Simulation of natural drying kinetics model of carrot (*Daucus carota* L.) on shape variation: Research from home

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Abstract. One of the consequences of the coronavirus pandemic in 2020 is the constraints of research activities at university laboratories. All kinds of activities must be limited including educational, teaching and research. At this time, there are some studies that can be done around the house or research from home. One of operation module is research on natural drying that can be done while at home where this research is very simple and only requires modest equipment. This research uses carrot samples with shapes variation. The aim of this study is to investigate the natural drying kinetics in carrot samples.

1. Introduction

Carrots (*Daucus carota* L.) are a tuber vegetable. This type of vegetable is easily found in various places and can grow throughout the year both rainy and dry. Carrots have short stems that are almost invisible. Its roots are taproots that change shape and function into round and elongated. Carrot plants can grow optimally in cold temperatures or in the mountains with a height of about 1200 m above sea level. Carrots have wet leaf stems in the form of a bunch of midribs on the leaf stems that arise from the base of the upper tubers, which are similar to leaves celery [1]. Figure 1 is the sample of fresh carrot.

![Carrot](image)

*Figure 1. Carrot*
In Indonesia, carrots are very easy to get. People can buy carrots in traditional markets. Carrots have become a daily food in urban and rural communities, whether they are made into soups, salads, or just eaten. Most carrots are used as a food supplement, both as a complement to fried foods or additional ingredients for sautéing. At the industrial level, carrots have been processed into various forms of processed food, such as health drinks, frozen carrots and dried carrots as a mixed component in instant soup products, instant noodle supplements, instant foods for babies and so on [2].

Drying is the most ancient and traditional process that is still widely used for food conservation. The degree of drying is influenced by transfer mechanisms, such as vapour pressure, drying air, temperature, air velocity, thickness, and exposed surface [3,4]. Drying is one of the cheap and common preservation methods for biological products [5], so that is the reason why this very old process is still used. The drying process is usually conducted using the smoking method. Such drying method has a disadvantage that is reduced sugar levels of samples. In addition to the smoking method, the drying process is also conducted by directly drying under the sun and placed over on matting and tarpaulin [6], or used tray dryer [3,7]. Such a method has weaknesses namely requires large space, more labour, longer time and contamination between the samples seeds and foreign objects so that damage possible occurs when stored [6]. Drying various materials like this has been reported by several researchers, for cabbage [8], cherry tomato [9], rice [10,11], onion [12], candlenut [13] and etc.

As a southeast Asia country, Indonesia have to follow the regulation in doing the daily activities including activity at school and university during the COVID-19 pandemic period. [14]. Most the activities are doing at home, including study activities. Lockdown of the most university force the students to do their research from home. As the environmental conditions have been reported impacting the environmental performance, company profitability and asset utilization [15, 16]. The current COVID-19 pandemic conditions were impact to procedural activities whole the world. The ability the virus in transmission is happened by person-to-person that may arise through droplet or contact transmission [17, 18].

The aim of this study is to identify the drying kinetics of carrot as samples with shape variation. The kinetic model is obtained from measuring the reduction of sample weight on the drying time.

2. Methods
The materials used in this study are carrots purchased at traditional markets in Selayang, Medan. The tool used for this research is a cutter and a ruler. Samples were prepared in three shapes, they are a quarter, half-round and rounded. The material is then weighed with a digital balance device (Camry EHA90). Also, the volume is measured with a measuring cup. OPPO F11 with 48-megapixel camera phone was used to take the photo of sample during drying operation. Drying is done openly with an online environment temperature analysis like the example in Figure 2.

![Figure 2. Openly online environment temperature [19]](image-url)
For drying kinetics, weight loss of samples were measured with a digital balance until the weight changes is stable at suitable time intervals. Weight of samples loss on the results are calculated by;

\[ W(t) = W(0) - WL(t) \]  

Where, \( W(0) \) is the initial weight of wet carrot before drying and \( W(t) \) is the weight of the dry carrot at specified interval time. \( WL(t) \) is the loss of weight samples weighed by digital balance at specified interval time. The study conducted this time only reviews the reduction in mass over the drying time, where the kinetics model is for predicting the relationship of mass transfer with the drying time.

### 3. Results and discussion
In table 1. explains the sample shape used in this study. There are three samples of carrots of different shape.

| Sample | Thickness (cm) | Shape       | Weight (mg) | Rho (mg/ml) |
|--------|----------------|-------------|-------------|-------------|
| 1      | 1              | a quarter   | 3.30        | 1.29        |
| 2      | 1              | half round  | 7.24        | 1.29        |
| 3      |                | Round       | 14.4        |             |

![Drying Kinetics](image)

Figure 3. The Drying kinetics model on first day in sample carrot.

In Figure 3, this shows the drying model of kinetics on the first day. For seven hours, the sample weight decreased. For sample 1 the initial weight is 3.30 mg until the next seven hours the weight becomes 0.50 mg. For sample 2 the initial weight was 7.24 mg until the next seven hours the weight became 1.82 mg. For sample 3 the initial weight was 14.40 mg until the next seven hours the weight became 5.12 mg. In sample 1 the weight reduction from the beginning of drying to the seventh hour according to the equation was 2.8 mg. In sample 2 it was 5.42 mg and sample 3 was 9.28 mg. This shows that some of the weight in the sample has disappeared into the air. This indicates that there is some mass lost, namely the water content in carrots.

The drying is influenced by a number of processes which can broadly be split between the heating of the sample and mass transfer processes such as the removal of moisture by the movement of air or water vapour and diffusion processes. Diffusion is the main process occurring to transfer heat and moisture within the sample of carrots. As a rule of thumb, the diffusion process around a material is substantially slower than heat transfer [11, 20].
Figure 4 is a profile showing the reduction in overall sample weight to constant sample weight shown on the eighth day. In Figure 4 the constant weight in sample 1 on the eighth day was 0.32 mg, in sample 2 it was 0.58 mg and in sample 3 it was 1.28 mg. In sample 1 the weight reduction from the beginning of drying to the end of drying ie on the eighth day according to the equation was 2.98 mg. In sample 2 it was 6.66 mg and sample 3 was 13.12 mg.

The convective heat transfer coefficient is an important parameter in the simulation of the drying rate because the temperature difference between air and sample varies with this coefficient. Simple analytic models such as simultaneous heat and mass transfer on the surface of the sample and including the effects of wind speed, relative humidity, product thickness, and the heat carried out to the ground for open sun drying need to be taken into account. Several theoretical and experimental studies of drying experimental data for thin-film barley drying to show that heat transfer and mass transfer models in one wheat kernel increase the predicted drying rate [17, 21]. The study conducted this time only reviews the reduction in mass over the drying time, where the kinetics model is for predicting the relationship of mass transfer with the drying time.

Figure 5. A. Raining in room, B. in room, C. Open
Figure 5 shows the change in weights when done under various conditions. In part A, the sample is carried out under rain conditions in a room. In part B the sample is carried out under the same conditions ie in a room without rain conditions. In section C the sample is carried out in outdoor conditions. The measured temperature was the mean temperature, when in section A the average temperature is 25 °C, part B is 27 °C, and part C is 31 °C.

From Figure 5 explains that the highest total weight reduction occurs in condition C, which is done in outdoor conditions. The best conditions for drying material are open conditions which are directly exposed to the sun. In accordance with Figure 5 which shows the graph. It increases the rate of drying of the material because higher temperatures are increased, which under these conditions the rate of heat transfer due to temperature increases accelerates the transfer of water mass from the sample to the air [5, 22].

![Figure 5](image)

**Figure 5**

Drying has a substantial effect on the physical texture and color of the carrot samples. Figure 6. shows the changes that occurred in the sample. Figure A is the initial condition of the carrot sample and Figure B shows the changes in shape and surface after drying for five days. Changes in the surface structure of the sample along with the release of water from the sample material, resulting in wrinkles.

The drying will change in the structure, volume, porosity, and density of the samples. In this drying operation, the color of samples become brown caused by chemical changes in pigments such as carotene and chlorophyll. One of the reactions is a browning reaction which produce heat and oxidation that occurs during drying [4, 23].

**Figure 6. A sample H0 and B sample H5**

4. Conclusion
Recently, the coronavirus pandemic is the constraints of activities at university including on educational, teaching and research at laboratories. Alternative ways are studies and researchs that can be done from home. Research on drying naturally with carrot as sample have investigated. Drying operation was to remove the water in the carrots sample. The study was on reduction of the mass over the drying time. The drying kinetics used for predicting the relationship of mass transfer with the drying time. The best conditions for drying material are open conditions which are directly exposed to the sun. Changes in the surface structure of the sample along with the release of water from the sample material, resulting in wrinkles. In this study, the largest value of weight reduction was in sample with round shape with a total reduction 13.12 mg. In this drying operation, the color of samples become brown caused by chemical changes in pigments such as carotene and chlorophyll.
5. References

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