Anjoro: International Journal of Agriculture and Business
Vol. 3 Issue 2, September 2022
p-ISSN: 2721-8678 | e-ISSN: 2721-7914. **DOI: 10.31605/anjoro.v3i2.1672**

Effect of temperature and drying time on physicochemical of beetroot (*Beta vulgaris* L. *var. Rubra* L.) flour

Ulya Sarofa* and Rina Aprilia

Department of Food Technology, Faculty of Engineering, University of Pembangunan Nasional Veteran Jawa Timur, Gunung Anyar, Surabaya, Indonesia

**Corresponding author's e-mail: sarofaulya@yahoo.co.id*

Received June 12th, 2022; revised August 14th, 2022; accepted September 8th, 2022

ABSTRACT

Beetroot is a food source that is rich in nutrient value, including carbohydrates, minerals, vitamin C and betalains as a source of antioxidants. The high-water content causes the beetroot to be easily damaged, therefore a suitable method, is needed to preserve it. Like being processed into intermediate goods such as flour. The aim of this research was to determine the effect of temperature and drying time on the chemical characteristics and color of beetroot flour. This research used a completely randomized design (CRD) in factorial with two factors, namely the drying temperature range (50 °C, 60 °C, and 70 °C) and the drying time range (6, 7, and 8 hours). ANOVA and DMRT advanced test were used to test the resulting data. The results showed that the best treatment was obtained from sample treated a drying temperature of 50°C and a drying time of 6 hours, the yield value was 13.53%, with water content of 12.61%, ash 2.65%, fat 0.73%, protein 11, 16%, carbohydrate 72.85%, antioxidant activity 69.80%, anthocyanin 69.81 mg.100 g^{-1}, Vitamin C 31.92 mg.100 g^{-1}, color intensity L 15,825, a* 7.82, b* 2.78.*

Keywords:
Beetroot, Temperature, Time, Drying, Flour

1. Introduction

Beets are root crops which has multiple benefits, both as a food ingredient with high nutritional value and also has medicinal properties. This tuber is believed to be a source of health from the various nutritional content it has, namely vitamins, antioxidants, and carbohydrates. The red pigment named betalains in beetroot is a nitrogen compound that has high antioxidant activity and is water soluble, but this compound is susceptible to degradation due to the influence of pH, light, air, and it was stable at low temperatures (< 14 ºC), dark conditions and in the pH range. 5.6 [1]. Beetroot has a fairly high-water content, and a large volume that causes it to be easily damaged during post-harvest and delivery process due to poor transportation, so it needs to be processed into a product that is more durable and practical, such as flour. Processing beetroot into flour will extend the shelf life, and provide added value to the beetroot itself, so that it can be applied more widely to various types of products.

The most important step in the manufacture of beetroot flour is to determine the quality of the flour during drying process. The drying treatment aims to reduce the water content to a certain extent so that it can inhibit enzyme activity and microbial growth that can cause damage to food ingredients. The principle of the drying process is the process of heat transfer and water diffusion from the material being dried [2]. The drying process affects the changes in physical properties such as shape and color, chemical properties, and the content of nutrition so that the quality is reduced. In the drying process, the food will lose its water content and cause the concentration of the remaining ingredients, such as carbohydrates, fats, and proteins so that they will be present in greater amounts per unit weight of dry matter compared to the fresh form. The decrease in the number of components, especially in some vitamins, especially those that lost during washing through leaching processing and heat unstable characteristic, will decrease during the drying treatment The longer the drying time and the higher the drying temperature, the more pigment changes [3]. There are two basic factors that affecting the drying process efficiency, namely factors related to drying air such as temperature, drying air flow velocity, and air humidity, while factors related to the material being dried are initial moisture content, material size and partial pressure used [4].

Based on several previous studies, this research focuses on the relationship between drying time and temperature on the quality of beetroot flour. In this study, the drying of beetroots used temperatures of 50 °C, 60 °C, and 70 °C for 6, 7, and 8 hours. Temperature and drying time in this study are two factors that affect product quality.

2. Materials and Methods

2.1. Materials

The materials used in this method was beetroot obtained from traditional market in Surabaya. The chemicals used were Amylum, Iodine, H_2SO_4, Na_2SO_4-HgO, PP indicator, NaOH, DPPH, Petroleum ether, acetone 80% obtained from Merck KGaA, Darmstadt, Germany. The equipment used in this research included: cabinet dryer, waring blender, 80 mesh-sieve, oven, furnace, analytical balance, and spectrophotometer UV-vis.

2.2. Methods

Preparation of materials include the preparation of beetroot flour that was: sorting the material (beetroot), blanching at 90 °C, 5 minutes. grating to 5 mm thickness, then drying in a cabinet dryer at the 50 °C, 60 °C, 70 °C for 6, 7, and 8 hours, then grinding and sieving through the 80-mesh sieve. The beetroot flour produced then was analysis includes of yield [5], color [6], chemical analysis (water, ash, protein, fat, carbohydrate by difference), vitamin C [7], anthocyanin content [8], antioxidant activity [9].

This research used a Complete Randomized Design factorial pattern with 2 factors and 3 repetitions. The data was processed using ANOVA 5% and further tested by DMRT 5%. To determine the best treatment based on all parameters, used effectiveness index [10].

3. Results and Discussion

3.1. Chemical Characteristics of Beetroot Flour

Based on statistical analysis result, there was significant interaction ($p \leq 0.05$) between temperature and drying time in all parameters. Table 1 showed the result of effect temperature and drying time in yield and chemical analysis of beetroot flour. Table 2 showed the result of effect temperature and drying time in antioxidant activity, anthocyanin content and Vitamin C content of beetroot flour.

Table 1. The mean value ± std. deviation of yield and chemical constituents of beetroot flour undergo drying process at different combination of temperature and time

Treatments		Yield (%)	Water (%)	Ash (%)	Protein (%)	Fat (%)	Carbohydrate (%)
Temp. (°C)	Time (hr)						
50	6	13.53±0,008^{g}	12.61±0.057^{g}	2.65±0.099^{cd}	11.16±0.014^{a}	0.73±0.014^{a}	72.85±0.127^{e}
	7	13.50±0.014^{g}	12.49±0.021^{fg}	2.58±0.028^{bc}	11.35±0.028^{b}	0.89±0.007^{c}	72.50±0.007^{c}
	8	13.42±0.015^{f}	12.30±0.071^{de}	2.76±0.064^{de}	11.54±0.014^{c}	1.02±0.007^{d}	72.33±0.064^{bc}
60	6	13.36±0.016^{e}	12.53±0.028^{fg}	2.39±0.014^{a}	11.31±0.014^{b}	0.81±0.021^{b}	72.82±0.014^{e}
	7	13.12±0.014^{d}	12.44±0.057^{ef}	2.54±0.014^{b}	11.55±0.057^{cd}	0.90±0.007^{c}	72.58±0.021^{cd}
	8	13.10±0.013^{d}	12.22±0.049^{d}	2.73±0.028^{d}	11.68±0.035^{d}	1.13±0.014^{e}	72.27±0.064^{b}
70	6	13.05±0.042^{c}	11.53±0.057^{c}	2.85±0.057^{ef}	11.85±0.042^{e}	1.18±0.014^{e}	72.59±0.028^{cd}
	7	12.98±0.016^{b}	11.30±0.042^{b}	2.93±0.028^{f}	11.92±0.028^{ef}	1.31±0.014^{f}	72.54±0.057^{cd}
	8	12.94±0.032^{a}	10.78±0.085^{a}	3.10±0.014^{g}	12.08±0.028^{af}	1.44±0.057^{g}	72.23±0.057^{a}

Description: The average value accompanied by different letters expresses a significant difference ($p \leq 0.05$).

Table 1 showed the yield decreases with the longer the drying time and the higher the drying temperature, this is related to the material moisture content which is also temperature and drying time affect significantly. Water that evaporates due to heating treatment. The higher the difference between the temperature of the heating medium and the material being dried, the faster the heat transfer into the material the faster the evaporation of water from the material indicated based on the weight of the material is reduced.

Table 2. The mean value ± std. deviation of antioxidant activity and chemicals constituent of beetroot flour undergo drying process at different combination of temperature and time

Treatments		Vitamin C (mg.100g^{-1})	Antioxidant Activity (%)	Anthocyanin (mg.100g^{-1})
Temp. (°C)	Time (hr)			
50	6	31.92±0.021^{h}	69.80±0.091^{h}	69.81±0.021^{i}
	7	31.54±0.049^{g}	68.75±0.227^{f}	68.12±0.014^{h}
	8	31.38±0.042^{fg}	68.22±0.068^{e}	67.05±0.049^{g}
60	6	31.37±0.007^{f}	69.39±0.027^{g}	65.89±0.028^{f}
	7	31.09±0.014^{e}	68.09±0.023^{e}	63.04±0.021^{e}
	8	30.85±0.007^{d}	67.59±0.045^{d}	62.30±0.014^{d}
70	6	30.67±0.057^{c}	67.27±0.045^{c}	60.84±0.064^{c}
	7	30.35±0.042^{b}	66.90±0.114^{b}	58.73±0.042^{b}
	8	30.49±0.042^{a}	65.60±0.136^{a}	57.45±0.127^{a}

Description: The average value accompanied by different letters expresses a significant difference ($p \leq 0.05$).

For the chemical constituent values included of ash, protein and fat contents were showed significantly influenced by drying time and temperature , totally related to final moisture content achieved indicated the longer the time and the higher the temperature, the less of the moisture content obtained. This is due to the longer the drying time and the higher the temperature the water component in the material will evaporate more so that the solid component in the material will increase in concentration. This is in line with [11], which states that increasing the ash content, fat content and protein content in the material and decreasing the water content caused of the length of time and the high temperature used in the drying process. Meanwhile, carbohydrates calculated by different will give the opposite value to the total content of water, ash, fat, and protein components.

Table 2 showed the vitamin C and anthocyanins decreased by increasing drying time and temperature. This is because drying treatment related to heat sensitive compounds and this drying process catalyzed the oxidation process due to expose to oxygen. Oxidation reactions are accelerated in the presence of heat. This is in accordance with [12], that vitamin C is the most perishable vitamin. Vitamin C is easily oxidized, besides being easily soluble in water, the process is accelerated by alkali, heat, light, enzymes, and oxidizing agents, as well as by iron and copper catalysts. Increasing temperature and drying time, leads to decrease the anthocyanin content, due to its property that are easily damaged by heating. According to [13], anthocyanins are stable at temperatures below 50 °C, heating at more than 50 °C caused damage of the anthocyanins occurred. In line with vitamin C and anthocyanins, antioxidant activity also decreased with increasing drying time and temperature. Antioxidants are compounds that are able to slow down or prevent the oxidation process. Anthocyanins belonging to flavonoids and vitamin C are natural antioxidant compounds found in beetroots [14], so that damage to both components will reduce antioxidant activity.

3.2. Color of Beetroot Flour

Based on the result of statistical analysis, there was a significant interaction ($p \leq 0.05$) between temperature and drying time in color (L*, a*, b*) parameters. Table 3 showed the result of effect drying time and temperature in color of beetroot flour.

Table 3. The mean value ± std. deviation of beetroot flour color undergoes drying process at different combination of temperature and time

Treatment		L* (Lightness)	a* (Redness)	b* (Yellowness)
Temp. (°C)	Time (hr)			
50	6	15.82±0.205^{g}	7.82±0.205^{a}	2.78±0.014^{g}
	7	15.46±0.148^{g}	9.88±0.148^{b}	2.40±0.014^{f}
	8	14.85±0.184^{f}	10.33±0.304^{c}	2.72±0.071^{g}
60	6	13.32±0.106^{d}	12.34±0.177^{d}	2.12±0.042^{e}
	7	13.77±0.170^{e}	12.95±0.099^{e}	1.93±0.071^{d}
	8	12.69±0.120^{c}	13.70±0.092^{g}	1.56±0.156^{c}
70	6	10.08±0.042^{b}	15.18±0.092^{g}	1.29±0.064^{b}
	7	9.77±0.163^{b}	15.83±0.092^{h}	1.18±0.028^{a}
	8	9.15±0.106^{a}	16.22±0.028^{h}	1.40±0.014^{c}

Description: The average value accompanied by different letters expresses a significant difference ($p \leq 0.05$).

The results of color measurements obtained three values which were converted into three color notations, namely L, a*, b*. The L value expresses the reflected brightness that produces black, gray and white chromatic colors with a value of 0 (dark/black) to 100 (light/white). The values of a* and b* are chroma coordinates. The notation a denotes a mixed chromatic color of red and green with a+ (positive) from 0 to +127 to indicate the intensity of red color, the value of a- (negative) from 0 to -127 for green. The notation b denotes a mixed chromatic color of blue and yellow with b+ (positive) from 0 to +127 to indicate the intensity of the yellow color, a- (negative) value from 0 to -127 for blue [16]. The following were figures of the effect of drying time and temperature on the color of beetroot flour. The following is a picture of beetroot flour with drying time and temperature treatment.

Figure 1. The effect of temperature and heating time on the color of beetroot flour

The longer the drying time and the higher the temperature causes the brightness level of the beetroot flour to decrease, the redness level increases, and the yellowness level decreases, meaning that the color appearance is getting darker. This is because there are some of the content in beetroot such as sugar, vitamin C, carbohydrates, protein, and fat will affect the occurrence of non-enzymatic browning reactions [15] One of the non-enzymatic browning reactions is the Maillard reaction which is caused by a reaction between amino acids and reducing sugars when heated. Color is an important attributes that determine consumer acceptance of a product. Therefore, the color intensity test becomes an important test in determining the physical characteristics of a good product [16].

3.3. Yield Recovery Quality

An effectivity test was used to determine the best treatment. Based on the results of the effectivity test on all research parameters, treatment at drying temperature of 50 °C and a drying time of 6 hours was the best treatment. The yield value, water content, ash content, fat content, protein content, carbohydrate content by difference, antioxidant activity, anthocyanin content, Vitamin C content and color intensity L*, a*, and b* were 13.53%, 12.61%, 2.65%, 0.73%, 11.16%, 72.85%, 69.80%, 69.81 mg.100g^{-1}, 31.92 mg.100 g^{-1}, and 15,825, 7.82, and 2.78, respectively.

4. Conclusion

Treatment of temperature and drying time affected the yield, chemical characteristics and color of the beetroot flour produced. The higher the temperature and drying time, the lower the yield, water content, vitamin C, anthocyanin, and antioxidant activity. However, it increases ash, fat, and protein. In color parameters, high drying temperature and time decreased the lightness and yellowness values but increased the redness value. The best treatment was obtained at drying temperature of 50 °C and a drying time of 6 hours.

References

1. Castellanos-Santiago E, Yahia EM. Identification and quantification of betalains from the fruits of 10 mexican prickly pear cultivars by high-performance liquid chromatography and electrospray ionization mass spectrometry. J Agric Food Chem. 2008;56:5758–64.
2. Mujumdar AS. Handbook of industrial drying. New York: CRC Press; 2015.
3. Engin D. Effect of drying temperature on color and desorption characteristics of oyster mushroom. Food Sci Technol. 2020;40:187–93.
4. Estiasih T, Ahmadi K. Teknologi pengolahan pangan. Jakarta: Bumi Aksara; 2017.
5. Rohadi. Sifat fisik bahan dan aplikasinya dalam industri pangan. Semarang: Semarang University Press; 2009.
6. FAO, WHO. Specifications for the identity and purity of food additives and their toxicological evaluation: Some food colours, emulsifiers, stabilizers, anticaking agents, and certain other substances (Thirteenth report of the Joint FAO/WHO Expert Committee on Food. Geneva; 1970.
7. AOAC. Official methods of analysis of AOAC international. 18th ed. Horwitz W liam, Latimer GW, editors. Maryland: AOAC International; 2005.
8. Giusti MM, Wrolstad RE. Characterization and Measurement of Anthocyanins by UV-Visible Spectroscopy. Curr Protoc Food Anal Chem. 2001;F1.2.1-F1.2.13.
9. Cheng Z, Moore J, Yu L. High-throughput relative DPPH radical scavenging capacity assay. J Agric Food Chem. 2006;54:7429–36.
10. DeGarmo EP, Sullivan WG, Canada JR. Engineering economy. 7th ed. London: Macmillan; 1984.
11. Adawyah R. Pengolahan dan pengawetan ikan. Jakarta: Bumi Aksara; 2007.
12. Winarno FG. Kimia pangan dan gizi. Jakarta: Gramedia Pustaka Utama; 2002.
13. Nasrullah N, Husain H, Syahrir M. Pengaruh suhu dan waktu pemanasan terhadap stabilitas pigmen antosianin ekstrak asam sitrat kulit buah naga merah (Hylocereus polyrizus) dan aplikasi pada bahan pangan. Chem J Ilm Kim dan Pendidik Kim. 2020;21:150–62.
14. Parwata MOA. Antioksidan. Kim. Terap. Progr. Pascasarj. Univ. Udayana. Denpasar; 2016.
15. Slavov A, Karagyozov V, Denev P, Kratchanova M, Kratchanov C. Antioxidant activity of red beet juices obtained after microwave and thermal pretreatments. Czech J Food Sci. 2013;31:139–47.
16. Susila BA, Resmisari A. Tepung jagung kompbsit, Pembuatan dan Pengolahannya. Pros Semin Naslonal Teknol lnovatif Pascopanen untuk Pengemb lndustri Berbas Pertan. Bogor: Balai Besar Penelitian dan Pengembangan Pascapanen Pertanian; 2006. p. 462–73.