Drying Rate of Turmeric Herbal (Curcuma Longa L.) Using Tray Dryer

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Abstract. This study reports the turmeric of drying operation. Variables that have been compared are size or surface area of the sample, drying air rate and drying temperature. In this case it was found that the effect of increasing surface area would be able to increase the amount of water evaporated from the sample. The effect of drying air flow rate at the same temperature decreases the ability to evaporate air in turmeric samples. This is due to the reduced time of interaction of the drying air with the sample surface. Relatively small temperature variations do not show significant differences. The optimal drying rate is achieved by using drying air temperature at 39°C with drying flow of 4.5 m/s and the turmeric sample with surface area of 0.00525 m². The effect of this drying variable obtained significantly on the size of the dried turmeric.

1. Introduction
Drying is the oldest method for preserving food. Throughout history, the sun, wind, and smoky fire were used to remove water from fruit, meat, seeds, and spices. Food dehydration is the process of removing water from food by circulating hot air through it, which prohibits the growth of enzymes and bacteria. Dry food is delicious, nutritious, light, easy to prepare, and easy to use and use. Put less energy than is needed to freeze or can, and storage space is minimal compared to what is needed to stir jars and frozen containers. The nutritional value of food is only slightly affected by drying [1].

Curcuma longa, or turmeric is a perennial herb and member of the Zingiberaceae (ginger) family and is cultivated extensively in Asia mostly in India and China. The rhizome, the portion of the plant used medicinally, yields a yellow powder. Dried Curcuma longa is the source of turmeric, the ingredient that gives curry powder its characteristic yellow color. It has many names such as Curcum in the Arab region, Indian saffron, Haridra (Sanskrit, Ayurvedic), Jianghuang (yellow ginger in Chinese), Kyoo or Ukon (Japanese) [2].

Components of turmeric are named curcuminoids which include mainly curcumin. Curcumin is the important fraction which is responsible for the biological activities of turmeric. Curcumin, a potent antioxidant is believed to be the most bioactive and soothing portion of the herb turmeric and posses the antioxidant, anti-inflammatory, anti-platelet, cholesterol lowering, antibacterial and antifungal effects. The curcumin contain vitamins or vitamin precursor which produces vitamin C, beta-carotene as well as polyphenol coupled with fatty acid and essential oil [3].
Drying rate is calculated by measuring the weight of a drying material over function of time. Drying rate curves represented in three different types of plots that are drying rate versus sample dimension, drying rate versus drying-air temperature and drying rate versus drying-air flow. The objective of this study is to determine the effects of the variables and to find which variable resulting the fastest drying rate of turmeric samples.

2. Method

2.1 Experimental apparatus

The tray dryer (Armfield UOP 8) is shown in Figure. 1. This is an equipment unit at The Unit Operation Laboratory of the Department of Chemical Engineering Universitas Sumatera Utara. This equipment consists of three trays. The tray dryer also equipped with air-drying temperature and air-drying flow control.

![Figure 1. Tray dryer (Armfield UOP 8) [4]](image)

The sample that used in this experiment is turmeric. Turmeric used in this experiment was obtained from traditional markets around Universitas Sumatera Utara. Turmeric is selected manually then the turmeric was skinned and cut into bar shape with different thickness.

2.2 Problem formulation

In order to obtain the evaluation factors used for the research, measurement of air-drying temperature and moisture content were made. Drying time was determined with a stopwatch. The drying air temperature was controlled with the aid of a thermostat attached to the heating element of the dryer, which was previously calibrated to read its maximum at the drying air temperature and turn off heating if maximum threshold is exceeded.

The turmeric sample is first weighed to get the initial sample weight. Three of the samples with the same dimensions are placed in each tray. Weight changes every 4 minutes are recorded then drying is stopped after the weight has reached a constant three times. The results of this sample weighting are used to calculate the wetness content of the sample. The variations made can be seen in Table 1. Then the dry-weight basis moisture content \(M_d\) can be written as follows [5]:

\[
M_d = \frac{w-d}{d} \quad (1)
\]
Where, \( w \) = initial sample weight, \( g \) & \( d \) = weight of dry product, g. Moisture content on dry weight has been used for all calculation purpose in this paper. \( M_d \) then used for calculating the drying rate (\( R_c \)). \( R_c \) can be written as follows [6]:

\[
R_c = \frac{M_d}{A} \left( \frac{X_1 - X_2}{t} \right)
\]

Where, \( R_c \) = drying rate, g/m\(^2\).minute; \( A \) = surface area of samples, m\(^2\); \( M_d \) = moisture content, \( X_1 \); \( X_2 \) = initial moisture content and end & \( t \) = time, minute.

**Table 1.** Experiment Design of Drying Process

| Run   | Drying Air Flow (m/s) | Drying Air Temperature (°C) | Surface Area (m\(^2\)) |
|-------|-----------------------|-----------------------------|-------------------------|
| Run I | 4,0                   | 36                          | 0,0035                  |
| Run II| 4,0                   | 36                          | 0,00525                 |
| Run III| 4,0                  | 36                           | 0,00525                 |
| Run IV| 4,5                   | 36                          | 0,0006                  |
| Run V | 4,0                   | 36                          | 0,0006                  |
| Run VI| 4,0                   | 39                          | 0,0006                  |

3. Results and Discussions

The results will be discussed in 3 subjections, they are effect of sample surface area, drying air flow and drying air temperature on the drying rate.

3.1 Effect of Sample Dimension on the Drying Rate

*Figure 2. The variation of drying rate for different sample surface area*

Figure 2 shows drying rate of the turmeric sample when dried at drying air temperature of 36°C and drying air flow of 4,0 m/s. The variation of surface area for Run I and Run II are 0,0035 m\(^2\) and 0,00525 m\(^2\) respectively. The drying rate is constant at minute 220 for Run I at minute 212 for Run II.

The distance of water molecule that passes in a sample before evaporates from the surface determines how fast the sample will dry. In constant rate periods, smaller particles have larger surface
area, so it is sufficient for the process of evaporation. Whereas in the fall period, smaller sample thickness makes the distance pass by water molecule is shorter to move to the surface of the sample [7].

The results from the graph are appropriate where the greater surface area of the sample, the drying rate will higher. This is indicated by the time to a constant for Run II ($A = 0.00525 \text{ m}^2$) shorter than Run II ($A = 0.0035 \text{ m}^2$).

### 3.2 Effect of Drying Air Flow on the Drying Rate

![Figure 3. The variation of drying rate for drying air flow](image)

Figure 3 shows the effect of drying air flow on drying rate with drying air temperature $39^\circ\text{C}$ and sample surface area of $0.00525 \text{ m}^2$. The variation of drying air flow for Run III is $4.0 \text{ m/s}$ and Run IV is $4.5 \text{ m/s}$. The drying rate is constant at minute 132 for Run III and at minute 96 Run IV.

The drying air flow in drying process that touches the surface of the sample affects the mass transfer from the sample to the air. Increased drying air flow will take more moisture from the sample surface and prevent moisture from creating saturated condition on the sample surface. Besides that, this also shortens the duration of the constant drying rate period [7].

The results of the graph are suitable where the higher drying air flow, the drying rate will increase. This is indicated by the time going to be constant for Run III (drying air flow $4.0 \text{ m/s}$) longer than for Run IV (drying air flow $4.5 \text{ m/s}$).
3.3 Effect of Drying-Air Temperature on the Drying Rate

Figure 4 show the drying rate when the turmeric samples were dried at the respective air-drying temperature of 36°C and 39°C and sample surface area 0.0006 m² and drying air flow of 4.0 m/s. The drying rate reach constant value at minute 188 for Run V and minute 172 for Run VI.

The greater the temperature difference between the drying air and the sample, the greater the heat transfer. The increase of the drying air temperature increases the drying rate by affecting external conditions such as constant period rate and internal conditions such as fall period rate. However, temperatures that are too high can cause a decrease in the quality of materials such as sample colors. Therefore, the drying air temperature must be controlled and maintained in order to obtain maximum drying and maintained sample quality [7].

The results obtained from the graph are appropriate where the higher the temperature of the inlet air the drying rate will increase. This is indicated by the time to a constant for Run VI (drying air temperature 39°C) faster than Run V (drying air temperature 36°C).

4. Conclusions

From this drying rate study, it can be concluded that drying rate is affected by variables such as sample surface area, drying air flow and drying air temperature. The optimal drying rate in this study is achieved by using drying air temperature 39°C and drying air flow of 4.5 m/s for the drying of turmeric sample with surface area of 0.00525 m². The effect of this drying variable obtained significantly on the size of the dried turmeric.

5. References

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