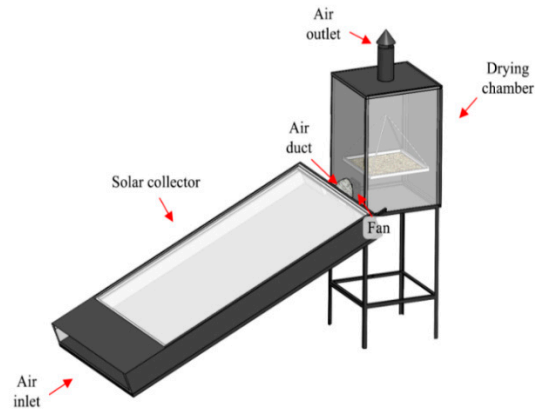


Figure 2. Coffee dryer with forced convection

Coffee bean samples were obtained from Marsangap Village, Toba Regency. Samples were washed after the outer skin was removed and fermented for 6 hours after being picked from the garden and then removed the outer skin and sorted to select good beans for further drying. Coffee beans that have been dried after peeling the outer skin are then dried without using solar heat or additional heat and the water content is 87%. Coffee bean samples are put into the drying rack with a thickness of 0.5-1.0 cm evenly. The rack filled with coffee beans is then put into the DB1, DB2, DB3, DB4 and DB5 drying boxes each with the same weight. Measurements were taken from 08.00 am to 18.00 pm. Drying was carried out for 25 hours until it reached 19% moisture content. The fan is turned on with different speeds for each solar coffee dryer. DB1 = 1 m/s, DB2 = 1.5 m/s, DB3 = 2 m/s. DB4 = 2.5 m/s and DB5 = 3 m/s. The energy source that drives the fan comes from electrical energy where the fan is set with dimmer controlled. It can be seen in Figure 3. experimental set-up used in this study

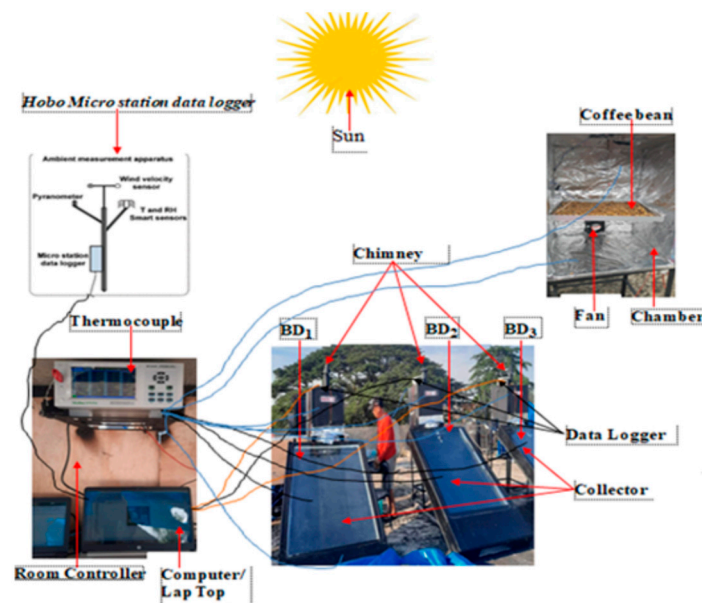


Figure 3. Set-up experimental solar collector

3. Thermal analysis

In this section there are several formula used to analyze the heat transfer and drying that occurs in the coffee solar drying equipment. Moisture content (M) of substance is expressed as percentage by weight of wet basis. The moisture content wet basis was according to:

$$M_C = \frac{M_w - M_d}{M_w} \times 100\% \quad (1)$$

where M_w = is the mass of the wet material and M_d = is the mass of dry materials Amount of moisture to be removed can be calculated as:

$$M_w = \frac{M_{cI} - M_{cF}}{100 - M_{cF}} \times M_p \quad (2)$$

where M_w is amount of water to be removed of water, kg, M_{cI} is initial moisture content M_p is initial mass of product to be evaporate to the time interval required is second.

$$D_R = \frac{M_w}{t} \quad (3)$$

System drying efficiency for forced convection solar dryer in day time is defined as the ratio of energy supplied to evaporate the the moisture of the product to the energy supplied too the drier.

$$\eta_s = \frac{M_w \times L}{A_s \times I \times t + E} \times 100 \quad (4)$$

Where L = Latent in KJ/kg, I = is the solar intensity m/m^2 , A_s = is the surface area of the solar collector m^2 . T = total time of drying in second, E = Energy supplied to the Blower in joule. Effectiveness factor: it can be defined as ratio of drying rate in the cabinet solar dryer to the drying rate in the open sun drying.

$$E_f = \frac{\text{drying rate in solar dryer}}{\text{drying rate in open sun drying}} \quad (5)$$

To analyze the thermal efficiency of solar collectors, the following equation is used:

$$\eta = \frac{Q_u}{Q_{in,total}} \quad (6)$$

With Incoming heat energy (Q_{in}):

$$Q_{in} = I \times A \times \tau \times \alpha \quad (7)$$

Where, I = solar radiation intensity (W/m^2), A = collector surface area, τ = glass transmissivity = 0.88, and α = plate absorptivity = 0.97 (The absorptivity value of the black painted plate is assumed to be 0.97). And to calculate the use heat energy (Q_u) used:

$$Q_u = F \times (Q_{in,total} - Q_{loss,total}) \quad (8)$$

In calculation of the solar collector efficiency factor (F') is assumed to be 90%. The absorptivity value of the black painted plate. The total heat loss of the collector (Q_{loss}) can be used equation:

$$Q_{total} = Q_{wall} + Q_{bottom} + Q_{top} + Q_{rad} \quad (9)$$

Radiation heat loss (Q_{rad}):

$$Q_{rad} = \frac{A \cdot \sigma (T_p^4 - T_k^4)}{\left(\frac{1}{\epsilon_p} + \frac{1}{\epsilon_c} - 1 \right) + \left(\frac{1}{\epsilon_c} + \frac{1}{\epsilon_c} - 1 \right)} \quad (10)$$

Top-side heat loss (Q_{top}):

$$Q_{top} = U_{top} \cdot A \cdot (T_p - T_a) \quad (11)$$

Overall heat transfer coefficient:

$$U_{top} = \left\{ \frac{N}{\frac{C}{T_p} \left[\frac{(T_p - T_a)^e}{(N+f)} \right]} + \frac{1}{h_w} \right\}^{-1} + \frac{\sigma(T_p - T_a) + (T_p^2 + T_a^2)}{(\varepsilon p + 0,00591 \times N \times h_w)^{-1} + \frac{2N + f - 1 + 0,1333 \varepsilon p}{\varepsilon k} - N} \quad (12)$$

heat loss at the bottom (Q_{bottom}):

$$Q_{bottom} = U_{bottom} \cdot A \cdot (T_p - T_u) \quad (13)$$

$$\frac{1}{U_{bottom}} = \frac{1}{h_1} + \frac{t_1}{K_{Acp}} + \frac{t_2}{K_{Glasswool}} + \frac{t_3}{K_{Styrofoam}} + \frac{t_4}{K_{Seng}} \quad (14)$$

heat loss at the wall (Q_{side}):

$$Q_{side} = U_{side} \cdot A \cdot (T_p - T_u) \quad (15)$$

$$\frac{1}{U_{side}} = \frac{1}{h_1} + \frac{t_1}{K_{Acp}} + \frac{t_2}{K_{Glasswool}} + \frac{t_3}{K_{Styrofoam}} + \frac{t_4}{K_{Seng}} \quad (16)$$

where N = amount of glass, $F = (1 + 0.089 h_w - 0.1166 h_w \varepsilon p) (1 + 0.07866N)$, $C = 520 (1 - 0.000051\beta^2)$, $E = 0.430(1 - 100/T_p m)$, β = Collector's angle (deg), εg = Acrylic emissivity (0.88), εp = plate emissivity (0,97), T_a = Ambient temperature (K), T_p = Plate temperature (K), h_w = convection heat transfer coefficient (W/m^2C).

4. Result and Discussion

4.1. Solar Irradiation

The experimental testing of airflow speed variations on this solar coffee dryer was carried out for 3 days, namely on October 9, 2023 - October 11, 2023. So that the measurement of solar irradiation that occurs during experimental testing can be seen in Figure 4.1

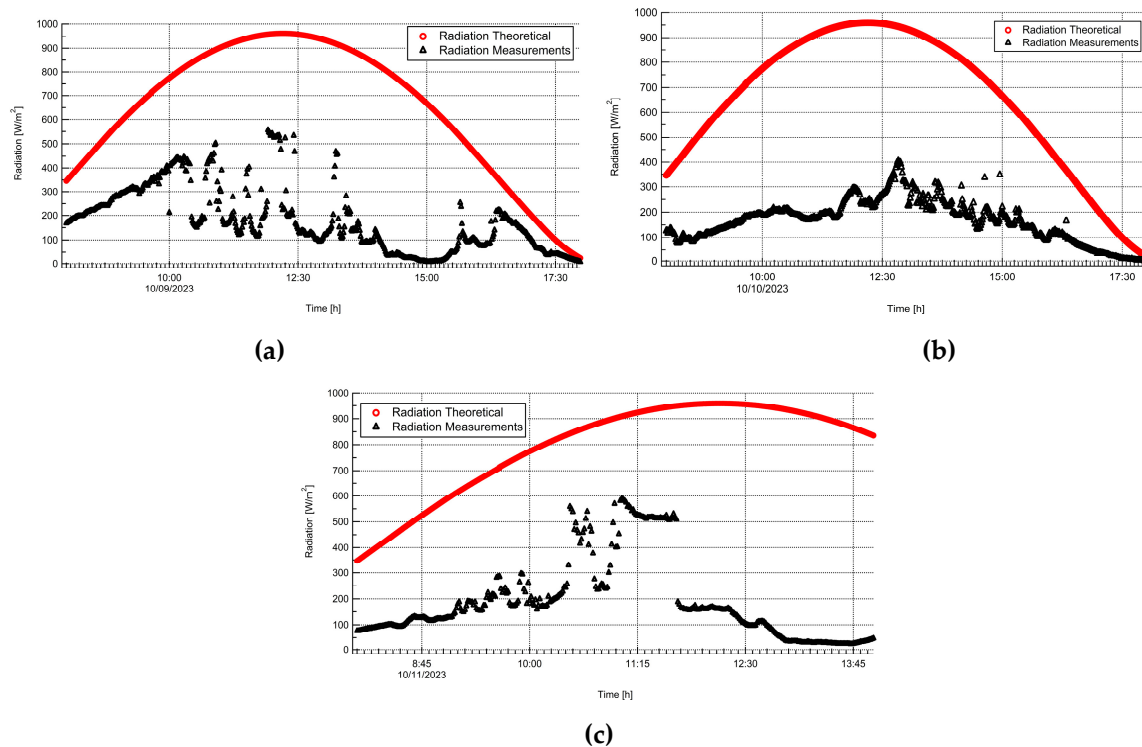


Figure 4. Theoretical solar radiation and measured radiation. (a) on October 9, 2023, (b) on October 10, 2023, (c) on October 11, 2023.

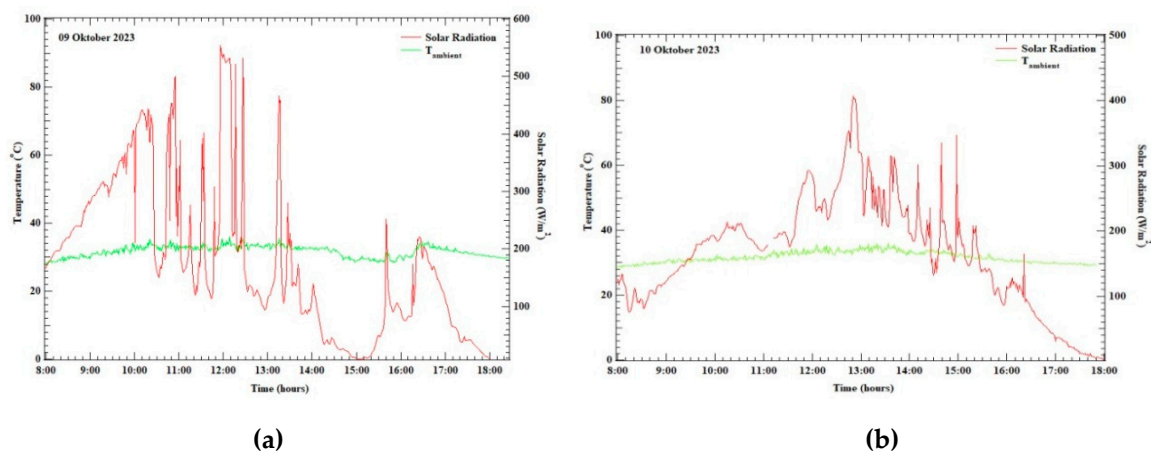
In Figure 4. shows the solar radiation that occurred during the experimental testing experienced a sky that tends to be cloudy. This can be seen from the measurement radiation value during experimental testing is below the theoretical radiation on clear day conditions. On October 9, 2023 in the morning at 08.00 a.m. to 10.00 a.m. the sky conditions tend to be sunny, but from noon to evening the sky tends to be cloudy, so that solar radiation is obtained which tends to fluctuate up and down. And only a few moments were obtained at 12.00 solar radiation increased to 538.1 W/m² and until 15.00 p.m. radiation fell and increased again in the afternoon. Whereas on October 10, 2023 from morning to evening, the sky tends to be a little cloudy, so that solar radiation is obtained which tends to be constant but rises slowly until 13.00 p.m. with a radiation of 398.1 W/m² and slowly decreases towards 18.00 p.m. And on October 11, 2023 in the morning the sky tends to be cloudy with a radiation value of 171.1 W/m², but at 11:00 a.m. until 12:00 a.m. the sky becomes bright reaching 568.1 W/m², and then at until 14:00 a.m. the sky starts to become cloudy and overcast.

The total energy coming from the sun during the experimental testing can be seen in Table 1 below.

Table 1. Total solar irradiation per day during the drying process

No	Time	Energi (MJ/m ²)
1	Day I	6.50202
2	Day II	5.94993
3	Day III	4.21117

It was found that the total solar energy during the experimental testing took place which was measured using the Hobo Microstation data logger on the first day was obtained at 6.50202. MJ/m², the second day amounted to 5.94993 MJ/m² and on the third day amounted to 4.21117 MJ/m². This indicates that the sky conditions that occurred during the test were cloudy, with total solar irradiation still very far from the theoretical potential if the sky was clear.



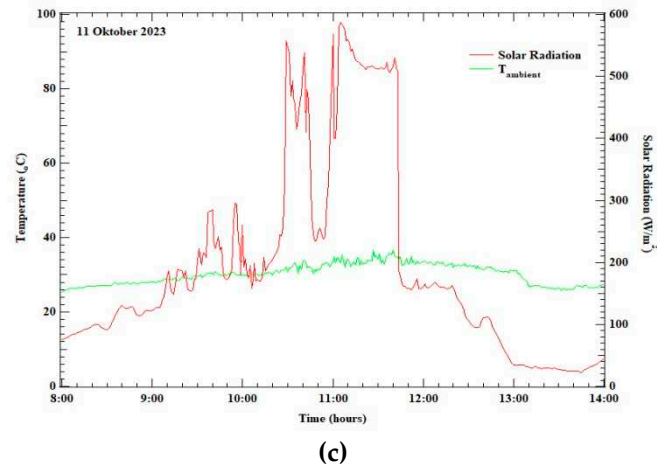


Figure 5. Solar radiation and ambient temperature (a) October 9, 2023, (b) October 10, 2023, (c) October 11, 2023.

The ambient temperature seems to follow the trend of solar radiation during the test, the higher the value of solar radiation, the higher the ambient temperature, and vice versa. On the first day the average ambient temperature was 31.8°C and a maximum of 36.1°C. On the second day of testing the average ambient temperature was 31.6°C and a maximum of 35.8°C, then testing on the third day the average ambient temperature was 30.1°C and a maximum of 36.6°C where during the three days of testing the ambient temperature tended to be evenly high in the position of 35.0°C to 36.0°C

4.2. Solar coffee dryer performance

4.2.1. Temperature absorbent

The absorber plate on the solar coffee dryer has the most important function in absorbing solar irradiation which is used to dry coffee. Absorber plate temperature measurements on each solar coffee dryer can be seen in Figure 6.

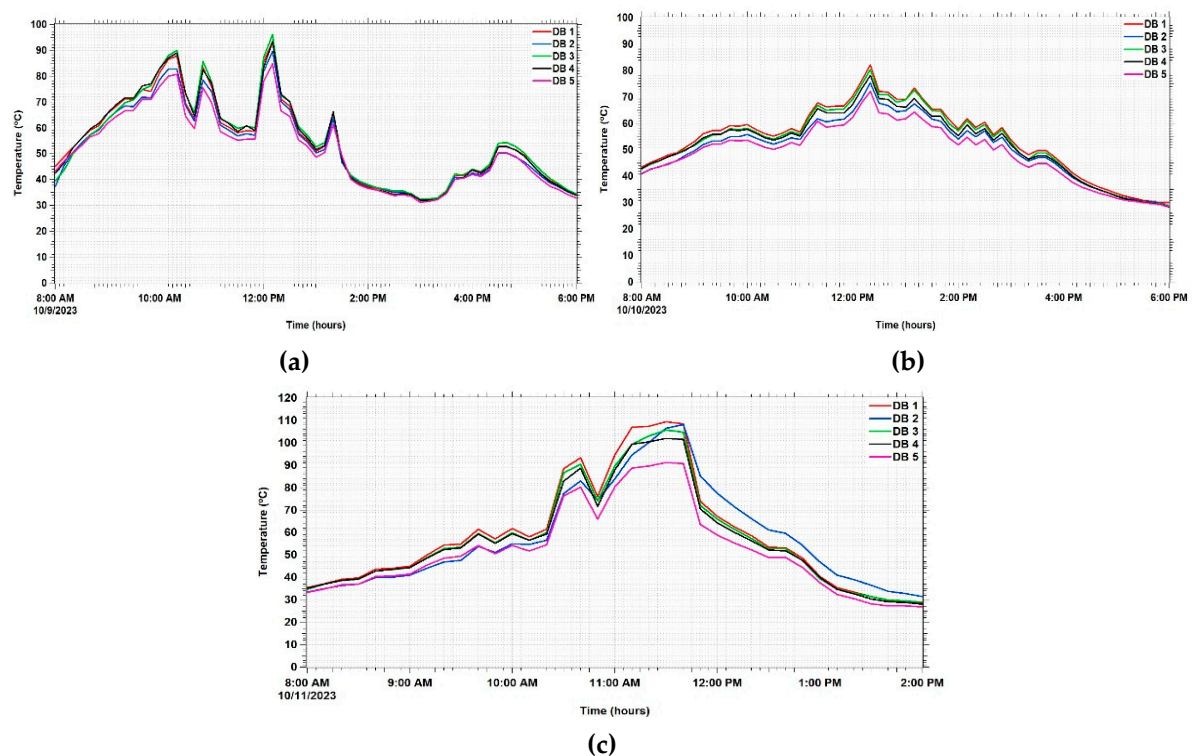


Figure 6. Absorbent Plate Temperature. (a) First day, (b) Second day, (c) Third day

Figure 6. shows the temperature graph of the absorber plate on the first day seen in DB1, DB2, DB3, DB4, and DB5 increased until 10:20am by reaching a temperature was of 87.8°C and decreased again at 11:20 am. At 12:10 a.m., the highest temperature was 96.1°C in DB3, 93.3°C in DB4, followed by 93.5°C in DB1, 93.3°C in DB4, 89.2°C in DB2, and 84.9°C in DB5 until 18:00. It can be seen that on the second day the highest temperature was at DB1 of 82.1°C followed by DB3 of 80.3°C, followed by DB4 of 78.3°C, followed by DB5 of 72.1°C. In the last test on October 11, 2023, the highest absorbent temperature was DB1 at 109.4°C followed by DB2 at 108.2°C followed by DB3 at 105.6°C followed by DB4 at 102.0°C and DB5 at 91.2°C. So that the accumulative average temperature for 3 days of testing on each solar coffee dryer is DB1 55.35°C, DB2 53.25°C, DB3 54.80°C, DB4 54.17°C, DB5 50.69°C, respectively. It is observed that there is a difference in absorber temperature in the five solar coffee dryers due to variations in airflow velocity into the drying chamber. DB1 has a higher absorber temperature than DB5, this is due to the small airflow speed can reduce convection heat transfer so that the absorber temperature in DB1 tends to be higher than the absorber temperature with a higher speed.

4.2.2. Drying chamber temperature

The temperature of the drying chamber greatly affects the drying process that occurs in coffee. The drying chamber temperature comes from the heat collected from the solar collector absorber discussed in the previous section. The drying chamber temperature measurements on the five solar coffee dryers can be seen in Figure 7.

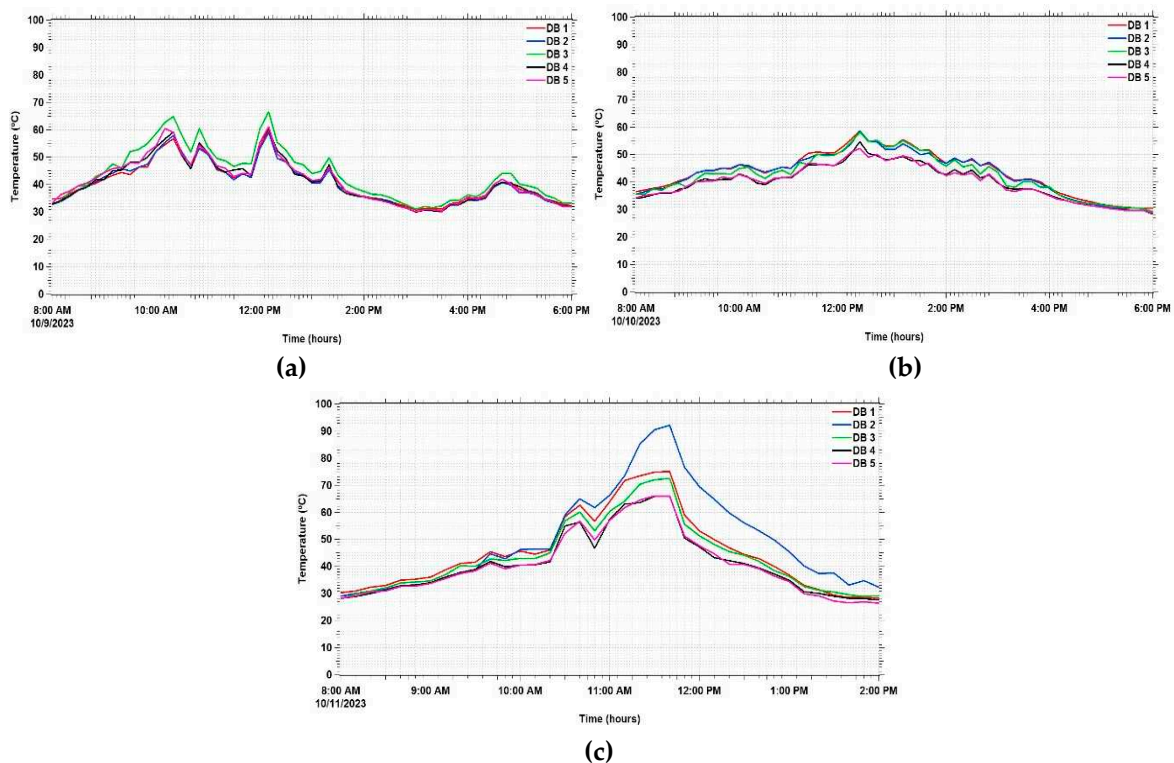


Figure 7. Temperature Chamber. (a) Day 1, (b) Day 2, (c) Day 3.

On the first day DB3 had an average temperature entering the drying chamber of 43.70 °C, followed by DB5 at 41.3 °C, DB4 at 41.0 °C, followed by DB1 at 40.69 °C, and followed by DB2 at 40.4 °C. The 10th Oct test during the test the highest temperature was DB1 at 42.7 °C, followed by DB2 at 42.20 °C, followed by DB3 at 40.70 °C, and followed by DB5 at 39.86 °C, followed by DB4 at 39.80 °C. On day 3, the highest temperature was in DB2 at 46.19°C followed by DB1 at 44.9°C, then followed by DB4 at 40.7°C and finally followed by DB3 at 37.76°C.

The temperature in the drying chamber that occurs during experimental testing has a value that is not too different in each drying chamber. The temperature of the drying chamber is strongly influenced by the absorber collector temperature, the higher the absorber collector temperature, the higher the temperature flowed into the drying chamber. Collector efficiency calculations use analytical analysis based on incoming heat, used heat and wasted heat. A graph of the total heat loss that occurred in the five solar coffee dryers can be seen in Figure 8.

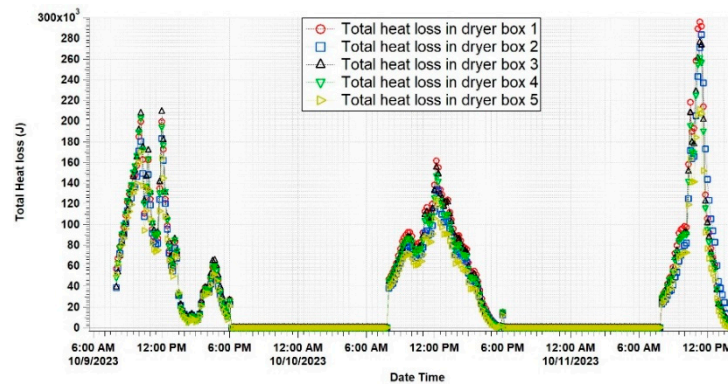


Figure 8. Total heat loss in a solar coffee dryer

High collector temperatures will increase heat loss, so speed variations in solar coffee dryers can affect solar collector efficiency. Solar coffee dryer DB1 which uses a smaller fan speed than other solar coffee dryers, so it has a higher temperature on the absorber plate and increases the heat wasted as well. The total heat loss that occurs in each solar coffee dryer during experimental testing is obtained: DB1 12.75 MJ, DB2 11.49 MJ, DB3 12.44 MJ, DB4 12.05 MJ, and DB5 9.98 MJ

So that the average collector efficiency can be obtained for each box used, which can be seen in Table 2 below.

Table 2. Average collector efficiency

No	Dryer	Efficiency collector
1	Dryer Box 1	32.32996 %
2	Dryer Box 2	38.02492 %
3	Dryer Box 3	33.77358 %
4	Dryer Box 4	35.50234 %
5	Dryer Box 5	44.88686 %

Actually, dryer box 5 with a speed of 3 m/s has the highest collector efficiency, this is because the high airflow speed can move and utilize the heat that enters the collector more than the dryer box with a lower speed.

4.3. Coffee drying quality

4.3.1. Drying rate

One of the qualities of coffee beans is the water content contained in coffee beans. The less water content contained in coffee beans it will prevent spoilage, so coffee beans that have little water content will last longer. The mass of beans to be dried in each solar coffee dryer is 1500 grams, then the mass of coffee beans will decrease, due to the drying process of the coffee beans by evaporating the water content contained in the coffee beans with temperature and air flow in the drying chamber. The decrease in coffee mass during experimental testing can be seen in Figure 9.

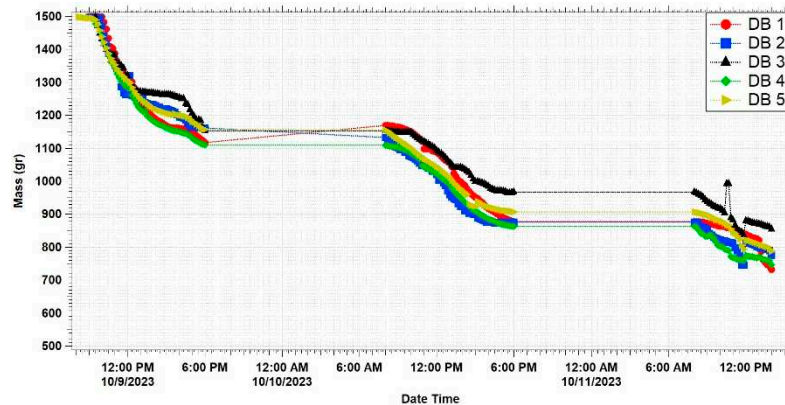


Figure 9. Decrease in coffee bean mass during experiment

Coffee that has been dried using speed variations on a solar coffee dryer will experience a decrease in mass, which is due to the evaporation of water content contained in coffee. On the first day, DB4 and DB1 with the final mass on the first day of 1109.08 grams and 1117.34 grams are solar coffee dryers that dry the coffee mass faster. then on the second day, DB4, DB2, and DB1 with a final mass of 863.12 grams, 876.13 grams, and 877.71 grams. On the third day, the final mass of coffee beans after drying was obtained, namely: DB1 732.24 grams, DB2 774.70 grams, DB3 855.10 grams, DB4 745.79 grams, and DB5 786.40 grams. With the percentage of coffee mass reduced respectively DB1 51.18%, DB2 48.35%, DB3 42.96%, DB4 50.28%, and DB5 47.57%. Based on this research, DB1 with a fan speed of 1 m/s can dry coffee beans faster than dryer boxes with other larger fan speed variations. The variation of airflow speed in the solar coffee dryer can affect the drying process of coffee beans even though the results obtained are not linear between airflow speed and mass reduction, because the drying process is a very complicated phenomenon, because each object being dried has different temperature conditions and certain flow velocities to get optimal drying results.

4.3.2. Quality of coffee content

The final results of coffee beans that have been dried for 3 days are tested for proximate content quality based on the Medan Industrial Standardization and Service Center. With the composition of the content measured water content, protein content, carbohydrate, and free fatty acid. Water content is needed to determine the quality of coffee, because water content can affect the process of preservation or decay of coffee. If the water content is high, it will accelerate the process of coffee decay. Protein content, and carbohydrate, are contents that have an important role in human growth, so the higher the value of protein content and carbohydrate is a good thing. Free Fatty Acid is a coffee content that can cause flatulence, for that low free fatty acid has better coffee quality. The data on the test results of coffee bean content can be seen in Table 3 below.

Table 3. Proximate content test results Arabica coffee beans

Composition	Sample and Proximate Test				
	DB 1	DB 2	DB 3	DB 4	DB 5
Water content (%)	12.0	13.6	18.5	12.9	15.2
Protein content (%)	11.7	12.2	11.5	11.6	11.3
Carbohydrate (%)	21.7	22.8	19.9	18.1	20.4
Free Fatty Acid (%)	0.05	0.05	0.09	0.09	0.08

Based on the content test data obtained at DB2 has the most optimum coffee quality content. water content 13.6%, Protein content 12.2%, Carbohydrate 22.8%, Free Fatty Acid 0.05% contained in DB2 coffee bean content is the most optimum quality compared to other speed variations. Based on

this data, we can see that to produce the optimum quality of coffee content, special drying behavior conditions are needed, namely with a drying air speed of 1.5 m/s.

5. Conclusions

Solar coffee dryer with airflow velocity variations of 1 m/s, 1.5 m/s, 2 m/s, 2.5 m/s, and 3 m/s used to dry coffee beans have been experimentally carried out for 3 days or 25 hours. Thus, several conclusions can be obtained based on the effect of variations in air flow velocity on the drying process of coffee beans.

1. Variations in air velocity flow can affect the temperature that occurs on the absorber plate, drying chamber and solar dryer efficiency. So obtained DB1 with an air flow velocity of 1 m / s can produce the highest average absorber temperature, which is 55.35 C. DB2 with an air flow velocity of 1.5 m / s can produce the highest average drying room temperature, which is 43.68 C. DB5 with a speed of 3 m / s has the highest collector thermal efficiency of 44.88686%.
2. The optimum quality category is that the coffee beans produced have the lowest water content and free fatty acid, as well as the highest protein content and carbohydrate. DB2 with a drying air speed of 1.5 m/s is a condition that can produce the most optimum coffee quality. DB2 has a water content of 13.6%, Protein content 12.2%, Carbohydrate 22.8%, Free Fatty Acid 0.05%.

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