Journal of Positive School Psychology http://journalppw.com
2022, Vol. 6, No. 6, 8277-8286

Research Activities From Home During Coronavirus Disease (Covid) 19: Drying Kinetic Study Of Ginger (Zingiber Officinale Rosc.) Naturally (Natural Drying)

Bode Haryanto[1] , Mia Yunita[1] , Rondang Tambun[1] , Maya Sarah[1] , And Tubagus Rayyan Fitra Sinuhaji[1]

[1]*Indonesia, Universitas Sumatera Utara, Medan, Faculty of Engineering, Department of Chemical Engineering, bode.haryanto@usu.ac.id*

Abstract

During pandemic covid-19, drying naturally operation is an idea to continue the research activity study from home. Ginger is a type of medicinal plant and spice in the form of a pseudo-trunked clump and is part of the rhizome of a plant with the scientific name Zingiber officinale Rosc. Ginger is one agricultural commodity with good prospects for being commercialized in Indonesia. Agricultural product handling techniques are very important things to do, this is because if you master the handling techniques you can reduce the level of damage from various agricultural products. Drying is a food processing process that has long been known. The drying process in this study was carried out by natural drying (natural drying) with conditions outside and inside the room. The length of the sample is 4 cm, the width is 2 cm, and the thickness of the sample which is varied is 0.5 cm; 1 cm; and 1.5 cm. This research was conducted to determine the drying kinetics of ginger using natural drying on ginger's dimensions and to determine ginger's drying characteristics. The results showed that the best conditions for drying ginger were outdoor conditions exposed to direct sunlight. The best drying rate occurred in sample 1 with outdoor conditions. The best equation model for predicting the drying rate of ginger is Newton's model with R^2 of 0.9894 outdoors and 0.9929 indoors.

Keywords: characteristics, kinetics, drying rate, drying, mathematical model.

Introduction

The coronavirus disease (COVID-19) pandemic has had many impacts such as on the environment [1], society [2] business activities [3] and etc. The covid pandemic reported had a big impact on the mental health and psychosocial conditions of everyone including students [4]. The covid pandemic also impacts research activities by limiting activities in the laboratory. Research from home was an idea for the student to fulfill their education standard [5]. Drying modules with natural operation from home have been reported as references [[6],[7],[8],[9]]

The ginger plant has been used as a cooking spice and medicine, in Southeast Asia such as Malaysia, the Philippines, and Indonesia, ginger has also been widely used as a spice in cooking and traditional medicines [[10]].

Ginger can be used as perfume and traditional herbal medicine in the pharmaceutical industry. Ginger has many benefits for humans, while the benefits are a cough laxative (both dry cough and phlegm), sweat laxative, menstrual laxative, preventing nausea, increasing appetite, helping to expel wind, strengthening the stomach, improving the digestive cycle, and warming the body [11]. The sample of ginger as shown in Figure 1.

The prospect of developing ginger in Indonesia is still quite good, this can be seen in terms of domestic market demand for the needs of various industries that have not been fulfilled, so Indonesia still imports ginger from abroad, namely China. The market demand for ginger exports from Indonesia is quite large, for example, the Netherlands requires 40 tons of ginger every month [[12],[13]].

In the post-arvest period, special handling of the ginger plant commodity is needed with the aim that the ginger commodity that has been harvested is in good condition and suitable for sale and consumption by the community. Special handling of ginger plants can be done by the drying method.

Drying is a food processing process that has long been known. The purpose of the drying process is to reduce the water content of the material to become more durable, reduce the volume of the material to make it easier, and save on transportation, packaging, and storage costs. However, there are losses incurred during the drying process, namely changes in the physical and chemical properties of the material and a decrease in the quality of the material [14]

Fig. 1. Ginger (zngiber officinale rosc.) [15]

Sun-drying is the largest and oldest method of food preservation. However, as technology advances, we cannot depend on elements that cannot be predicted with certainty such as the weather. In addition, drying in the sun usually requires a large enough container or area, and the level of hygiene is not guaranteed [7].

Therefore, it is necessary to conduct research on food processing from ginger using natural drying methods with the help of sunlight and to see the effect of drying variables on the drying rate. This study specifically aims to examine the effect of ginger varieties on the water content presentation and food processing of processed ginger products. This research is expected to be able to develop research-based on local plants, especially ginger, and increase the community's economic income by processing ginger food. During the coronavirus disease (COVID-19) pandemic all activities in this research were worked from home.

.

Methods and Equipment

This research was conducted at Jalan Pembangunan No. 107, Padang Bulan I Village, Medan Selayang District, Medan City, Sumatra Utara Province, Indonesia.

Fig. 2 Online environmental temperature measurement.

In this study, the ingredients used were: Aquadest, and Ginger (Zingiber officinale Rosc.). The equipment used in this study includes the following: Cutter, measuring cup, iron ruler, tarpaulin, and electric scale. The image of the sample was taken by camera OPPO F1s 16MP. Surface analysis was done using scanning electron microscopy (SEM Hitachi Tm 3000) at

Laboratory TERPADU of Universitas Sumatera Utara, Medan.

Data on environmental conditions such as temperature and humidity at the research site were taken from www.weather.com as shown in Figure 2. Sample length was 4 cm, width 2 cm, and the thickness of the sample varied is 0.5 cm; 1 cm; and 1.5 cm, and conditions of drying variation that is indoors and outdoors [8]. Drying of the sample is carried out for 8 hours each day until the sample reaches a constant weight. The drying process starts at 10.00 WIB and ends after 8 hours of drying at 18.00 WIB. In this study, the average daily environmental temperature was between 29-31 ^{o}C. Drying kinetics, the weight loss of the sample is measured with digital scales until the sample reaches a constant weight at predetermined time intervals. The weight of the missing sample is calculated using the equation:

$$WL_{(t)} = W_{(0)} - W_{(t)} \quad (1)$$

Where WL(t) is the weight of a sample lost at a given time interval. W(0) is the initial weight of wet ginger before drying. W(t) is the dry weight of ginger at certain time intervals [9].

Drying Modeling

The drying process has a model based on a mathematical equation that typically describes the drying kinetics of a food ingredient. The use of this mathematical model is very important to predict the performance of the drying system [16]. Some of the models below are mathematical models that are often used, namely:

1. Newton's Model
2. Page Model
3. Henderson dan Pabis Model

From the mathematic equations of the newton model, page model, and Handerson-Pabis model above, then converted into a linear form [17]. The following is shown the linear form of the mathematical model in Table 1:

Tab. 1. Drying Kinetic Model

Model Name	Model Equation	Linear Equation
Newton	MR = exp(kt)	ln MR = -kt
Page	MR = exp(kt^{n})	Ln(-lnMR) = ln k +n ln t
Handerson-Pabis	MR = aexp(kt)	ln MR = ln a-kt

Parameters a, k, and n are calculated by non-linear regression analysis using the Excel Solver program (Microsoft Office Excel, Professional Edition).

The linear form of each model can be plotted into the Microsoft Excel program to obtain the MRpre value (MR prediction obtained from the equation in Table 1). For the Newton and Henderson-Pabis model, the ln MR vs t plot is used, while the ln (-ln MR) vs ln t plot is used for the Page model.

Results and Discussions

Physical Properties of Ginger

Each sample is weighed and measured in volume, where the data obtained can be seen in Table 2.

Table. 2. Identification of Physical Properties of Ginger

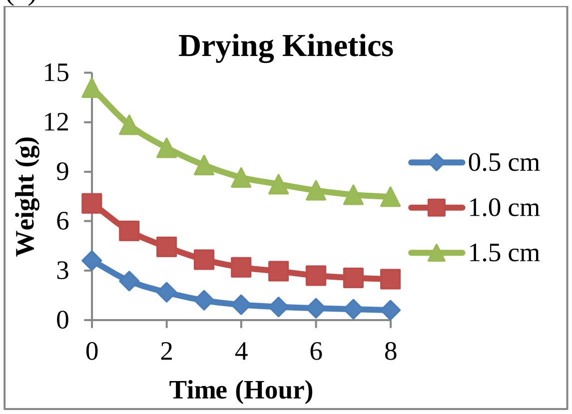
Sample	thickness (cm)	Length (cm)	Width (cm)	Weight (g)	Volume (mL)	ρ (g/mL)
1	0.5			3.20	4.0	
2	1.0	4.0	2.0	8.51	7.0	1.07
3	1.5			13.38	11.25	

In this study, measurements of density (density) were carried out on samples with different size variations. Each sample was weighed and measured in volume so that the data contained in table 2. The data obtained can estimate each sample's specific gravity (ρ (g/mL)). The specific gravity obtained from all samples is 1.07 g/mL.

Drying Kinetic

The drying process on the first day showed a decrease in water content in the sample by a large amount. The kinetics of drying ginger on the first day outdoors and indoors can be seen in Figure 3.

(a)



(b)

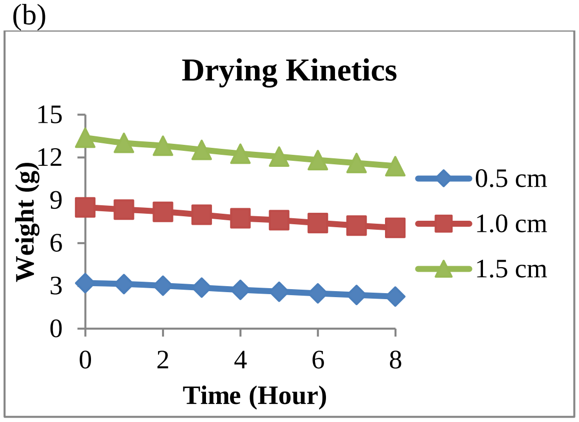


Fig. 3. First day drying graph
(a) outdoor, (b) indoor.

The kinetics of drying ginger outside and indoors can be seen in the picture above. Figure 3 shows the drying kinetics on the first day. The first-day drying process displays a relatively fast and large reduction in moisture content. This is because the preheating that occurs only evaporates the free water on the surface of the sample. Free water is water that evaporates easily from foodstuffs due to weak hydrogen bonds in free water [18].

Then on the following day, the reduction in water content slowly decreases until it reaches a water content balance. The drying process, longer the drying process occurs, the lower the water content, and the drying rate will also slow down. This is because, at the time of drying in addition to the presence of free water which tends to evaporate more easily during the initial drying period, there is also bound water, namely water that is difficult to move up to the surface, so the longer the drying rate, the lower the drying rate [19]

Figure 3 shows the drying kinetics on the first day outdoors and indoors. It can be seen that for 8 hours, the samples were dried from 10:00 Am to 06:00 Pm, after that the samples outside the room were put into the room, then drying was carried out again for 8 hours until the sample mass was constant per day. In the outdoor conditions, it can be seen that in the first 3 hours the sample changed drastically compared to indoors, sample 1 with a thickness of 0.5 cm, the initial weight was 3.61 grams, carried out in 8 hours so that the weight became 0.60 grams. Sample 2 with a thickness of 1.0 cm and an initial weight of 7.08 grams was dried for 8 hours until the weight became 2.48 grams. Sample 3 with a thickness of 1.5 cm and an initial weight of 14.08 grams was dried for 8 hours until the weight became 7.47 grams. In a study conducted indoors with a sample of 0.5 cm thick and an initial weight of 3.20 grams, drying was carried out for 8 hours so that the weight was 2.25 grams. Sample 2 with a thickness of 1.0 cm and an initial weight of 8.51 was dried for 8 hours so that the weight was 7.07 grams. Sample 3 with a thickness of 1.5 cm and an initial weight of 13.38 was dried for 8 hours so that the weight became 11.40 grams. From this research, it can be seen that the weight of the sample slowly disappears because the water in the sample evaporates into the air and makes the weight of the sample decrease with drying time.

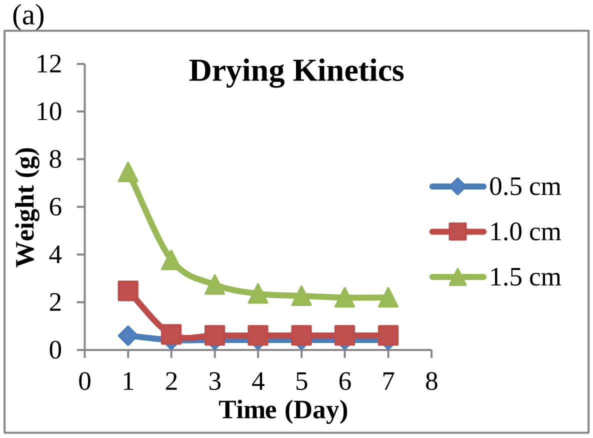
Figure 4, it can be seen a graph of the drying kinetics of samples outdoors and indoors which shows that the drying rate at the beginning of the period decreased with time. The decreasing drying rate explains that the water in the material still has the potential to experience evaporation during the final drying period. This happens because during the drying process, in addition to the presence of free water which tends to evaporate more easily during the initial drying period, there is also bound water, namely water that is difficult to move up to the surface of the material during drying so that the rate of evaporation of water decreases over time [20],[21].

In outdoor conditions, the sample weight of Ginger decreased constantly at run 1 of 0.42 g, run 2 of 0.61 g and run 3 of 2.20 g. The constant weight loss occurred on the seventh day. In run 1 there was a decrease in weight from the beginning of drying to the end of drying, resulting in the final weight at running 1 being 3.19 g, in run 2 is 6.47 g, and in run 3 is 11.88 g.

While in indoor conditions, the weight of the ginger sample decreased constantly at run 1 of 0.41, run 2 of 0.81 g, and run 3 of 1.08 g. The constant weight loss occurred on the seventh day. In run 1 there was a decrease in weight from the beginning of drying to the end of drying so that the final weight at running 1 was 2.79 g, run 2 was 6.3 g, and run 3 was 11.77 g.

Based on Figure 4, it can be seen that the longer the drying process, the lower the water content. The process of drying ginger outdoors takes 3-7 days to reach its constant weight, while indoors it takes 4-7 days to reach its constant weight. It shows. The thicker the pile of material being dried, the longer it will take to evaporate the water during drying [22].

(a)



(b)

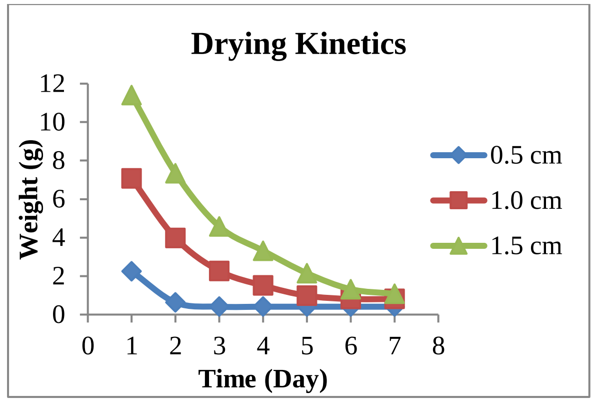


Fig. 4. Kinetics drying of samples per day (a) outdoor, (b) indoor

The drying process will cause changes in color, texture, and aroma [[23],[24]]. Factors that affect drying there are two groups, namely factors related to the drying air and factors related to the nature of the material being dried. Factors belonging to the first group are temperature, volumetric velocity, drying airflow, and humidity. Factors belonging to the second group are the size of the material, the initial moisture content, and the partial pressure in the material [25].

Based on Figure 5 the graph of the drying variation conditions shows the variation of ginger drying carried out in the study. Variations made are drying outdoors and indoors. The temperature measured is the average temperature, outside the room has an average temperature of 30.31°C, and indoors has an average temperature of 28 °C. From Figure 5, it can be seen that the highest total weight loss occurred in outdoor drying conditions.

The best conditions for drying the material are open conditions that are directly exposed to sunlight. During the drying process, heat transfer occurs from the surface of the material, causing the water content on the surface of the material to decrease. The higher the temperature of the drying air, the greater the heat energy carried by air, so that more mass of liquid is evaporated from the surface of the material being dried [26].

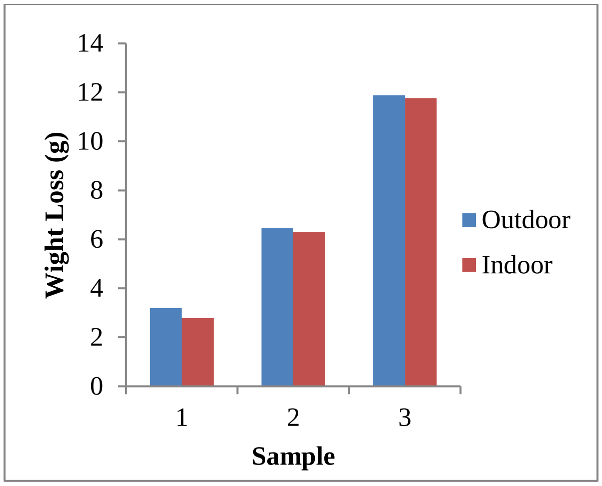


Fig. 5. Conditions variation of drying

Sample Shape and Surface

Figure 6 shows the changes in the shape and surface of the sample before and after drying. Changes in the surface structure of the sample along with the release of water from the sample, result in shrinkage. Shrinkage is a decrease in volume, a change in shape, and an increase in the hardness of a material. Shrinkage increases with more water coming out of the material. Drying causes the cavities of the material that were previously filled with water to become interconnected so that the outer surface of the material will shrink inward and reduce the surface area of the material [27].

H0

H0

H3

H3

H7

(a)

H7

(b)

Fig. 6. Sample shape and surface (a) outdoor, (b) indoor.

The higher the drying temperature, the lower the yield. The size of the yield produced is influenced by the water content. The higher the drying temperature, the lower the water content, so the resulting yield is also lower because the water content in the material is evaporated which causes the weight of the material to decrease or shrink. Treatments using various drying temperatures have varying effects on physical characteristics [28].

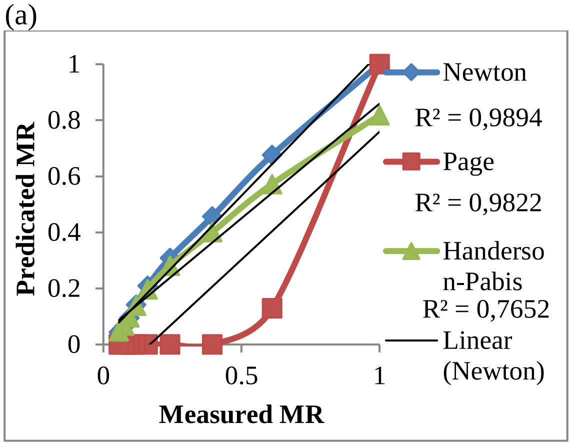
Comparison of Models on The Best Drying

Evaluation of the various equations of the kinetic model is carried out using the data available in practice to see how accurate the drying rate predictions. The prediction of the drying rate is calculated using an equation that has determined the kinetic constant for each model. The following is a comparison graph of the drying rate prediction with the actual data on each kinetic model [29].

Figure 7a shows the predicted results of the outdoor drying rate of ginger in various models compared to the actual data. The regression equation obtained above is an equation that shows the functional relationship between the dependent variable (Y) and the independent variable (X). The higher the correlation coefficient value between the two variables (the closer to 1), the higher the level of closeness of the relationship between the two variables. Figure 7a shows the accuracy of various models in predicting the value of ginger's drying rate, which is depicted in the proximity of the predictive data on the y = x line.

Based on Figure 7a, it is found that the prediction of the drying rate of ginger in the Newton, Page, and Henderson-Pabis models are equally acceptable because their values are almost close to the actual data. The best kinetic model whose predictions are closest to the actual data is Newton's model with a predicted value of 0.9894. The predicted value is close to the actual data with 98% accuracy. Based on this comparison, the best equation model for estimating the drying rate is the Newton model. Based on Figure 7a, it can also be concluded that all the equation models are suitable for predicting the drying rate of ginger [29].

(a)



(b)

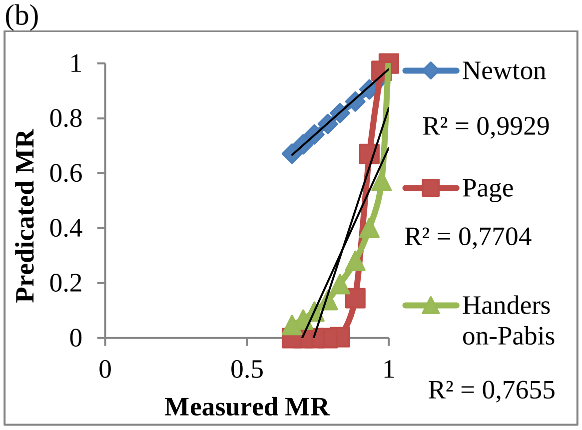
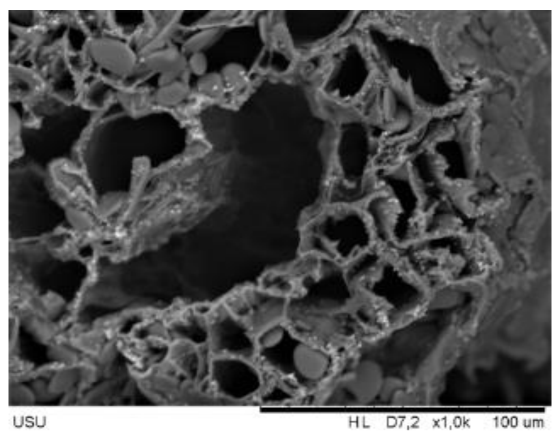


Fig. 7. (a) Comparison of Actual Data with Predicted Drying Rates of Ginger Outdoors on Various Equations of Kinetic Models, (b) Comparison of Actual Data with Predicted Drying Rates of Ginger Indoors on Various Equations of Kinetic Models

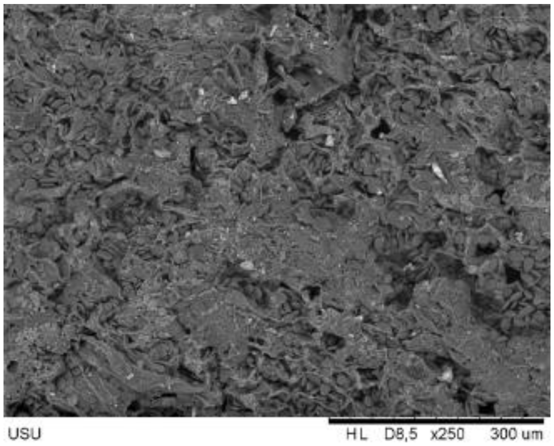
Based on Figure 7b, it is found that the predicted drying rate of ginger in the Newton, Page, and Henderson-Pabis models are equally acceptable because their values are almost close to the actual data. The best kinetic model whose predictions are closest to the actual data is Newton's model with a predicted value of 0.9929. The predicted value is close to the actual data with 99% accuracy. Based on this comparison, the best equation model for estimating the drying rate of ginger is the Newton model. Based on Figure 7b, it can also be concluded that all equation models are suitable for predicting the drying rate of ginger [29].

Drying Characteristics

The results of the SEM characteristics of ginger samples can be seen in the image above. Figure 8 shows the surface of ginger before and after drying. Before drying, the surface of the ginger appears to be hollow filled with water and after drying, the cavities of ginger which previously filled with water become interconnected so that the outer surface of the ginger will shrivel inward and experience a reduction in surface area. The shrinkage of the dried material has a negative impact on the quality of the dry product.



(a)



(b)

Fig. 8. (a) Before drying (b) After drying

Other changes that occur during drying are changes in the physical appearance of the product such as color, texture, and aroma. One of the important physical changes during drying is the reduction in the volume of the material. Loss of water and heating causes the cell structure of the material to experience stress followed by changes in shape and size reduction [30].

Conclusion

The results of the research can be concluded among others:

During pandemic covid 19, the research from home was possible to apply for natural drying study.

On the first day of drying, there was significant drying, this was because the water that evaporated on the first day was free water which tends to evaporate easily on the first drying.

From the research conducted, it was found that the larger the size and thickness of the sample, the longer the drying time needed because the different components of material size and time make a difference in the drying kinetics for each sample.

The best kinetic model for the natural drying rate of ginger outdoors is the Newton model with a predictive value of 0.9894 and the best kinetic model for the natural drying rate of ginger indoors is the Newton model with a predictive value of 0.9929.

References

[1] A. K. Verma and S. Prakash, "Impact of Covid19 on environment & society," J. Glob. Biosci., vol. 09, no. 5, pp. 7352–7363, 2020.

[2] J. Singh and J. Singh, "D. COVID Impact on Society," Electron. Res. J. Soc. Sci. Humanit., vol. 2, no. I, pp. 168–172, 2020.

[3] S. Kalogiannidis, "Covid Impact on Small Business," Int. J. Soc. Sci. Econ. Invent., vol. 6, no. 12, 2020, doi: 10.23958/ijssei/vol06-i12/257.

[4] A. Pragholapati, "Covid-19 Impact on Students," pp. 1–6, 2020, doi: 10.35542/osf.io/895ed.

[5] L. Harper et al., "The impact of COVID-19 on research," J. Pediatr. Urol., vol. 16, no. 5, pp. 715–716, 2020, doi: 10.1016/j.jpurol.2020.07.002.

[6] B. Haryanto, T. R. F. Sinuhaji, E. A. Tarigan, M. B. Tarigan, and N. A. B. Sitepu, "Sun energy on natural drying of cucumber and radish," IOP Conf. Ser. Earth Environ. Sci., vol. 782, no. 2, 2021, doi: 10.1088/1755-1315/782/2/022051.

[7] B. Haryanto, T. R. F. Sinuhaji, E. A. Tarigan, M. B. Tarigan, and N. A. B. Sitepu, "Simulation of natural drying kinetics of carrot (Daucus carota L) on thickness variation," IOP Conf. Ser. Earth Environ. Sci., vol. 782, no. 3, pp. 0–7, 2021, doi: 10.1088/1755-1315/782/3/032086.

[8] B. Haryanto, M. B. Tarigan, T. R. F. Sinuhaji, E. A. Tarigan, and N. A. B. Sitepu, "Drying kinetics on mass reduction with natural operation of potatoes as simulation model," IOP Conf. Ser. Earth Environ. Sci., vol. 912, no. 1, pp. 0–6, 2021, doi: 10.1088/1755-1315/912/1/012067.

[9] B. Haryanto, M. B. Tarigan, N. A. Br Sitepu, and R. B. Bukit, "Stay Home Practical: Simulation Model on Ginger As the Samples on Dryer Naturally Operation Module," IOP Conf. Ser. Mater. Sci. Eng., vol. 1003, no. 1, pp. 0–6, 2020, doi: 10.1088/1757-899X/1003/1/012137.

[10] T. S. Mastuti and A. F. Setiawanto,

"Characteristic of Red Ginger Jelly Stick with Variation Type of Gelling Agent," Proc. 6th Int. Conf. Food, Agric. Nat. Resour. (IC-FANRES 2021), vol. 16, pp. 199–207, 2022, doi: 10.2991/absr.k.220101.026.
[11] D. A. Mujiyanti, Dwi Rasy; Nisa, Hayatun; Rosyidah, kholifatu; Ariyani, "Indonesian Journal of Chemical Research," Indones. J. Chem. Res., vol. 8, no. 2, pp. 151–158, 2020, doi: 10.30598//ijcr.
[12] Y. Prasetyo, A. Zainudin, and M. Muhidin, "No Title," J. Trop. Crop Sci. Technol., vol. 2, no. 1, pp. 31–40, 2020, [Online]. Available: https://ejournal.umm.ac.id/index.php/jtcst/article/view/13913.
[13] F. D. Prasetyo, N. I. Muztahidin, A. A. Fatmawaty, A. Laila, and M. Nurfadilah, "Analysis of the diversity of local ginger (Zingiber officinale Rosc.) in Pandeglang Regency, Banten Province based on morphological characteristics," IOP Conf. Ser. Earth Environ. Sci., vol. 978, no. 1, 2022, doi: 10.1088/1755-1315/978/1/012025.
[14] Ida Bagus Alit and I Gede Bawa Susana, "Evaluate the thermal performance of the dryer using a perforated wall furnace-heat exchanger for drying," World J. Adv. Eng. Technol. Sci., vol. 2, no. 2, pp. 084–090, 2021, doi: 10.30574/wjaets.2021.2.2.0044.
[15] S. Imtiyaz, K. Rahman, A. Sultana, M. Tariq, and S. S. Chaudhary, "Zingiber officinale Rosc.: A traditional herb with medicinal properties," Tang [Humanitas Med., vol. 3, no. 4, pp. 26.1-26.7, 2013, doi: 10.5667/tang.2013.0009.
[16] I. B. Alit, I. G. B. Susana, and I. M. Mara, "Utilization of rice husk biomass in the conventional corn dryer based on the heat exchanger pipes diameter," Case Stud. Therm. Eng., vol. 22, no. June, p. 100764, 2020, doi: 10.1016/j.csite.2020.100764.
[17] R. H. Wafa, T. W. Agustini, and A. S. Fahmi, "Drying Kinetics and Study of Physical Characteristic Using Image Analysis of Dried Salted Striped Catfish (Pangasius hypophthalmus)," IOP Conf. Ser. Earth Environ. Sci., vol. 750, no. 1, 2021, doi: 10.1088/1755-1315/750/1/012045.
[18] W. L. Kerr, "Chapter 12 - Food Drying and Evaporation Processing Operations," in Handbook of Farm, Dairy and Food Machinery Engineering (Second Edition), Second Edition., M. Kutz, Ed. San Diego: Academic Press, 2013, pp. 317–354.
[19] S. Suherman, E. E. Susanto, A. Firdauzi, and N. Wuryaningtyas, "Solar dryer applications for cassava slices drying," AIP Conf. Proc., vol. 2197, no. January, 2020, doi: 10.1063/1.5140947.
[20] Z. L. Liu et al., "Moisturizing strategy for enhanced convective drying of mushroom slices," Renew. Energy, vol. 172, pp. 728–739, 2021, doi: 10.1016/j.renene.2021.03.066.
[21] C. Rekik et al., "Study of interval infrared Airflow Drying: A case study of butternut (Cucurbita moschata)," Lwt, vol. 147, no. January, p. 111486, 2021, doi: 10.1016/j.lwt.2021.111486.
[22] M. Djaeni, I. Bernadi, M. P. Wijayanti, and F. D. Utari, "Drying rate of onion (Allium cepa L.) drying using air dehumidification with silica gel," AIP Conf. Proc., vol. 2197, no. January, 2020, doi: 10.1063/1.5140911.
[23] M. Starowicz and H. Zieliński, "How Maillard Reaction Influences Sensorial Properties (Color, Flavor and Texture) of Food Products?," Food Rev. Int., vol. 35, no. 8, pp. 707–725, 2019, doi: 10.1080/87559129.2019.1600538.
[24] N. Wulandari, M. P. Koentjoro, Isdiantoni, I. Ekawati, and E. N. Prasetyo, "The effect of washing methods on hygienic and quality level of industrial Moringa oleifera leaves," AIP Conf. Proc., vol. 2215, no. April, 2020, doi: 10.1063/5.0000695.
[25] D. Nurba, M. Yasar, Mustaqimah, R. Fadhil, S. P. Sari, and C. V. Mysa, "Performance of Corncobs and Wood Charcoal Briquette as Heat Energy Sources in In-Store Dryer," IOP Conf. Ser. Earth Environ. Sci., vol. 365, no. 1, pp. 0–9, 2019, doi: 10.1088/1755-1315/365/1/012048.
[26] B. Yu et al., "Water-heat balance characteristics of the sewage sludge bio-drying process in a full-scale bio-drying plant with circulated air," Waste Manag., vol. 141, no. September 2021, pp. 220–230,

2022, doi: 10.1016/j.wasman.2022.01.041.
[27] S. Parthasarathi and C. Anandharamakrishnan, “Modeling of shrinkage, rehydration and textural changes for food structural analysis: A review,” J. Food Process Eng., vol. 37, no. 2, pp. 199–210, 2014, doi: 10.1111/jfpe.12073.
[28] A. Sałata, S. Lombardo, G. Pandino, G. Mauromicale, H. Buczkowska, and R. Nurzyńska-Wierdak, “Biomass yield and polyphenol compounds profile in globe artichoke as affected by irrigation frequency and drying temperature,” Ind. Crops Prod., vol. 176, no. December 2021, 2022, doi: 10.1016/j.indcrop.2021.114375.
[29] H. S. EL-Mesery, A. I. EL-Seesy, Z. Hu, and Y. Li, “Recent developments in solar drying technology of food and agricultural products: A review,” Renew. Sustain. Energy Rev., vol. 157, no. December 2021, p. 112070, 2022, doi: 10.1016/j.rser.2021.112070.
[30] A. Zaccaron, V. de Souza Nandi, and A. M. Bernardin, “Fast drying for the manufacturing of clay ceramics using natural clays,” J. Build. Eng., vol. 33, no. April 2020, p. 101877, 2021, doi: 10.1016/j.jobe.2020.101877.