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Effect of Drying Temperature on Quality of Dried Red Ginger (*Zingiber Officinale* Var. Rubrum)

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ABSTRACT

Red ginger is a source of herbal medicines that contain phenolic compounds. The advantage of red ginger as an herbal medicine requires proper handling and treatment so that the phenolic compounds in red ginger are not damaged. Drying is the right method for obtaining red ginger extract. The aims of this study were to investigate the effect of temperature on the proximate composition of dried red ginger and to investigate the suitable temperature for drying red ginger. Red ginger drying was carried out at various temperatures (40, 50, and 60 °C). The simplicia of red ginger was then mashed and sieved. Measurement of the quality of the simplicia included yield, moisture content, ash content, fat content, protein content, crude fiber content, and carbohydrate content. Dried red ginger was observed that all parameters examined were affected by drying at various temperatures except for ash content. The result of drying temperature at 50 °C showed a better quality of dried red ginger based on yield (17,64%), moisture content (6,88%), protein content (1,80%), and crude fiber content (1,86%).

1. INTRODUCTION

Red ginger is a rhizome commodity that can be found in Indonesia. Generally, red ginger is consumed in a fresh form as a complementary seasoning for cooking, mixed drinks, and as flavouring for sweets and snacks. In traditional markets, rhizomes are usually sold in fresh form. Rhizome plants are often used as an alternative medicine and herbalisme.

Red ginger is a rhizome plant that is one of the sources of raw materials for herbal medicinal plants. According to BPS 2018, red ginger is a biopharmaceutical plant that has the highest demand than other rhizome plants. High productivity of red ginger makes it potential to be developed. There are several biopharmaceutical industries that use red ginger as the main raw material for medicine and food supplement. That is because red ginger contains compounds that are good for the body.

The chemical compounds contained in ginger are volatile oil and non-volatile oil. The phenolic compounds found in red ginger are gingerol, shogaol, and paradol. In fresh ginger, the most phenolic compounds are the types of gingerols consisting of 6-gingerol, 8-gingerol, and 10-gingerol (Stoner, 2013). The active phenolic compounds in red ginger have antioxidant, anti-inflammatory, antibacterial, and antiplatelet properties. Gingerol compounds in ginger can be used as a sedative, analgesic, and antibacterial in vivo and in vitro (Connel & Sutherland, 1969). Shogaol contained in ginger has antifouling (Etoh *et al.* 2002). Phenolic compounds of red ginger are also trusted as immunomodulators to increase body endurance (Lestari *et al.* 2020; Untari *et al.* 2015).

This current pandemic situation forces people to consume food supplements to support their immune systems to prevent viruses and diseases. Red ginger is one of the herbal medicines that are suitable for consumption to increase the body's immune system. The utilization of red ginger as herbal raw material requires proper handling and treatment to keep its phenolic compounds. The proper handling of red ginger as a medicinal material is drying process.

Drying is one of the conventional methods used to preserve food due to its low cost. Different drying methods and temperatures generate different mineral and proximate compositions, phytochemical properties, and sensory qualities of foods. Several researchers have studied this comprehensively, namely Paramanandam *et al.* (2021), Alakali *et al.* (2015), Sun *et al.* (2015), and Yuan *et al.* (2015) on different drying methods. There are some studies that have also been conducted on medicinal plants which show that temperature can affect the proximate and mineral content. This study was conducted extensively by Ogundeleolusola *et al.* (2019), Ajagun *et al.* (2017), and Alakali *et al.* (2015). In the food drying process, drying method and drying temperature are key factors for preservation of the product's quality. However, there are few studies focused on discovering the optimal drying temperature applied in the same drying method that allows both the gain of a high-quality powdered red ginger and also the patronage of bioactive compounds with maximum beneficial properties.

Due to the increasing consumption of red ginger in Indonesia, it can be used as immune support and in the food and pharmaceutical industries. It is necessary to use the right drying temperature and not harm the proximate composition of red ginger powder. Drying red ginger can also be used to improve its quality and shelf life of red ginger. Therefore, this study was conducted to determine the proximate content of red ginger rhizome at different drying temperatures.

2. MATERIALS AND METHODS

2.1. Material

The rhizome of fresh red ginger were obtained from local farmers in Leuwiliang, Bogor, West Java, Indonesia. The diameter of fresh red ginger were 2-3 cm. After cleaning and washed, the red ginger was sliced into pieces of 2 mm thickness. Standard oven drying method (AOAC, 1995) was used for the approximation of moisture content and was found to be in the range of 87-88%. The sliced red ginger samples were dried at several drying temperatures. The dried samples were milled with a grinder into powder and stored in desiccators until required for analysis.

2.2. Sample Preparation

Fresh red ginger rhizomes were cleaned with tap water for removing impurities. After cleaning, the red ginger is washed and drained. The red ginger rhizomes then sorted to separate between fresh and rotten red ginger. After sorting, the red ginger is then sliced lengthwise with 2 mm of thickness. The red ginger slices were arranged in layers on racks and dried using a rotary oven dryer at drying temperatures of 40, 50, and 60 ° C. The red ginger simplicia was then ground using a grinder.

2.3. Proximate Analysis

The proximate analysis was carried out on the rhizome dried at various temperatures which are 40, 50, and 60 °C. Proximate composition of sample was decided using AOAC method. Proximate analysis of red ginger simplicia included water content, ash content, fat content, protein content, crude fiber content, and carbohydrate content.

2.3.1. Determination of Moisture Content

Sample of powdered red ginger of about 5 g was weighed into an aluminium crucible. The sample was heated for 5 hours in an oven at 105 °C. After removing from the oven the crucible was cooled down in a desiccator room temperature and re-weighed. The percentage of moisture content based on wet basis (MC_{wb}) was calculated according to Equation (1).

$$MC_{wb} = \frac{(m_1 - m_2)}{m_1} \times 100\% \tag{1}$$

where m_1 is the weight of the initial sample (before drying), and m_2 is the weight of the final sample (after drying)

2.3.2. Determination of Ash Content

Sample of powdered red ginger was weighed about 5 g in a tared ceramic crucible. The ceramic crucible was heated at about 550 °C in a furnace and maintained the temperature for about 2 hours or until white ash were obtained. The muffle burner was then shut off and allowed to cool down before being opened. Using safety tongs, the ceramic crucible was swiftly moved into a desiccator that contained a porcelain dish and desiccant, allow it to cool down. The crucible was weighed again. The percentage of ash content was calculated using Equation (2).

$$AC = \frac{W_o - W_c}{W_f - W_c} \times 100\% \tag{2}$$

where AC is the ash content of the sample (%), W_f is the weight of the cup and the initial sample (g), W_o is the weight of the cup and the final sample, and W_c is the weight of the empty cup (g).

2.3.3. Determination of Fat Content

Sample of powdered red ginger was weighed about 10 g in a dry extraction thimble and heated at 100 °C for 6-18 h. The thimble containing dry sample was put in a fat beaker. An amount of 150 ml hexane was added into the fat beaker and extraction was controlled at a rate of 5 or 6 drops per second for about 4 h. Removed the flask and the solvent was evaporated by heating. The boiling beaker with the extracted fat was dried for two hours at 100 °C in an air oven, then cooled in a desiccator and weighed. The percentage of fat content was calculated using Equation (3).

$$AC = \frac{W_o - W_c}{W_f - W_c} \times 100\% \tag{3}$$

where FC is the fat content of the sample (%), W0 is the weight of receptacle before extracted (g), W1 is the weight of receptacle after has been extracted (g), and S is the quantity of the initial sample (g).

2.3.4. Determination of Protein Content

The protein content of powdered red ginger was determined using the Kjeldahl method. Sample of 100 mg was placed into a Kjedhal flask. Sequentially, 2,5 gram SeO_2, 100 g K_2SO_4, and 20 g $CuSO_4.5H_2O$, one or two selenized boiling granules and 10 ml of concentrated H_2SO_4 were added to the flask. The solution were digested until its almost colorless greenish. The distillation stage, cautiously added a little amount water through the flask and shaken carefully to prevent solidification and let it cooled down. Then, followed by adding 150 ml distilled water and 50 ml of 40% NaOH slowly down the side of the Kjeldhal flask to form the layer underneath the digestion mixture. Immediately, distilled the solution for 10 minutes and thoroughly mix the contents. Erlenmeyer flask was placed under the condenser with 10 of 2% borate solution end of the condenser must be soaked in borate solution. During the titration step, the sample solution was diluted and titrated with 0,01 N standardized HCl until a gray color appeared. With standardized acid that is proportional to the quantity of nitrogen, the borate anions produced in the previous step were titrated. Using Equation (4), the protein content was determined.

$$PC = \frac{(V_1 - V_2) \times N \times 0{,}014 \times fc \times fd}{W} \times 100\% \tag{4}$$

where PC is the protein content of the sample (%), V1 is the volume of HCl used in titrating the sample (ml), V2 is the volume of HCl used in titrating the blanc (ml), N is the normality of HCl, fc is the convertion factor for protein, and fd is the dilution factor, and W is the weight of the initial sample (g).

2.3.5. Determination of the Crude Fiber Content

Sample of powdered red ginger weighed 2-4 grams and released the fat by Soxhletation method. The sample was added 50 ml of H_2SO_4 1,25% and then boiled for 30 minutes. Then added 50 ml NaOH 3,25% to boil it again for another 30 minutes. Filtered the solution with Whattman 541 while the solution was still hot. The filtrate was washed squencelly with hot H_2SO_4 1,25%, hot water, and ethanol 96%. The sample and filter paper was placed into an aluminum crucible, then dried in the oven at 105 °C. Cooled down the sample and stored it in desiccator. Weighed the sample repeatedly until reached a constant weight. The percentage of crude fiber content was calculated using Equation (5).

$$CFC = (W_i - W_a) \times 100\% \tag{5}$$

where *CFC* is the crude fiber content of the sample (%), W_i is the weight of the intial sample (g), and W_a is the weight of the ash sample (g).

2.3.6. Determination of Carbohydrate Levels

The calculation of carbohydrate (Carb) content used the "by difference" method as in Equation (6).

$$\text{Carb (\%)} = 100\% - [\text{protein (\%)} + \text{water (\%)} + \text{ash (\%)} + \text{fat (\%)}] \quad (6)$$

3. RESULT AND DISCUSSION

3.1. Drying Time and Yield

Drying of red ginger rhizome was carried out at various temperatures which are 40, 50, and 60 °C. The samples were dried until the sample weight was constant to become red ginger simplicia (Figure 1). Low temperature for drying was used to prevent degradation of red ginger compound. Based on the results of the research, the drying temperature had a significant effect on the yield of red ginger. The results of yield showed at 50 °C was the highest yield at 17,64%, while the yield at 40 °C and 60 °C respectively were 11,55% and 16,84%. The results of the yield was shown in Table 1.

Table 1. Effect of drying temperature on proximate composition of dried red ginger

Proximate Composition	Drying Temperature		
	40 °C	50 °C	60 °C
Moisture Content, %	5,92±0,34b	6,88±0,07a	6,73±0,08a
Ash Content, %	6,79±0,03a	6,81±0,68a	6,38±0,04a
Fat Content, %	0,19±0.03b	0,24±0,02a	0,28±0,08a
Protein Content, %	1,42±0,09b	1,80±0,17a	1,17±0,02c
Crude Fiber Content, %	2,48±0,09b	1,86±0,10a	2,86±0,07c
Carbohydrate content, %	85,67±0,22a	84,27±0,68b	85,49±0,14a
Yield, %	11,55±0,03c	17,64±0,03a	16,84±0,04b

The values presented are the means ± standard deviation of three measurements (*n* = 3). Different superscript letters indicate significant differences of drying temperatures at p < 0,05.

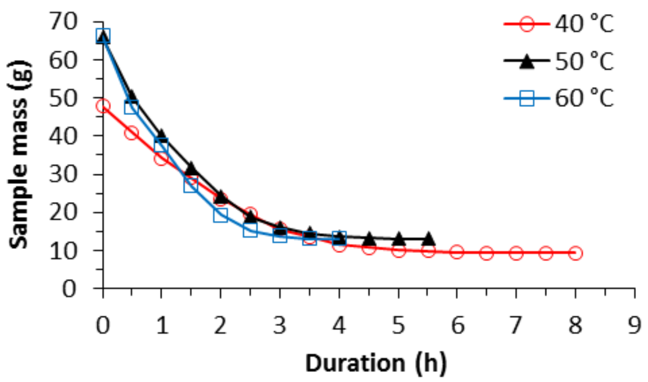

Figure 1. Graph of weight loss of red ginger during the drying process

Yield of powdered red ginger is the percentage of the weight of fresh red ginger and the weight of red ginger after drying. Yield was influenced by the temperature and drying duration. Product lost during the production process can also be seen from the yield produced (Priastuti *et al.*, 2016). Drying temperature and duration also affected the moisture content of powdered red ginger. According to Andriani *et al.* (2013), the amount of yield obtained was influenced by the moisture content. The lower moisture content of powdered red ginger caused a decrease in its yield of it. Higher drying temperature can be caused the water contained in fresh red ginger to evaporate even more so that the resulting yield decreases. This is in line with research conducted by Martunis (2012), the higher the temperature used, the lower the yield produced. The drying duration at 40 °C is longer than at 50 and 60 °C. It is presumed that was affected the moisture content and yield of powdered red ginger.

3.2. Dried Red Ginger Quality

Proximate analysis of food ingredients was usually carried out to quantitatively determine the components of a fresh or processed food ingredient. Drying red ginger at a certain temperature can affect the composition and content of nutrients in it. Drying red ginger at high temperatures causes denaturation or decomposition of nutrients or phenolic compounds in red ginger. Drying red ginger can extend shelf life and inhibit the growth of microorganisms. The result of the proximate composition of dried red ginger was shown in Table 1.

3.3. Moisture Content

Moisture content was one of the fundamental parameters of drying. The moisture content of fresh red ginger was relatively high which led to a shorter shelf life due to microbial decay (Dashak *et al.*, 2001). Based on the result of this study, drying temperature had a significant impact on the moister content of drying red ginger. The lowest moisture content of dried red ginger was found at 40 °C which was 5,92%.

According to SNI, the maximum value of moisture content of dried red ginger was 12%. As presented in Table 1, the moisture content of dried red ginger at 40, 50, and 60 °C respectively were 5,92%, 6,88%, and 6,73%. Statistically, moisture content of dried red ginger in this study was still under the SNI standard. Moisture content at 40 ° C was the lowest compared to 50 °C and 60 °C. Higher drying temperature has not affected the value of moisture content of dried red ginger. This statement is in agreement with Mahayothee *et al.* (2020), who reported moisture content was not significantly variant at various temperatures and several drying methods such as hot air drying method, greenhouse solar dryer, and drying in the sun. Ghafoor *et al.* (2020) declared the percentage of dried red ginger moisture content was not significantly different at 50 °C and 60 °C with an oven and a microwave oven.

3.4. Ash content

Ash content in red ginger was an indication of its mineral content. Ash content was a residual of inorganic material that was obtained through the combustion process at high temperatures. The total amount of ash content was associated with mineral content of a product. Beneficial of ash content measurement was to control the number of contamination, soil, and sand that were often included in the product while harvesting. The amount of ash content was also affected by several matters such as type of product, combustion procedure, and the duration and temperature used for combustion. The average food ingredient contains 96% organic matter and water. In this test, at least dry red ginger contains 94% organic compounds and water. The longer it takes to dry red ginger, the higher the ash content would be. The allowed ash content for red ginger simplicia is not more than 8% according to SNI.

Drying red ginger using a rotary oven at temperatures of 40, 50, and 60 °C resulted in good water content because it was still below the threshold (Table 1). The ash content parameter in red ginger drying showed a percentage that was not significantly different at each drying temperature. Drying at 50 °C showed ash content which tended to be higher than at 40 °C and 60 °C with a value of 6,81%. This is in line with research conducted by Ajagun *et al.* (2017) drying red ginger using temperatures of 40, 50, and 60 °C obtained ash content that was not significantly different, each of which was 6,76%; 6,85%; and 6,77%. Likewise, with the research conducted by Otunola *et al.* (2010), the ash content of red ginger which was dried at 60 °C was 6,30%.

3.5. Fat Content

Based on the data of this research showed that the higher temperature used for drying, the fat content in dried red ginger would increase. Examination of fat content is needed to determine the number of calories in red ginger thus it can be used as a reference for the manufacture of medicines with the basic ingredients of red ginger. Sarkar *et al.* (2021) reported that fat content in food affected its taste, organic volatiles, and microbial contamination. Based on SNI, the maximum fat content quality requirement for dried red ginger is 2%.

In contrast to moisture content, decreasing fat content was directionally proportional to drying temperature. The higher the drying temperature, the higher the fat content of dried red ginger. This is related to the increase in total solids in ginger powder with increasing drying temperature. The data of the fat content of this research was shown in Table 1. The results showed that the drying temperature had no significant effect on the fat content of dried red ginger. The fat content of dried red ginger at 40, 50, and 60 °C respectively were 0,19%, 0,24%, and 0,28%. This was in line with the research conducted by Ajagun *et al.* (2017) at drying temperatures of 40, 50, and 60 °C, the results of fat content were not significantly different. Sarkar *et al.* (2021) also researched drying red ginger with several methods, namely the sun drying method, oven drying, mechanical drying, and shade drying. The data showed results that were not significantly different in fat content examination. In other studies, Shirin-Adel & Prakash (2010) and Odebumi *et al.* (2010) reported that the fat content of ginger simplicia dried at 40 °C was 3,72% and 5,62%, respectively, while Sangwan *et al.* (2014) obtained a lower fat content of 0,78% at a drying temperature of 50 °C.

3.6. Protein content

The protein content was an important component to determine the nutritional content of food materials. Determination of protein content was the key for analytical measurements and were widely used in the processing and qualification of food samples. According to Odebunmi *et al.* (2010) and Mohamad *et al.* (2020) spices has a low crude protein content. In drying process, Decreasing in protein content was most likely caused by denaturation and changes in its molecular and structural characteristics of it. Drying at high temperatures can be caused proteins to bind with water and get insoluble to water (Cherrat *et al.*, 2019).

Based on the results of the study showed that the drying temperature was significantly different from the protein content of red ginger (Table 1). The highest protein content of dried red ginger was found at 50 °C which was 1,80%, while the protein content at 40 °C and 60 °C were 1,42% and 1,17%, respectively. Alterations in protein percentage in dried red ginger were in line with moisture content percentage. Hydrogen bonds and non-polar hydrophobic interactions would be damaged if exposed to heat so that the material would lose its structure and moisture. According to this research results showed that the highest protein content was obtained at 50 °C with moisture content was 1,80% on dried red ginger. Based on this statement it can be concluded that the consumption of dried red ginger is not a good substitute food for the recommended daily protein needs.

3.7. Crude Fiber Content

The crude fiber in food analysis was a combustible residue of carbohydrate, fat, and protein residues. Crude fiber was a carbohydrate residue that cannot be hydrolyzed by acids or alkalis. Crude fiber was used as a differentiator to distinguish the type of fiber. This residue consists mostly of cellulose lignin fiber and a small part of hemicellulose and a part of carbohydrates that cannot be assimilated and cannot be digested by humans. This component has a low nutritional value but provides most of what was needed for peristalsis in the digestive tract.

Based on the results of the research, the drying temperature significantly affected the crude fiber content of dried red ginger. The results of the crude fiber content data can be seen in Table 1. The lowest crude fiber content was found at 50 °C, which was 1,86%, while the crude fiber content at 40 °C and 60 °C were respectively 2,48% and 2,86%. The crude fiber content of red ginger powder in this study was relatively low. The low levels of crude fiber obtained in the study would not pose a danger to consumption because the fiber content usually was not consumed separately and as an addition or additive to other food preparations. The low crude fiber content serves as an addition to the total dietary fiber of a processed product. This was in line with the research of Otunola *et al.* (2010) drying some spices would produce low crude fiber and can be used as additional fiber in preserved and processed foods. According to research conducted by Akshitha *et al.* (2020), the crude fiber content of commercial dried ginger varied from 1,5% to 6,0%.

The crude fiber content in red ginger powder has different percentages depending on the type, variety, and drying method. In a study conducted by Sarkar *et al.* (2021), the examination of crude fiber content was carried out in powdered red ginger which was dried by several methods, such as mechanical drying, oven, drying in the shade, and drying in direct sun. In the research of Sarkar *et al.* (2021) drying using a mechanical dryer produces the highest crude fiber content and the lowest crude fiber content was obtained in drying with the oven method. It is believed that the crude fiber content of dry red ginger in the research conducted was relatively low because it used oven drying. In a study conducted by Akter *et al.* (2020), crude fiber content using the oven method was the lowest level compared to other red ginger drying methods significantly.

3.8. Carbohydrate Levels

Based on the results of the research, the drying temperature significantly affected the carbohydrate content of red ginger (Table 1). The highest carbohydrate content was found in drying red ginger at 40 °C, which was 85,69%, while the carbohydrate content at 50 °C and 60 °C respectively were 84,53% and 85,46%. High carbohydrate content indicates that powdered red ginger can accumulate sugar content for consumption, but this carbohydrate content cannot be used as a source of carbohydrates if it were compared to primary carbohydrate sources such as tubers.

In the proximate test of powdered red ginger, the carbohydrate content was the highest of all parameters. That was believed that consuming red ginger can add energy to the body. Verenzia *et al.* (2022) reported that the higher carbohydrate content in powdered red ginger would produce a greater energy level. That explained the consumption of red ginger can increase energy for the body (Verenzia *et al.*, 2022).

4. CONCLUSION

Drying red ginger at 40, 50, and 60 °C does not negatively affect its proximate composition of red ginger. Lower temperature and brief drying are recommended to maintain mineral compound of red ginger and to prevent degradation of compound. Hence, rapid reduction in moisture content of red ginger is recommended during drying to enhance its quality and shelf life.

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