Effect of Drying Airflow Rate on H2 O Mass Evaporated on Banana Chips Drying using Photovoltaic Solar Panel

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Effect of Drying Airflow Rate on H_2O Mass Evaporated on Banana Chips Drying using Photovoltaic Solar Panel

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Abstract. Solar energy is one source of heat energy that can be utilized with photovoltaic technology using solar panels. One application process that can be used is drying. The dryer uses a heating air media that is produced through the process of converting solar heat absorbed by solar panels. The process of drying bananas is done using variations in the rate of air flow of the dryer entering through the pipe integrated with the fan so that it is expected to be able to speed up the drying time. In this study, the air velocity varied to get the maximum moisture content, and H_2O mass evaporated on banana chips. Based on the test results, with a drying time of 3 hours using a maximum airflow rate of 6.090 L/s and a temperature of 39.91 °C, moisture content of 65.30% was obtained with a mass of H_2O evaporating as much as 208 grams.

Keyword: drying, flowrate, photovoltaic, solar cell

1. Introduction

Indonesia is a country that is rich in energy resources, both energy that is unrenewable resources and those that are renewable resources. However, the exploration of energy resources is more focused on fossil energy that is unrenewable resources, while renewable energy is relatively underutilized [1-3].

One of the uses of energy in South Sumatra, especially for food products, is to use solar heat. Solar heat is usually used in the drying process. According to Rachmawan, the drying process aims to reduce the water content contained in foodstuffs, reduce water activity in the foodstuffs and inhibit microbial activity in them to increase product durability, and for specific economic purposes such as reducing weights, increasing flavor product, as well as others [3,4].

Based on observations in the Mengulak Village of East OKU Regency, South Sumatra, drying of bananas is still using the traditional method of placing bananas on bamboo arranged like curtains and fumigating at the bottom and can also be done by direct drying in the sun. If it uses the sun's heat directly, it will be constrained by the weather, and you need a large place to dry. When it rains, the drying process is hampered which can trigger microbial growth, causing the banana to rot, besides direct sun drying can cause the resulting product to be less hygienic due to insects alighting, dust and dirt particles carried by air and the need to flip through bananas continuously to dry evenly.

Solar power dryer is one form of solar energy usage. Until now, there are two kinds of technology that have been applied, namely thermal solar energy technology and photovoltaic solar energy technology [5-9].

Furthermore, researchers will develop a dryer using solar heat considering that Indonesia is always exposed to the sun every year so that it can be used as an alternative for employers to facilitate the work in terms of drying and improving the quality of the products produced. From previous studies conducted the utilization of a heat absorbent plate concentrator in drying with a good efficiency level of 70% but this type of collector relies heavily on the intensity of the sun for the drying process [10]. Subsequent research has made a dryer with steel material, but the tool has a substantial heat loss of up to 50% [11]. Subsequent research uses thermal and photovoltaic collectors but also has the disadvantage of a large heat loss from solar collectors so that much energy is not utilized [12]. The renewal made is by using photovoltaic energy, adding a heater to the inside of the drying chamber so that the product dries faster and reducing heat losses that occur, adding a motor to the rack so that the dried product gets heat evenly, and using the Thermal Backup Unit as a source reserve heat to dry the product if the sun is not scorching so that the drying process can run continuously. From the results of the design of the dryer, researchers expect that the solar dryer can dry banana chips products quickly and hygienically [12].

2. Methods and Materials

The prototype of this dryer uses 2 photovoltaic solar modules with a capacity of 100 Wp in order to produce enough power for the drying process, and when the solar module is exposed to the sun for more than 4 hours, the remaining power can be stored in batteries.

Drying chamber or oven is the place of the drying process. In this study, the drying chamber is made measuring 49.5 cm x 39.5 cm x 70.5 cm from stainless steel with several shelves as much as 2 levels directly connected to the motor, to move the rack with a certain slope so that the drying process on the product is more evenly distributed. The selection of stainless steel is made because stainless steel has resistance to rust and corrosion.

In this study the research variables used consisted of the mass of raw material, temperature and humidity with a fixed variable are the mass of material to be dried, and the variable is not fixed in the form of time. Weight measurements are carried out using a scale, and the air flow rate is measured using an anemometer. Inlet temperature, drying chamber temperature, outlet temperature, and humidity are measured through thermocouples and sensors whose readings can be seen on the control panel.

Table 1. Specification of Dryers with Photovoltaic Solar Panels

Material	Specification
Energy Sources	Solar Panels and LPG Gas Stoves
Heat Sources	Blower Heater and Iron Heating Pipes
Solar Panel Dimension	Dimension : 2000 x 1000 mm
	Capacity : 100 Wp Quantity : 2 pcs
Dryer Rooms	Dimension : 495 x 395 x 705 mm
	Shape : Rak Bersusun 2

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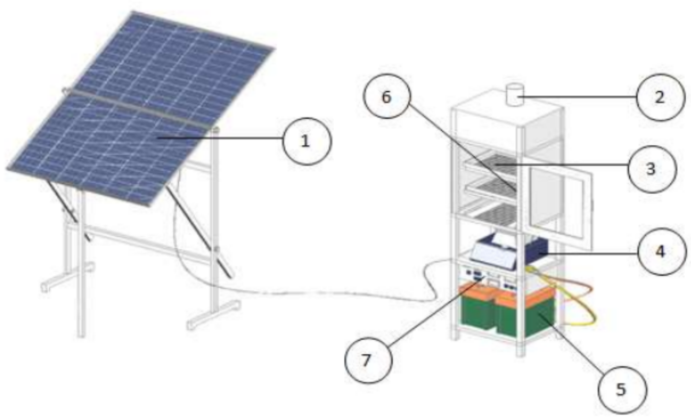
	Capacity : 0.6 kg
Shelf	Dimension : 295 x 360 mm
Electric Motors	Capacity : 5 W
Blower Heater	Quantity : 6 buah
	Capacity : 100 W
Battery	Battery 70 AH
Inverter	Capacity : 1200 Watt
Fan	Capacity : 1,68 Watt Dimension : 2 inchi
Stoves Fuel Sources	LPG 3 kg
Thermocouples	Type "K"
Cable	Ø 0.75 mm



Keterangan:
1. Solar Panel 2. Stakes 3. Drying Racks
4. Battery 5. Gas Stoves 6. Rotating Motors
7. Control Panel

Figure 1. Design of photovoltaic solar panel dryers

3. Result and Discussion

In this research, a prototype of a tray or rack type banana chips dryer has been made. This tool consists of photovoltaic solar panels that are used to capture solar heat and convert it into electrical energy to be able to supply the needed power to the dryer so that it does not use a power source from PLN but instead uses a source of solar energy stored in batteries.

The heating system in the dryer uses environmental air that enters with a certain flow rate by controlling the speed control integrated with the fan through a 2-inch diameter pipe, then the air enters the drying chamber and is immediately heated by the heater. The size of the oven used is 49.5 x 39.5 x 70.5 cm with a drying room temperature ranging from 40°C. Drying racks are made in two layers and motors are added so that the drying racks can swing so that it is expected that heat transfer in the air can spread to all parts of the material surface.

The process of drying bananas aims to reduce the water content of bananas to reach a maximum limit of 40% based on SNI standards. The weight of the dried banana dried in this study was 600 grams with the process variable being studied in the form of a variable that changes the speed of the drying air. The results of the research data are used to determine the mechanism of drying air velocity to the amount of H_2O evaporated on bananas, so an analysis of the decrease in water content in bananas is needed.

Tabel 2. Research and Calculation Data

Air Flowrate (L/s)	Air Temperature (°C)		Relative Humidity (%)		Evaporated H_2O Mass (gr)
	In	Out	In	Out	
2.026	35.7	38.7	46	71	119
3.045	35.6	39.2	41	60	149
4.060	34.2	37.5	52	67	164
5.075	33.8	36.6	58	72	185
6.090	33.6	36.9	55	67	208

3.1 *Effect of drying air flow rate on the evaporated H_2O*

Drying of a solid is the separation of a small amount of water or a liquid from a solid material, thereby reducing the remaining liquid content in the solid to the lowest acceptable value inhibiting the development of spoilage organisms [13]. If a wet solid substance is contacted with air whose humidity is lower than the moisture content of the solid substance, then the solid substance will release some of its wetness and dry until it is balanced with the air.

In the process of drying, an ingredient, water content is very important because it affects the duration of drying, the course of the drying process and changes that occur in a material.

After conducting research drying banana chips with drying room temperature around 40 ° C and air drying speed of 2.026 L/s; 3.045 L/s; 4.060 L/s; 5.075 L/s; and 6.090 L/s, the pattern of water content reduction can be seen as shown in Figure 2.

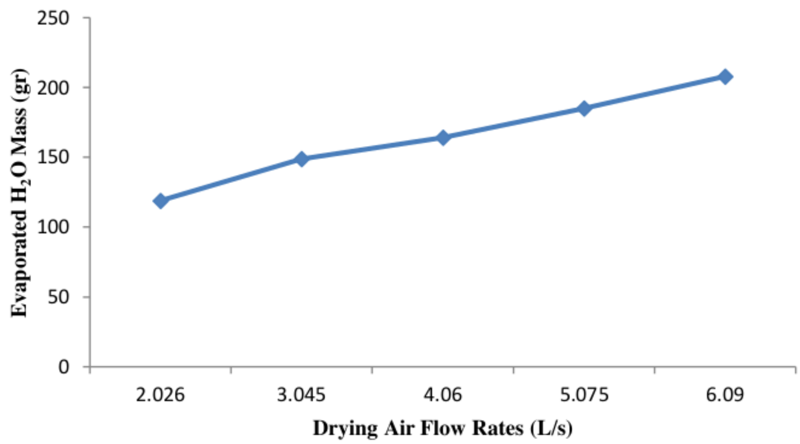


Figure 2. Graphs of Drying Air Discharge on Evaporated H_2O

In Figure 2, a water pattern curve is evaporated from a thin slice of plantain with a thickness of ± 0.5 cm. From this curve, it appears that the process of releasing water vapor in the material can be influenced by the drying air velocity, which is where the greater the drying air velocity, the greater the mass of water in the material that can be evaporated. This is consistent with the statement who said the higher the drying air flow rate, the drying process will run faster [14]. Similar to the statement which states that the greater the volume of air flow, the greater the ability to carry and hold water from the surface of the material and the drying process will be faster [15].

From the results of this study note that with the same drying time of 3 hours will evaporate more water at a drying air speed of 6.090 L/s which is 208 grams, while for the smallest mass of water that evaporates at 119 grams with a drying air speed of 2.026 L/s.

3.2 *Effect of Moisture Content on The Drying Air Flow Rate*

Water content is one of the physical properties of the material that shows the amount of water contained in a material. Figure 3 shows the effect of drying air velocity on the water content in bananas, which tends to decrease due to the H_2O levels that are evaporated also increasing with increasing drying air velocity. This indicates that the water content in a material tends to decrease and will experience a constant weight when the drying time increases or reaches a state of equilibrium. However, researchers can only take variations of data for only 3 hours with a drying temperature of around 40°C with different drying airflow rate due to the ability of the tool and a relatively short period.

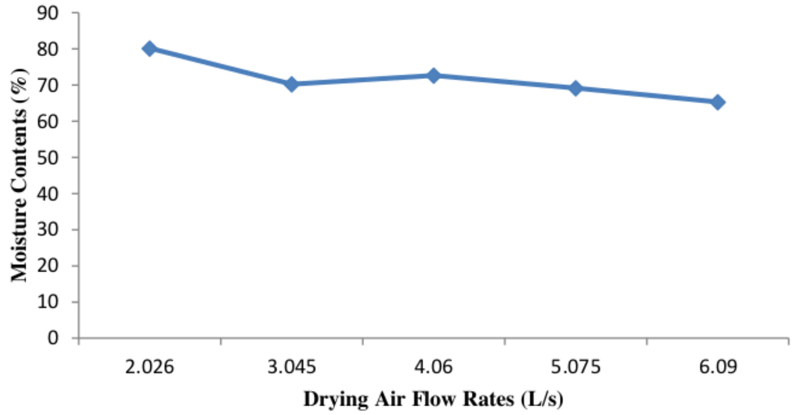


Figure 3. Graph of Drying Air Discharge on Moisture Content (%)

Based on observations made, the highest water content of 80.17% occurred at an air velocity of 2.026 L/s while the lowest water content occurred at 65.30% at a speed of 6.090 L/s. However, based on the Indonesian National Standard of banana chips, the maximum water content permitted is 40%. This indicates that the banana products produced have not reached SNI standards. This is influenced by several factors, including drying room temperature and drying time. According to another research, the temperature used for drying is 60-80°C with drying time between 6-16 hours [16]. The use of drying temperature that is too low results in a long drying process time, while if the temperature is too high, the texture of the material will be unfavorable. The use of temperature in the dryer is only around 40-45 °C and drying time is only for 3 hours to make the evaporated mass in bananas only a little which causes the reduced water content only slightly reduced [17].

3.3 *Effects of Drying Air Flow Rates on H_2O Evaporation Heat*

From the data variations in the speed or discharge of drying air obtained heat absorbed by different materials, as shown in Figure 4.

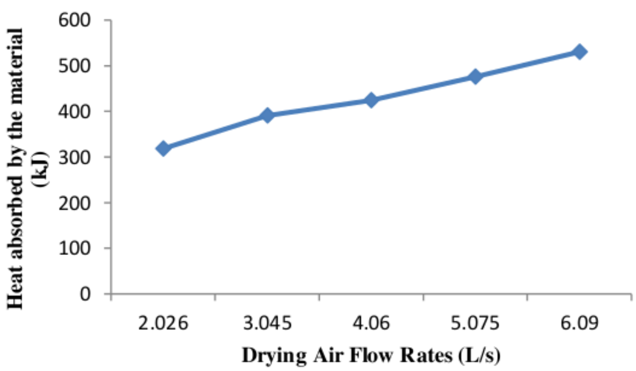


Figure 4. Graphic Relationship of Dryer Air Flow Rates to Heat Absorbed by Material

The heat absorbed by the material is obtained from the amount of heat evaporation H_2O produced and sensible heat in the material. By looking at the graph in Figure 4, it is found that with increasing speed or discharge of drying air, the heat absorbed will be even greater. When the drying air temperature increases, hot air will blow through the entire surface of the material. Due to the temperature difference where the temperature of the drying air is higher than the temperature in the material, so there is a process of heat transfer into the material. This transfer causes a mass transfer of water (H_2O) that is in the material to the surface and evaporates into the air. This shows that the greater the speed or discharge of drying air, the ability to evaporate water (H_2O) will increase, this is caused by evaporation that occurs due to differences in water vapor pressure in the material and water vapor in the air. When the heat absorbed by the material is getting bigger, then the large energy will make water molecules in the material move faster to the surface of the material. The water contained on the surface of the material is then vaporized into the drying air which has a low moisture value so that the forgotten amount of water will continue to increase and the water content of the material will shrink with increasing drying time.

Based on Figure 4, when banana chips absorb smaller heat which is equal to 318.217 kJ with a velocity or air discharge of 2.026 L/s, the amount of water (H_2O) that is evaporated will get smaller at 119 grams. Vice versa, when the banana chips absorb the heat of 530.512 kJ when the maximum air flow rate of 6.090 L/s, the amount of water (H_2O) that is evaporated will also be greater, namely 208 grams.

4. Conclusions

Dryers using photovoltaic solar panels are more efficient than manual drying. The rate of the drying air affects the mass of the H_2O being evaporated. When banana chips absorb smaller heat, amounting to 318.217 kJ with a velocity or air discharge of 2.026 L/s, the amount of water (H_2O) that evaporates will get smaller at 119 grams. Vice versa, when the banana chips absorb 530.512 kJ of heat when the maximum air flow rate of 6.090 L/s, the amount of water (H_2O) that will also be evaporated will be greater that is 208 grams and the maximum water content of banana chips that evaporates based on the drying process is 65.30%

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