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Characteristics of drying *cayenne pepper* (*Capsicum frutescens* L.) using a portable type of dryer

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Abstract. Agricultural materials need to be dried because they are perishable and overgrown by microbes. Sun drying is helpful because it is cheap and available, but it is often interrupted if the weather is cloudy or rainy. If the dryer is large, it will be difficult to move. In this study, a designed portable dryer was technically tested on cayenne pepper. The research method was carried out experimentally. The results showed that the temperature inside can reach 55.8 0 C-57.09 0C. The length of effective time for drying cayenne pepper using the portable dryer takes a range of 23-28 hours, with an average initial moisture content of 75.01% reaching the final moisture content of 9.05%. The drying rate time is 2.64% / hour. Further research suggests the presence of artificial airflow in the dryer so that the uniformity of water content reduction in each drying shelf can be achieved.

1. Introduction

Chili (*Capsicum*) originates from Central America and is currently an important commodity in people's lives in Indonesia [1]. Most households consume chili every day as a complement to daily family meals [2]. The average chili consumption in Indonesia is 4.6 kg per capita per year [3].

Cayenne pepper (*Capsicum frutescens* L.) is one of the horticultural products with high demand and market needs. Cayenne pepper has a spicier taste than red chili, which is why cayenne pepper is so much in demand that many farmers are interested in cultivating it [3]. Cayenne pepper has a short shelf life (easily damaged) because the fresh cayenne pepper fruit has a high-water content. At the time of the cayenne pepper harvest, a lot of spoilage occurs due to not being sold at that time, the price of agricultural products is strongly influenced by the availability of materials on the market if the available goods are far less than the demand, the price will soar and vice versa [4].

Drying or reducing water content is done to preserve the product so that it can be stored longer without experiencing excessive damage, increasing the economic value of a product, and controlling the product to achieve the requirements desired by the next process [5]. The drying process can be done by drying (naturally with sunlight) or by artificial drying using a dryer [6]. The basic essence of drying is to reduce the moisture content of the product so that it is safe from damage within a certain period, which is termed the safe storage period [7]. Factors that influence the drying process include temperature, humidity, and time. The greater the temperature difference (between the heating medium and the material), the faster the heat transfer process will take place, resulting in a faster evaporation process. The more humid the air in the drying chamber, the longer the drying process will take and vice versa [8].

Direct drying, as is often done today, is relatively weather-dependent. If it suddenly rains, it will require labor and energy to move them back to a place where they are not disturbed by the rain. This will be even more difficult if the weather changes quickly, otherwise drying for the sake of drying takes a long time. Drying efforts with fuel-based drying equipment are relatively expensive and limited [9]. Drying devices that assist in the drying process so that it is not interrupted if the weather is cloudy or rainy are made, such as solar dryer dome, and box dryer. In some places, a simple type of dome dryer



has been developed. This dryer can overcome the problem of hot or rainy weather as well as day and night conditions so that farmers can increase their productivity. Therefore, this dryer can be useful for small-scale industries because it is simple and cheap [10].

This research aims to analyze the moisture content, drying temperature, and relative humidity (RH), and calculate the drying rate against time in a portable type of dryer. It is expected that the use of this portable type of dryer can shorten the drying time so that the material gets uniform drying. Also, this tool can provide an overview of the utilization of solar energy in the process of drying cayenne pepper.

2. Materials and methods

2.1. Materials and tools

- a. Cayenne pepper with a harvest age of about 60-75 days
- b. Dome dryer.
- c. NDO-410 drying oven.
- d. Analog scales with a capacity of 100 kg, to calculate the weight of cayenne pepper.
- e. Analytical scales to calculate the weight of cayenne pepper samples.
- f. Digital thermometer (HTC 2) and mercury thermometer to measure the temperature inside the dryer room and outside the dryer and measure humidity.
- g. Digital Lux meter AR813A, to measure light intensity.
- h. Container for sample holder.
- i. Stationery, to record any observations obtained in the study.
- j. Tarpaulin, a base for drying cayenne pepper under the sun.
- k. Camera for documentation
- l. Computer, for data processing and analysis.

2.2 Portable dryer equipment

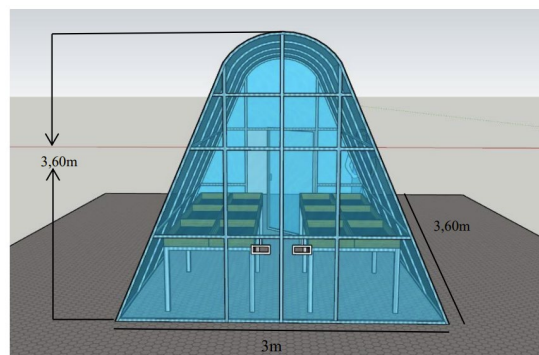


Figure 1. Design of Portable Dryer

Functional Design

- Lightweight steel frame to support the weight of UV plastic and polycarbonate.
- UV (Ultra Violet) plastic to distribute heat evenly throughout the drying room
- The base of the building is made of cement to keep moisture from below and does not interfere with the drying room.

2.3 Research method and procedures

The method used in this research is the experimental method of data then analyzed descriptively.

Procedures of research:

The cayenne pepper drying process in this study was carried out in (3) three stages, namely:

a. Preparation Stage

- 1) Preparation of Tools and Materials
- 2) Cayenne pepper is sorted to separate damaged chilies, the color is not yet red.
- 3) Cayenne pepper is cleaned, and separated from the stalk of cayenne pepper.

b. Drying Stage

- 1) Prepare the sample
- 2) Place an HTC 2 type digital thermometer and mercury thermometer, inside the dryer and outside the dryer, to measure temperature, and measure humidity.
- 3) Weigh cayenne pepper as much as 1.5kg per tray.
- 4) Cayenne pepper is spread evenly on the tray on the dome dryer.
- 5) Cayenne pepper is spread evenly also in sacks on the outside of the tool, for drying in the sun.
- 6) Place the cayenne pepper sample that has been prepared, inside and outside the dryer.

c. Observation Stage

1). Water content

Observing the initial moisture content of cayenne pepper using the oven method, before the drying process using a Portable type dryer.

2). Temperature & Humidity

Observation of temperature and humidity inside and outside the dryer using HTC 2 digital thermometer and mercury thermometer.

3). Weight loss of materials

Observation of material weight loss is carried out by removing the cayenne pepper sample from the dryer and then weighing it, after weighing it is then put back into the dryer, and weighing is carried out at an interval of 1 hour (60 minutes).

4). Light intensity %.

5). Observations began at an interval of 08.00 - 16.00

6). Length of time required for drying to 7-11% moisture content.

Observation of material weight loss is carried out by removing the cayenne pepper sample from the dryer and then weighing it, after weighing it is then put back into the dryer, weighing is carried out at an interval of 1 hour (60 minutes). Observations began at an interval of 08.00 - 16.00. The target drying time is until the product reaches a moisture content of 7-11%.

2.4. Calculation

a. Moisture content

Moisture content was calculated using the following equation:

$$m = W_m / (W_m - W_d) \times 100\% \quad (1)$$

Description:

m = Moisture content %

W_m = Initial moisture content (gr)

W_d = final water content (gr)

b. The drying rate (% wb/min) is calculated based on the change in moisture content over a certain time interval (t(I)).

$$LP = (K_{A(i)} - K_{A(i-1)}) / t \quad (2)$$

Description:

W_b = Wet based

LP = Drying rate at a certain time (%)

K_{Ai} = Weight of initial material at a certain 't' (g)

K_{Ai-1} = Weight of final material at a certain 't' (g)

t = Drying time (minutes)

c. Drying Efficiency

Drying efficiency is expressed as the ratio of heat used for evaporation of moisture content from cayenne pepper to solar radiation energy in the dryer. So the drying efficiency equation is written as follows:

$$\mu_p = Q_e / Q_{in} \times 100\% \quad (3)$$

Description:

μ_p = Drying Efficiency (%)

Q_e = Heat used for drying (kJ)

Q_{in} = The amount of energy obtained (kJ)

To find the heat used to dry the water content (Q_e) used the following equation:

$$Q_e = (M_w - M_k) \times h_{fg} \quad (4)$$

Description:

Q_e = Heat used for drying (kJ)

M_w = Wet mass of material (kg)

M_k = Dry mass of material (kg)

H_{fg} = Enthalpy of vaporization at average temperature (kJ/kg)

$$Q_{in} = I_{Total} \times A_k \quad (5)$$

Description:

Q_{in} = The amount of energy obtained (kJ)

I_{total} = Solar radiation intensity (W/m²)

A_k = Collector Area (m²)

3. Results and Discussion

3.1 Temperature Changes in the Drying Process

Temperature is one of the most important factors for the drying process. The self-life of fresh chilies if stored at low temperatures can last up to 14 days, but at room temperature only last about 2-4 days [11]. The suitable drying conditions for chili pepper were found at 35% RH, 50°C drying temperature and 70 hours drying time [12].

The drying process in this study obtained temperature data in the drying chamber and ambient temperature, which can be seen in Figure 2.

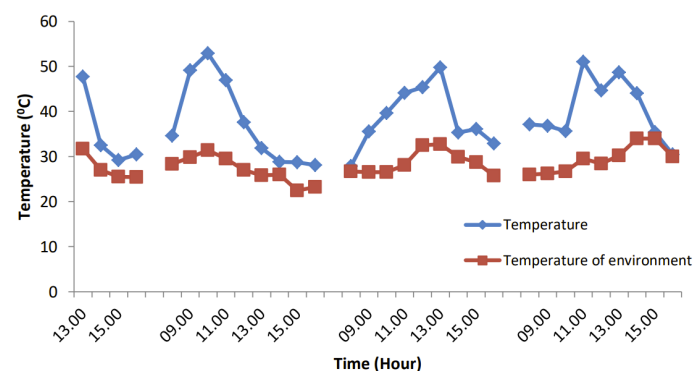


Figure 2. Temperature changes in the drying process

The first-day drying process starts at 13:00, it can be seen that the first day has an average temperature of 13:00 which is 47.680C, and the air temperature starts to decrease at 14:00-16:00 which is 30.70C.

The temperature between the drying chamber and the environment always experiences a high difference, where the temperature of the dryer is always higher than the ambient temperature due to the reflection of sunlight trapped in the drying chamber resulting in a high temperature increase in the drying chamber. Observations continued on the second day, drying began at 08.00 am with an initial temperature of 34.620C, at 10.00 the intensity of sunlight increased so that the temperature in the dryer reached 52.90C, but after 10:00 the intensity of the sun began to fall again, due to cloudy weather and at 13.00-14.00 there was a change in the weather there was rain, resulting in the temperature of the tool decreased with a temperature at 16.00 which was 28.060C.

On the third day, the highest average temperature was at 13.00 with an air temperature of 520C, in the afternoon the temperature decreased to 32.90C. The fourth day is the last observation of the first treatment because the cayenne pepper has reached the specified moisture content. The temperature at 08.00 in the morning was 37.120C and increased so that at 11.00 the temperature reached 510C, after 13.00 the air temperature decreased until the final temperature at 16.00 was 30.440C.

The results showed that the highest temperature during the cayenne pepper drying process was in the drying room at 09.00-10.00 reaching an average temperature of 55.80C, this is because the solar irradiation at that time was quite high, and the ambient temperature during the drying process, measured using a digital thermometer (HTC 2) and a thermometer rod placed around the dryer, the average temperature data obtained from observations in the drying process of the first experiment was 27.070C.

The temperature of the drying chamber during the drying process fluctuates, this is due to the changing weather, the temperature from outside to inside the dryer, and high solar radiation during the day is also one of the factors that make the temperature in the drying chamber fluctuate.

3.2 Humidity in the drying process

Observations and calculations of air relative humidity (RH) were observed using wet bulb (TWB) and dry bulb (TDB) thermometers placed inside the drying equipment around the dryer. The observation data is attached. The observation data was plotted using a psychrometric chart calculator to obtain humidity data in percent units.

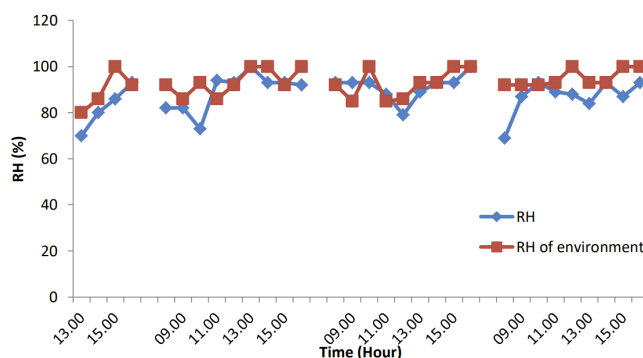


Figure 3. RH graph during the drying process.

It can be seen in Figure 3 above the relative humidity of experiment one started at 13.00 with a humidity of 70%, and the graph increased at 14.00-16.00 which is 80%-93%, on the second day the initial rh at 08.00 is 82%, due to the increasing air temperature at 09.00-10.00 rh the tool decreases which is 73%, the average rh tool on the third day is 91.2% and on the fourth day 87%. Environmental humidity for the first experiment on the first day was 89.5%, the second day was quite high at 93.4%, due to the low ambient temperature with an average temperature of 27.04°C, on the third day the average environmental rh was 92.6%, the fourth day 95%. Air humidity plays an important role in the drying process. Because air humidity shows the content of water vapor in the air. The higher the water vapor content in the air, the slower the drying process.

3.3 Moisture Content

Moisture content is the amount of water content contained in a material with units of percent (%). For the initial moisture content measurement using the oven method and subsequent moisture content measurements using material weight loss measured by weighing the sample using digital scales every hour until the moisture content is determined.

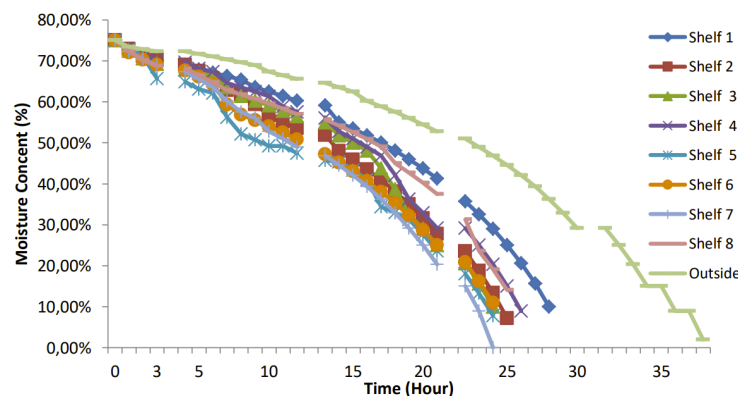


Figure 4. The decrease in moisture content of cayenne pepper

Figure 4 shows that during the drying process, the achievement of material moisture content is almost evenly distributed in this study the drying process was carried out for 23-28 hours, and the average initial moisture content in the first experiment was 75.01%, because drying began at noon at 13.00 than for the first-day drying was only carried out for 3 hours until 16.00, where the water content of cayenne pepper did not decrease much, the average decrease in water content on the first day was 69.98%, on the second day 57.15%, then on the third day the average water content was 34.05%, the fourth day the cayenne pepper had reached the specified water content at 09.00-14.00 with an average content of 9.11%.

3.4 Drying Rate

The drying rate is influenced by the water content in the material, the drying rate increases as the water content in the material decreases. Observation data during drying takes place, the results show that during the drying process in the material, there is a process of evaporation of water from the material to the surrounding air.

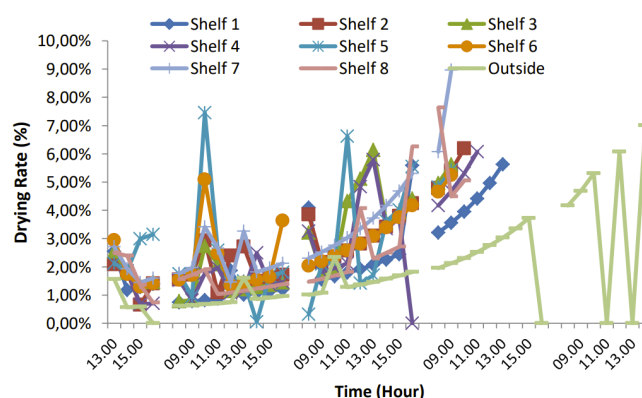


Figure 5. The drying rate of cayenne pepper

Observation data during drying can be seen that the drying rate of shelf 1 - shelf 8 is 2.32% - 2.87% per hour. The drying rate on the sample outside the tool or in the environment during drying is 1.69% / hour lower than the sample inside the dryer. The drying rate indicates the amount of water released per

unit of time. In the drying process, the rate of water evaporation is strongly influenced by temperature, RH, and drying air velocity. The higher the temperature and the speed of the drying air used, the higher the drying air rate.

3. Conclusions

The temperature in the highest drying chamber during drying is between 55.8 0-57.09 0C, the length of time for drying cayenne pepper uses 23-28 hours of effective daylight, from the initial moisture content of 75.01% to reach a moisture content of 9.05%, and the drying rate during drying time at 2.64%/ hour. The use of portable drying equipment can accelerate drying because the drying temperature in the drying chamber is higher, and it is easy to move and even though the weather changes with rain it does not interfere with the material inside physically.

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