Sun energy on natural drying of cucumber and radish

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Abstract. Drying is a very basic process for reducing the moisture content of a material or product. It is the oldest technique used to extend the shelf life of a material or product. The idea is to dry comparing cucumber and radish with the same thickness and shape of the sample. The result of the different samples, the operation time and temperature impact the drying kinetics. As the results of drying at open area and naturally gave the information have impacted the rate of drying. The type of sample with specific chemical compounds has a certain drying rate on a variation of temperature and operation time.

1. Introduction

The samples used in this study are cucumber and radish. Cucumber or Cucumis sativus L. is one of the Cucurbitaceae family members which grows in many tropical and subtropical areas of the world. This vegetable has a soft, fresh, and contains a lot of water and is preferred by many people to be consumed in various ways such as in salads, juices, and pickles [1]. Cucumber contains many vitamins that are good for the human body such as vitamins A, C, K, and B6. In various countries in the world, cucumbers are cultivated in the field during summer and winter in an artificial heating greenhouse [2]. Dried cucumber is often used as a spice powder and snack chips as a healthier alternative to potato chips [3].

Radish or Raphanus sativus L. is one of the vegetables that is grown and consumed throughout the world. Radish can be processed in many ways for consumption, such as in salads and juices. Radish is a root plant that comes from the Brassicaceae family, with various skin colours such as red, purple, yellow, white to pink with white flesh. This plant growth cycle is flash, which is about 30 days. Radish contains carbohydrates, sugar, dietary fibre, protein, fluoride, minerals, and various vitamins (B1, B2, B3, B5, B6, B9, and C). Radish can be used in traditional medicine to treat some illnesses, such as jaundice, gallstones, liver disease, rectal prolapse, indigestion, and stomach pain [4,5]. Dried radish is widely used as a food ingredient because of its unique texture and taste. When radishes are dried, the nutrient content contained will increase, such as calcium, phosphorus, glucose, and free amino acids [6].
Drying is a very basic process for reducing the moisture content of a material or product. It is the oldest technique used to extend the shelf life of a material or product [7]. Drying has been carried out in a unit operation laboratory Universitas Sumatera Utara using a tray dryer to measure the drying kinetics [8,9]. The easiest drying process for many people to do is by utilizing sun energy or natural drying. Sun energy is an energy source that is unlimited and environmentally friendly, however, sun solar energy is intermittent. In the natural drying, material or product will be directly exposed to solar radiation. The drying rate is influenced by sun radiation, environmental temperature, wind speed, relative humidity, and initial moisture content [7,10]. Figure 1 shows the sample product of the cucumber and radish. Many researchers have studied the use of solar energy for the drying of natural materials such as paddy [11], red chilli [12], cocoa [13], coffee beans [14], cassava [15], etc. And many researchers have researched the drying of cucumbers and radish by various methods, such as using the far infrared ray dryer [16], microwave drying [6], tray dryer [17] and hot air drying [18].

Cucumber and radish are perishable food ingredients due to their high water content, so that drying is needed to increase vegetable life by removing water content so that bacteria, yeast, and fungi will not be able to flourish. The objective of this study is to obtain a drying kinetics with sample variations of cucumber and radish base on the loss of weight sample in adding the drying time.

2. Materials and methods
The materials used in this study were cucumber and radish bought at the traditional market in Selayang, Medan. Samples were skinned and cut with a cutter and measured to obtain a specific size with a ruler as shown in Figure 2A. The cucumber and radish have the same thickness, which was 1 cm. The sample was weighed with a digital material balance HARNIC brand model EAH901 as shown in Figure 2B. The volume of each sample was measured with a Pyrex Measuring Cylinder (Figure 2C). Drying was done openly by analysing the online ambient temperature and relative humidity as shown in Figure 2D.
The drying process was done by measuring the sample's weight changes by weighing it every 20 minutes to one hour until the sample weight has been constant. The drying process air conditions such as temperature and relative humidity is constant. Measurement methods were carried out for each sample until the 6th day. In collecting images of sample was applies by using OPPO 11 camera digital with 48-megapixel image quality. For drying kinetics, the weight loss was measured with digital balance HARNIC until the weight changes are stable at suitable time intervals. Weight loss of the results was calculated by equation 1:

\[
\text{Weight loss}(t) = \text{Weight}(0) - \text{Weight}(t)
\]  

(1)

Where weight (0) is the weight of wet samples before drying and weight (t) is the weight of the dry samples at specified time intervals. Weight loss (t) is the weight of each sample at specified time intervals.

In calculating the drying kinetics was applied the equation (2) [6]:

\[
\text{Drying rate} = \frac{\text{Weight} (0) - \text{Weight} (t)}{dt}
\]

(2)

Where Weight (0) – Weight (t) is the weight of the dry samples at specified time intervals. Then plot the graph between weight loss and time to see the drying kinetic.
3. Results and discussion

Table 1 shows the physical properties of cucumber and radish as the samples. Weight and volume data can estimate the sample density, where the density of cucumber is 0.7620 mg/ml and radish is 0.7230 mg/ml. This data will be used to compare the drying rates of the samples.

| No | Sample  | Thickness (cm) | Weight (mg) | Volume (ml) | Rho (mg/ml) |
|----|---------|----------------|-------------|-------------|-------------|
| 1  | Cucumber| 1              | 5.56        | 7.30        | 0.7620      |
| 2  | Radish | 1              | 5.74        | 7.94        | 0.7230      |

As observed in figures 3 and 4, the weight of the samples was reduced continuously with an increase in drying time. Figure 3 shows the drying kinetics on the first day of the drying process. Sample 1 was cucumber with an initial weight 5.56 mg which was significantly reduced at the 6th hours to 2.56 mg. For sample 2, the radish initial weight was 5.74 mg. There were no significant weight changes, which until the 6th hours the radish weight became 4.04 mg.

Figure 4 shows the overall drying kinetics that occurred for 6 days. This observation was carried out until the sample weight has been constant. The weights of the samples 1 and 2 were constant on the 6th day with weights of 0.22 mg and 0.46 mg, respectively. This is in accordance with the study of Yahya, 2016 [12] that the drying rate decreases with increasing drying time. It happens because the rate of evaporation of moisture decreases in adding the drying time.

From the graph, it can be seen that cucumber has decreased significantly during H0 to H1 in comparing to radish. This is because radish has more solidity than the cucumber. According to the study of Bornhorst, et al. 2016 [19], that drying is also influenced by the pore structure of the material. The narrow pore structure will slow down the drying process. It might be impacting on the diffusion of moisture that cucumber drying was faster than radish.
Figure 4. The drying kinetics by adding the day

Figure 5. The impact of temperature on drying ability

Figure 5 shows the effect of temperature on the drying process. From the graph, it can be seen that temperature greatly affects the drying process. In sample 1 cucumber, there was a weight reduction at 29°C was 0.48 mg, at 31 °C was 0.513 mg, and at 33 °C was 0.79 mg. In sample 2 radish, the weight reduction at 29°C was 0.18 mg, at 31 °C was 0.36 mg, and at 33 °C was 0.52 mg. Yahya, et al. 2016 [11] state that the higher the ambient temperature during the drying process causes more water evaporated from the material and will shorten the drying process. Park, et al. 2015 [16] and Natarajan, et al. 2019 [20], in their study of drying radishes and cucumbers, state that the high temperature of the drying process would speed up mass transfer so that the moisture would be evaporated quickly.

The drying process caused several changes to products such as shape changes and colour changes. In Figure 6, the cucumber and radish have changed into brown and became shrinkage. The colour changes that occur in the samples is due to an enzymatic browning reaction during the drying process. The browning reaction will be very significant if the drying process is carried out with a long time and
low temperature. One of the negative impacts of drying is the material's physical changes. This physical change is the shrinkage of the material due to reduced moisture content during the drying process [21].

Drying openly the cucumbers and radishes in the sun will require a longer drying time. It is due to the influence of weather and uncontrolled operation condition, which that impact to the variation of physical changes in the sample such as shrinkage, surface hardening, and discoloration during the drying process [18,20].

![Figure 6](image)

4. Conclusions
This study gives the results that time, the temperature of sun energy to the environment, and the type of sample affect the drying kinetics. In this study, the pore structure of the sample also affects the drying rate. The cucumber changes significantly because of the radish pore structure is narrower compared to cucumber. The drying process also affects the sample's physical properties, such as colour changes into brown and shrinkage of the sample.

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