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The Effect of Drying Time on The Physicochemical Characteristics of Beetroot (*Beta vulgaris L.)* Sheet Jam

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ABSTRAK

Selai lembaran umbi bit merupakan modifikasi selai oles dan diversifikasi pangan berbasis umbi bit. Pengeringan menjadi salah satu faktor yang menentukan karakteristik selai lembaran. Tujuan penelitian ini untuk mengetahui pengaruh lama pengeringan terhadap karakteristik fisikokimia selai lembaran umbi bit. Pengeringan selai lembaran umbi bit menggunakan suhu 50 °C dengan variasi lama pengeringan 10, 12, dan 14 jam. Analisis yang dilakukan pada penelitian ini meliputi uji tekstur (Hardness, Cohesiveness, Adhesiveness, Gumminess, dan Chewiness), pH, kadar air, dan aktivitas antioksidan dengan 3 kali pengulangan pada setiap uji. Hasil dari penelitian ini pada parameter tekstur Hardness dengan rentang 12,66-17,65 N, Cohesiveness 291,76-581,04 N, Adhesiveness 7,35-33,58 Nmm, Gumminess 5198,15-7973,70 N, Chewiness 5117,80-7151,6 N, pH memiliki rentang nilai 3,93-5, kadar air 18,85-24,95%, dan aktivitas antioksidan (IC50) dengan rentang nilai 38,81-47,82 ppm. Kesimpulan dari penelitian ini adalah pengeringan berpengaruh terhadap karakteristik fisikokimia selai lembaran umbi bit.

ABSTRACT

The sheet jam from beetroot is a modification of spreadable jam and a diversification of food based on beetroot. Drying is one of the factors that determines the characteristics of the sheet jam. The objective of this study is to determine the effect of drying duration on the physicochemical characteristics of beetroot sheet jam. The drying process was conducted at a temperature of 50 °C with varying drying times of 10, 12, and 14 hours. The analyses performed in this study included texture tests (Hardness, Cohesiveness, Adhesiveness, Gumminess, and Chewiness), pH, moisture content, and antioxidant activity, with three repetitions for each test. The results showed that for the texture parameter, Hardness ranged from 12.66 to 17.65 N, Cohesiveness from 291.76 to 581.04 N, Adhesiveness from 7.35 to 33.58 Nmm, Gumminess from 5198.15 to 7973.70 N, Chewiness from 5117.80 to 7151.6 N, pH ranged from 3.93 to 5, moisture content from 18.85% to 24.95%, and antioxidant activity (IC50) ranged from 38.81 to 47.82 ppm. The conclusion of this study is that drying significantly affects the physicochemical characteristics of beetroot sheet jam.

1. PENDAHULUAN

Beetroot or what is often known as beetroot is a type of tuber that is often found in Indonesia. Beetroot is rich in antioxidants and several types of vitamins such as vitamin A, vitamin B1, vitamin B2, vitamin C and folic acid (Milton-Laskibar et al., 2021; Paula et al., 2025). Beetroot, a vegetable that is considered to be among the top 10 most potent vegetables in the world, has a total phenolic content that ranges from 50 to 60 μ mol/g of its dry weight. This is attributable to its enhanced antioxidant capacity (Rangani & Ranaweera, 2023). In general, beet tubers are often used as food or drink coloring and processed in the form of juice which has a short shelf life. The unpleasant smell of beetroot causes the low level of consumption of beetroot in Indonesia (Achyadi & Hervelly, 2020). Based on the low use of beetroot as a functional food, there is a need for beetroot-based diversification which can extend the life of beetroot and increase its economic value. One of the processed foods that has a long shelf life is sheet jam (Solichah et al., 2023).

Generally, jam has a soft and sticky texture, so to make it easier to serve, the jam is made in sheet form. Sheet jam is jam in the form of thin, plastic, compact and non-sticky sheets. Sheet jam is made by adding hydrocolloids (Putri et al., 2013; Samakradhamrongthai et al., 2024). Hydrocolloids in making sheet jam function to strengthen the texture so that it is formed with perfect characteristics. Sheet jam has good characteristics if it has a soft texture, is not runny or mushy, is consistent, and is not too stiff (Herawati, 2018). There are several factors that can influence the characteristics of sheet jam, including the composition of the ingredients, the amount of sugar used, the type and level of ripeness of the fruit, the

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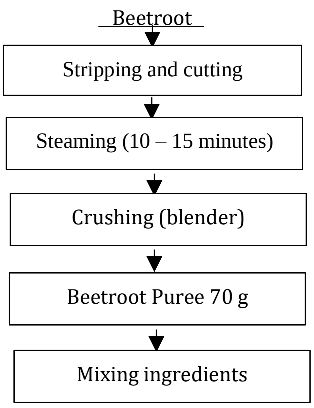
concentration of hydrocolloids used, the processing process, temperature and drying time (Ariani et al., 2023).

Making sheet jam goes through a process of crushing, cooking, molding into sheets and drying. The drying process greatly influences the texture of sheet jam (Raj & Dash, 2022). The longer the time, the less water is contained in the gel system, so the bond between the gels will be harder and the resulting texture will be. On the other hand, if the gel system contains a lot of water, the bonds between the gels will weaken and the resulting texture will be less firm (Rajoriya et al., 2021). Drying carried out at too high a temperature and a short time can cause the surface of the jam sheet to become hard or what is called Case Hardening (G. V. S. B. Raj et al., 2024). When case hardening occurs in the jam sheet, the water cannot come out, so the texture on the inside of the jam sheet becomes soft because the water in the material is still high. This can shorten the shelf life of sheet jam due to the activity of microorganisms (Nizamlioglu et al., 2022). It is essential to determine the appropriate drying duration to achieve high-quality sheet jam. Drying using high temperatures and long periods of time can cause damage and changes in the characteristics of the chemical components contained in the material such as antioxidants. Antioxidants are sensitive to heat and light (Eyiz et al., 2020). Drying time affects the length of time the material is exposed to heat. The longer the drying time, the longer the antioxidants in food will be exposed to heat, thereby reducing antioxidant activity due to degradation or damage to phenolic compounds (da Silva Simão et al., 2020; Suna & Özkan-Karabacak, 2019). Jam sheets that have a pH that is too acidic can increase syneresis due to weakened gel strength. Therefore, pH is one of the quality parameters that needs to be considered. Drying has no effect on the pH value because it is thought that there are organic acids that cannot be lost due to drying (Nizamlioglu et al., 2022).

The drying process for making jam sheets in this research uses a temperature of 50 °C using a cabinet dryer. Drying using a cabinet dryer has the advantage that temperature and sanitary conditions can be regulated so that the final product quality can also be controlled. Drying at a temperature of 50-55 °C is considered good because at this temperature movement between water particles occurs and evaporation can proceed well (Eyiz et al., 2020). Beetroot jam dried at 50°C with a drying time of 12 hours had a pH value of 3.62, with a water content value of 24.18%, and antioxidant activity of 39.41 ppm. Therefore, this research was conducted to determine the effect of drying time on the characteristics of beetroot sheet jam and to obtain the right drying time on the characteristics of beetroot sheet jam (Pandeirot & Handoko, 2022; Sofyan & Kusumawardani, 2022).

2. METHOD

An overview of the process for making samples of sheet jam made from beetroot can be seen in Figure 1, starting from steaming and cutting, steaming, crushing, weighing the puree, mixing the ingredients, cooking, adding citric acid, molding, drying, cooling until it becomes beetroot sheet jam. Making beetroot puree begins by peeling the skin of the beetroot, washing it, then cutting it into small pieces, heating the water until it boils, then adding the beetroot pieces and steaming for 10 – 15 minutes. The cooked beetroot pieces can then be mashed using a blender. The process for making beetroot jam consists of adding cornstarch with a concentration of 2.5% and CMC with a concentration of 0.5% to the beetroot puree. The next stage is the cooking process at a temperature range of between 70-80°C for 10-15 minutes. During cooking, add 25 g of granulated sugar and 1 g of citric acid to the beetroot puree. Once cooked, the jam mixture is molded into sheets with a thickness of ±3 mm using a baking sheet, then dried using a cabinet dryer at a temperature of 50°C for (10, 12 and 14 hours). After drying, the jam sheets are cut into 10×10 cm sizes (Raj & Dash, 2022; Sofyan & Kusumawardani, 2022).



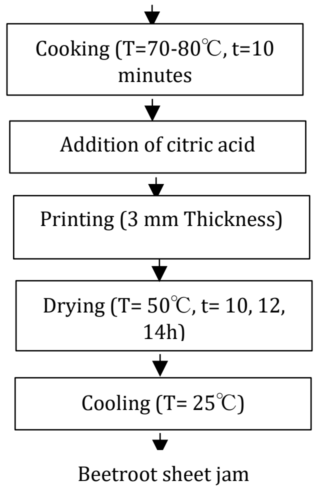
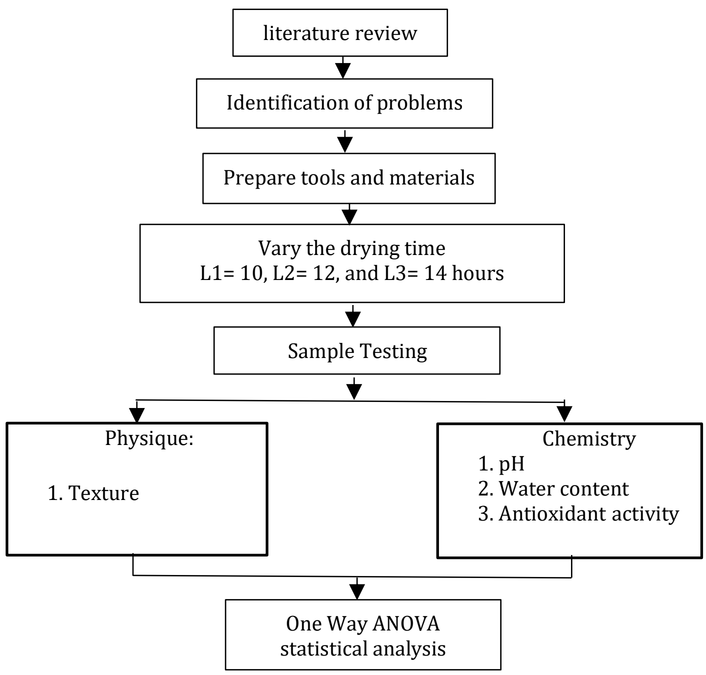


Figure 1. Flow Diagram for Making Beetroot Sheet Jam

The research stage can be seen in Figure 2. The beetroot used in making the sheet jam samples obtained from Banguntapan (characterized by the deep red flesh of the tuber, hard texture, and fresh stems), the hydrocolloid used was CMC (Carboxyl Methyl Cellulos) and cornstarch with the Maizenaku brand, granulated sugar, vanilla powder, and citric acid. This research method is drying beet tuber jam sheets at a temperature of 50°C with varying drying times of 10 hours, 12 hours and 14 hours. The parameters used in the physical test of beetroot jam sheets are texture which includes Hardness, Cohesiveness, Adhesiveness, Gumminess and Chewiness. Meanwhile, chemical parameter testing includes pH, water content and antioxidant activity tests with 3 repetitions of each test. The data obtained will then be analyzed using Analysis of Variance (ANOVA) with the Duncan Multiple Range Test (DMRT) follow-up test.

Testing the texture of beetroot jam sheets was carried out using a texture analyzer which aims to determine the values of Hardness, Cohesiveness, Adhesiveness, Gumminess and Chweness. This test was carried out in 3 repetitions, with the sample placed on the test plate so that it was directly under the probe. The probe was operated using Texture Analyzer software, with the probe speed setting for pressing the sample, namely 1.1 mm/s. As long as the sample is pressed, a graph will appear from zero to the peak force on the computer screen. This point is the maximum value of gel strength of the sample tested. The graph will return to zero once that point is reached. The peak point is then clicked to see the amount of pressure used to break the product (F), as well as the distance when the product breaks (D) (Karlan & Rahmadhia, 2022).



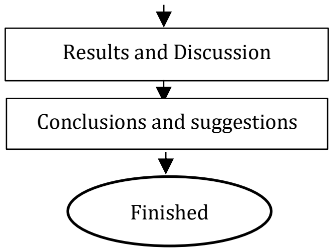


Figure 2. Research Flow Chart

In accordance with SNI 01-2891-1992, pH value measurements are carried out using a pH meter. The sheet jam samples were crushed first, then put into a glass beaker. Before use, the pH meter is calibrated first using a buffer solution with pH 4 (acid) and 7 (base). After calibrating, the pH meter is then dipped into a beaker containing a sample of crushed sheet jam until the screen on the pH meter shows a stable number. This test was carried out 3 times. Next, the average of the 3 repetitions is calculated (Rahmadhia et al., 2023).

Testing water content uses the oven method, which begins by placing a metal cup in the oven and drying it for 15 minutes at a temperature of 130 °C. The cup that has been dried is then weighed first. Next, weigh 2 grams of the sample using the cup and dry it in an oven for 24 hours at 105 °C, then cool it in a desiccator for 15 minutes and weigh it again. The sample is weighed until the weight is constant (the difference between weighing is less than 0.0001 g – 0.0005 g). The calculation of water content is using equation (1) (AOAC, 2005; Indriani & Khairi, 2023).

$$\text{Water content (\%)} = \frac{(initian\ weight - final\ weight)}{initial\ weight} \times 100\% \qquad (1)$$

Testing antioxidant activity began by extracting samples of beetroot jam with Methanol PA. Then proceed with making a DPPH solution, making a blank solution, making a stock solution, and measuring absorption using a UV-Vis Spectrophotometer. At this stage of absorbance measurement using a UV-Vis Spectrophotometer, dilution of the mother liquor was carried out using Methanol PA by making concentrations of 20, 40, 60, 80 and 100 ppm. Then 5 ml of each concentration was taken and 5 ml of DPPH solution was added, then homogenized with a vortex and incubated for 30 minutes. The sample's absorbance was then measured using a spectrophotometer with a wavelength of 517 nm. Calculation of % inhibition uses the equation (2).

$$\text{\% inhibtion} = \frac{blank\ absorbance - sample\ absorbance}{blank\ absorbance} \times 100\% \qquad (2)$$

The IC50 value is determined through a linear regression equation which is obtained in the form y = ax + b, the value (y) is the percent inhibition value of 50 and the x value will be obtained from IC50. The IC50 value states the concentration of the sample solution needed to reduce DPPH free radicals by 50% (Khairi & Nurkhasanah, 2020; Nizamlioglu et al., 2022).

3. RESULT AND DISCUSSION

Result

Table 1. Effect of Varying Drying Time tn the Ph Value of Beetroot Jam

Drying Time (hours)	pH
L1 (10 hours)	3.93 ± 0.06^a
L2 (12 hours)	4.23 ± 0.06^b
L3 (14 hours)	5.00 ± 1.00^c

Based on the analysis results shown in Table 1, from the ANOVA test results it can be seen that the pH significance value is $\underline{\alpha} \leq 0.05\%$, which means that the drying time has an effect on the pH of the beetroot jam. The pH value of beetroot jam increased with a value range of 3.9 – 5 as the drying process took longer.

Table 2. Effect of Varying Drying Time on the Water Content of Beetroot Jam

Drying Time (hours)	Water Content (%)
L1 (10 hours)	24.95 ± 2.27^{a}
L2 (12 hours)	21.30 ± 1.07^{b}
L3 (14 hours)	18.85 ± 1.01^{c}

Based on the analysis results shown in Table 2, from the ANOVA test results it can be seen that the significance value for water content is $\underline{\alpha} \leq 0.05\%$, which means that the drying time has an effect on the water content of beetroot jam. The water content of beetroot jam decreased with a value range of 24.95% - 18.85% as the drying process took longer.

Table 3. Effect of Varying Drying Time on the Antioxidant Activity of Beetroot Jam

Drying Time (hours)	IC_{50} (ppm)
L1 (10 hours)	38.80 ± 1.17^{a}
L2 (12 hours)	42.42 ± 0.86^{b}
L3 (14 hours)	47.82 ± 0.44^{c}

Based on the analysis results shown in Table 3, from the ANOVA test results it can be seen that the significance value of antioxidant activity is $\underline{\alpha} \leq 0.05\%$, which means that the drying time has an effect on the antioxidant activity of beetroot jam. The IC50 value of beetroot jam has increased with a value range of 38.80 – 47.82 ppm. The lower the IC50 value, the higher the antioxidant activity. If the IC50 value of an extract is below 50 ppm then the antioxidant activity is very strong, whereas if the IC50 value is between 50-100 ppm it means the antioxidant activity is strong (Molyneux, 2004). So it can be concluded that the antioxidant activity of beetroot jam decreases as the drying process takes longer.

Table 4. Effect of Varying Drying Time on the Texture of Beetroot Jam

Parameter	Drying Time (L1 = 10 hours)	Drying Time (L1 = 12 hours)	Drying Time (L1 = 14 hours)
Hardness (N)	12.66 ± 0.16^{a}	14.28 ± 0.00^{b}	17.10 ± 0, 23^{c}
Cohesiveness (N)	426.20 ± 21.02^{a}	581.04 ± 37.23^{b}	291.76 ± 29.49^{c}
Adhesiveness (Nmm)	24.01 ± 0.20^{a}	33.58 ± 0.33^{ab}	7.35 ± 10.06^{b}
Gumminess (N)	6477.95 ± 611.85^{a}	7973.70 ± 76.36^{b}	5198.15 ± 185.05^{c}
Chewiness (N)	5117.80 ± 482.81^{a}	7151.60 ± 486.64^{a}	5509.25 ± 557.84^{b}

Based on the analysis results shown in Table 4, from the ANOVA test results it can be seen that the significance value of texture is $\underline{\alpha} \leq 0.05\%$, which means that the drying time has an effect on the texture of the beetroot jam. Texture Hardness has a value range of 12.66 – 17.10 N, Cohesiveness has a value range of 291.76 – 581.04 N, Adhesiveness has a value range of 7.35 – 33.58 Nmm, Gumminess has a value range of 5198.15 – 677, 95 N, and Chewiness has a value range of 5117.80 – 7151.60 N.

Discussion

The acidity level is one of the things that is focused on in maintaining the quality of sheet jam because it can affect the firmness of the gel and the level of syneresis of sheet jam. The pH value is measured to determine the acidity level of a food ingredient (Rahmadhia et al., 2023). A low acidity level can maintain the shelf life of jam, because the growth of microbes, especially fungi, is inhibited. If the acidity level is too high it can cause syneresis, namely the release of water from the gel, which results in a reduction in the viscosity of the jam or even no gel forming at all (da Silva Simão et al., 2019; Singh & Tiwari, 2019).

Based on Table 1, it shows that the pH value of beetroot jam has increased. An increase in pH can occur due to evaporation of acid from the fruit during the long drying process. The longer the drying process, the pH tends to increase. Prolonged heating processes can damage organic acids in fruit, such as ascorbic acid. This acid damage can be accelerated by exposure to heat, light, alkali, enzymes, oxidizers, and copper catalysts over long periods of time (da Silva Simão et al., 2019; Yunita & Rahmawati, 2015) . One of the factors that influences pH is temperature. The drying principle involves the transfer of heat from the dryer to the material and the removal of water from the material being dried. Therefore, the longer the drying time, the longer the material will receive heat (Al-Amrani et al., 2020; da Silva Simão et al., 2020; Nizamlioglu et al., 2022). The pH of Liberica coffee tends to increase with increasing drying duration, so that the pH value of Liberica coffee is higher (Yunita & Rahmawati, 2015). Water content is the amount of water contained in a material expressed as a percentage (%). Water content is an important characteristic because it affects the texture, appearance, taste and shelf life of food ingredients. Knowing the water content of food is very crucial because it affects its quality and shelf life. High water content can cause microorganisms to easily grow and cause changes in the content of food ingredients (G. B. Raj & Dash, 2022; Yılmaz et al., 2017).

Based on Table 2, it shows that the water content of sheet jam decreases as the drying process takes longer. This decrease in the water content value can occur because the longer drying time causes the material being dried to receive more heat. Thus, the water content in food will easily evaporate from the surface of the material and decrease with increasing drying time. The longer the drying process is carried out, the greater the heat energy carried by the air, so that the amount of free water that evaporates from the material will also be greater (Mahajan et al., 2022; Tontul & Topuz, 2017). The longer sale bananas are dried, the water content of sale bananas decreases (Arsyad, 2022). The water content value decreases with increasing drying time because more water molecules evaporate (Riansyah et al., 2014). Higher drying temperatures and long drying times will cause the water content in the material to be lower, and vice versa. The decrease in water content of beetroot jam is in accordance with the opinion of (Mahajan et al., 2022), who stated that the longer the drying time, the more water evaporates and the water content in the material becomes lower. In addition, with increasing drying time and heat energy carried by the air, the amount of liquid evaporating from the surface of the jam sheet also increases. Beetroot jam currently does not have a national standard, so the water content refers to the standard for dry sweets for all drying durations, in accordance with the quality requirements for dried candied fruit (SNI 0718-83, 2005), namely a maximum of 25%.

Antioxidants work by binding highly reactive molecules and free radicals to stop the oxidation process. As a substance, antioxidants are able to significantly inhibit or prevent oxidation of substrates caused by free radicals, even in small concentrations. In food, antioxidants play an important role in maintaining product quality by preventing a decrease in nutritional value, preventing rancidity, and preventing changes in color, aroma and other physical factors caused by oxidation reactions (Aprilia et al., 2023; T. Wang et al., 2020). The method used to determine the antioxidant activity of beetroot jam is by using the DPPH method. DPPH (2,2-diphenyl-1-picrylhydrazyl) is used to determine antioxidant activity through its ability to capture free radicals. DPPH is a free radical with a blackish violet form, which is quickly oxidized by temperature and air, and dissolves in polar solvents such as methanol or ethanol. Methanol as the solvent was chosen to dissolve DPPH crystals and dissolve nonpolar components (Molyneux, 2004; Viola et al., 2024). Based on Table 3, it shows that the IC50 value has increased, indicating that the antioxidant activity of sheet jam has decreased. The lower the IC50 value, the higher the antioxidant activity. If the IC50 value of an extract is below 50 ppm then the antioxidant activity is very strong, whereas if the IC50 value is between 50-100 ppm it means the antioxidant activity is strong (Molyneux, 2004). So it can be concluded that the antioxidant activity in each treatment is very strong because it is below 50 ppm. Beetroot extract has an IC50 value of 21,888 ppm (Asra et al., 2020). Drying time affects antioxidant activity, the longer the drying time, the antioxidant activity will also decrease. This happens because antioxidants are damaged by heat and cooking (Mahajan et al., 2022).

The longer the heating is carried out, the more secondary metabolite compounds that act as antioxidants (flavonoid compounds) are damaged. Heating can increase oxidation of antioxidants contained in natural ingredients, resulting in a decrease in antioxidant activity in these ingredients. This decrease in antioxidant activity varies, depending on the type of component that acts as an antioxidant in the material (Izli et al., 2018; Mahajan et al., 2022). This is in accordance with research that drying time has a great influence on the antioxidant activity of dyed tea and cemcem leaves (Putri et al., 2023). Drying is carried out in making beet tuber jam using a temperature of 50 °C using a cabinet dryer. Pigments exposed to temperatures of around 40 °C to 50 °C show stability and do not experience significant degradation. However, at temperatures exceeding 50 °C, betalain degradation increases with increasing temperature (Attia et al., 2013).

The texture of a food product has an important role in relation to consumer acceptance. Hardness is a change in the shape of a sample that is subjected to force or pressure which can be used as a determinant of the level of density or tension of the gel created in sheet jam (Shinwari & Rao, 2018; Z. Wang et al., 2020). Based on Table 4, it shows that the Hardness value has increased. The drying process affects the texture of sheet jam. The longer the drying is carried out, the water content in the gel system will decrease, making the bonds between the gel forms tighter and the gel texture becomes harder. The higher the hardness value, the harder the product produced (Dubey et al., 2023; Samakradhamrongthai et al., 2024). Therefore, it can be concluded that the sample with the longest drying time will have the highest level of hardness. The reduction of water molecules during heating causes the material to shrink and increase the concentration of pectin, cellulose, and cell wall constituents. Apart from that, gel formation is also influenced by the percentage of sugar. The higher the concentration of hydrocolloids and sugar, the harder the resulting texture (Chang et al., 2021; Z. Wang et al., 2020). The hardness of dried candied carica fruit tends to increase with increasing drying time (Yunita & Rahmawati, 2015). The heating process in fruit products can increase product hardness because heating reduces the bonds in pectin molecules and strengthens them, especially cross-links.

Cohesiveness is an indication that shows the cohesiveness of materials that interact with each other. Cohesiveness includes adhesive and cohesive strength as well as gel viscosity and plasticity, so that the resulting product texture will be denser and more compact (da Costa et al., 2020). Based on Table 4, it can be seen that the Cohesiveness value has a value range between 291.76 - 581.04 N. The higher the Cohesiveness value shows that the more compact the texture of the product is (Parn et al., 2015). The drying process in making jam causes the tissue in the material matrix to become denser, thereby increasing the compactness of the resulting jam (Samakradhamrongthai et al., 2024). The heat energy during cooking and drying the jam sheets results in breaking the hydrogen bonds in the starch, so that the water in the jam enters the starch granules and forms hydrogen bonds with the molecules that make up the starch (amylose and amylopectin). The granules then expand and break, which causes a change in viscosity to become thicker, a process known as gelatinization (Chang et al., 2021).

Adhesiveness can be referred to as the force required to be able to attract food from the surface. Adhesiveness value is used to find out the stickiness between 2 particles of different types (Mohammadi-Moghaddam & Firoozzare, 2021). Based on Table 4, it can be seen that the Adhesiveness value has a value range between 7.35 – 33.58 Nmm. A high adhesiveness value indicates that the resulting jam sheet is too sticky. The lowest value was found in beet tuber jam with L3 treatment with a drying time of 14 hours. This is related to the decrease in water content on the surface of the jam sheet which went through the longest drying process among the other two samples (Leal et al., 2021). The addition of high levels of sugar causes the Adhesiveness value to be lower, this is due to the heating process where the molecules move quickly from the surface to become gas. Partial water displacement from the material matrix causes the density and stickiness to decrease (Chang et al., 2021; Leal et al., 2021).

Gumminess is the energy used to shrink food ingredients so they can be swallowed. Gumminess is a characteristic of semisolid food ingredients with low hardness and high cohesiveness (Fauziyah, 2017). Based on Table 4, it can be seen that the Gumminess value has a value range between 5198.15 – 7973.70 N. A high Gumminess value indicates that the product has a chewy texture that tends to be soft. Gumminess is only used for semi-solid food products. It is categorized as semi-solid if it has a texture that tends to be soft jelly, and is sticky to the touch (Chang et al., 2021; Hamzah et al., 2023). A decrease in water content will cause the Gumminess value to increase. This happens because drying treatment for a long time can reduce the water content in the gel system which causes the bonds between gel formers to become tighter and the gel texture to become harder (Chang et al., 2021; G. V. S. B. Raj et al., 2024).

Chewiness is the energy needed to chew food which is usually used in semi-solid foods. Chewiness simply means chewing power (Chandra & Shamasundar, 2015). Based on Table 4, it can be seen that the Chewiness value has a value range between 5117.8 -7151.6 N. Chewiness is related to product hardness, the higher the Chewiness value of a product, the harder the product is. Drying for a long time affects the texture of the sheet jam, the longer the drying time can reduce the water content in the gel system which causes the bonds between gel formers to become tighter and the gel texture to become harder (da Costa et al., 2020). Overall, this research contributed to determine the effect of drying time on the physicochemical characteristics of beetroot sheet jam. However, this study still needs to be developed further to obtain better sheet jam. For example, variations in the type of dryer are needed.

4. CONCLUSION

The drying time has a real influence on the physical characteristics of the beetroot jam sheet texture, including Hardness, Cohesiveness, Adhesiveness, Gumminess and Chewiness. Drying time also affects the chemical characteristics of beetroot jam, namely pH, water content and antioxidant activity. Further research regarding the shelf life of beetroot jam is needed to determine the age of the product so that it remains safe for consumption.

5. REFERENCES

Achyadi, N. S., & Hervelly. (2020). Perbandingan Sari Kacang Kedelai Dengan Bubur Umbi Bit Dan Konsentrasi Santan Terhadap Karakteristik Es Krim Nabati. *Pasundan Food Technology Journal*, *7*(2), 57–64. https://doi.org/10.23969/pftj.v7i2.2980.

Al-Amrani, M., Al-Alawi, A., & Al-Marhobi, I. (2020). Assessment of Enzymatic Browning and Evaluation of Antibrowning Methods on Dates. *International Journal of Food Science*, *2020*, 1–9.

https://doi.org/10.1155/2020/8380461.

AOAC, A. of O. A. C. (2005). *Officials Methods of Analysis* (18 Edn). Association of Official Analytical Chemist Inc.

Aprilia, D., Rahmadhia, S. N., Amelia, S., & Hidayah, N. (2023). Physicochemical Properties and Microbial Inhibition on Biofilms Cassava Starch with Green Cayenne Pepper Leaf Extract (Capsicum Frutescens L). *Jurnal Keteknikan Pertanian*, *11*(2), 153–164. https://doi.org/10.19028/jtep.011.2.153-164.

Ariani, P., Asikin, A. N., Pamungkas, B. F., & Zuraida, I. (2023). Pengaruh lama pengeringan terhadap penerimaan konsumen selai lembaran buah mangrove (Sonneratia ovata). *Ziraa'ah Majalah Ilmiah Pertanian*, *48*(3), 429. https://doi.org/10.31602/zmip.v48i3.12598.

Arsyad, M. (2022). Pengaruh Lama Pengeringan terhadap Karakteristik Fisikokimia Pisang Sale. *Perbal: Jurnal Pertanian Berkelanjutan*, *10*(1), 53–62. https://doi.org/10.30605/perbal.v10i1.1540.

Asra, R., Yetti, R. D., Ratnasari, D., & Nessa, N. (2020). Physicochemical Study of Betasianin and Antioxidant Activities of Red beet tubers (Beta vulgaris L.). *Journal of Pharmaceutical And Sciences*, *3*(1), 14–21. https://doi.org/10.36490/journal-jps.com.v3i1.35.

Attia, G. Y., Moussa, M. M., & Sheashea, E. E. D. R. (2013). Characterization of red pigments extracted from red beet (Beta vulgaris, l.) And its potential uses as antioxidant and natural food colorants. *Egyptian Journal of Agricultural Research*, *91*(3), 1095–1110. https://doi.org/10.21608/ejar.2013.167086.

Chandra, M. V., & Shamasundar, B. A. (2015). Texture Profile Analysis and Functional Properties of Gelatin from the Skin of Three Species of Fresh Water Fish. *International Journal of Food Properties*, *18*(3), 572–584. https://doi.org/10.1080/10942912.2013.845787.

Chang, X., Yang, A., Bao, X., He, Z., Zhou, K., Dong, Q., & Luo, W. (2021). An innovative structured fruit (SF) product made from litchi juice, king oyster mushroom (Pleurotus eryngii) and gellan gum: Nutritional, textural, sensorial properties. *LWT*, *152*, 112344. https://doi.org/10.1016/j.lwt.2021.112344.

da Costa, J. N., Leal, A. R., Nascimento, L. G. L., Rodrigues, D. C., Muniz, C. R., Figueiredo, R. W., Mata, P., Noronha, J. P., & de Sousa, P. H. M. (2020). Texture, microstructure and volatile profile of structured guava using agar and gellan gum. *International Journal of Gastronomy and Food Science*, *20*, 100207. https://doi.org/10.1016/j.ijgfs.2020.100207.

da Silva Simão, R., de Moraes, J. O., Carciofi, B. A. M., & Laurindo, J. B. (2020). Recent Advances in the Production of Fruit Leathers. *Food Engineering Reviews*, *12*(1), 68–82. https://doi.org/10.1007/s12393-019-09200-4.

da Silva Simão, R., de Moraes, J. O., de Souza, P. G., Mattar Carciofi, B. A., & Laurindo, J. B. (2019). Production of mango leathers by cast-tape drying: Product characteristics and sensory evaluation. *LWT*, *99*, 445–452. https://doi.org/10.1016/j.lwt.2018.10.013.

Dubey, K. K., Mishra, S. S., Marathe, S. J., Mahajani, S. M., Arora, A., & Singhal, R. S. (2023). Incorporation of jaggery in beetroot jam enhances its antioxidant properties with acceptable sensory and physicochemical profile. *Food and Humanity*, *1*, 985–995. https://doi.org/10.1016/j.foohum.2023.08.005.

Eyiz, V., Tontul, İ., & Türker, S. (2020). Effect of variety, drying methods and drying temperature on physical and chemical properties of hawthorn leather. *Journal of Food Measurement and Characterization*, *14*(6), 3263–3269. https://doi.org/10.1007/s11694-020-00574-2.

Fauziyah, E. (2017). Consumer Preference Towards Fruit Leather Attributes of Madurese Exotic Tropical Fruits. *International Research Journal of Business Studies*, *10*(2), 111–122. https://doi.org/10.21632/irjbs.10.2.111-122.

Hamzah, F. H., Herawati, N., Yunita, I., & Sriwulandari, A. (2023). Sensory analysis of fruit leather from the combination of pedada fruit and api-api fruit as natural dyes. *IOP Conference Series: Earth and Environmental Science*, *1182*(1), 012056. https://doi.org/10.1088/1755-1315/1182/1/012056.

Herawati, H. (2018). Potensi hidrokoloid sebagai bahan tambahan pada produk pangan dan nonpangan bermutu. *Jurnal Penelitian Dan Pengembangan Pertanian*, *37*(1), 17. https://doi.org/10.21082/jp3.v37n1.2018.p17-25.

Indriani, O. D., & Khairi, A. N. (2023). Physico-chemical Characteristics of Jelly Drink with Variation of Red Dragon Fruit Peel (Hylocereus polyrhizus) and Additional Sappan Wood (Caesalpinia sappan). *Journal of Agri-Food Science and Technology*, *4*(1), 37–48. https://doi.org/10.12928/jafost.v4i1.7069.

Izli, N., Izli, G., & Taskin, O. (2018). Impact of different drying methods on the drying kinetics, color, total phenolic content and antioxidant capacity of pineapple. *CyTA - Journal of Food*, *16*(1), 213–221. https://doi.org/10.1080/19476337.2017.1381174.

Karlan, L. S., & Rahmadhia, S. N. (2022). Physicochemical Characteristics Of Baby Java Orange Peel Pectin

(Citrus sinensis) And Corn Starch-Based Edible Film With Glycerol Plasticizer. *Jurnal Teknologi Pertanian*, *23*(2), 119–128. https://doi.org/10.21776/ub.jtp.2022.023.02.3.

Khairi, A. N., & Nurkhasanah, N. (2020). Bioactive compounds content of Snake Fruit Peel, Aloe Vera, and Stevia Extracts as Raw Material of Functional Drinks. *Journal of Agri-Food Science and Technology*, *1*(1), 34. https://doi.org/10.12928/jafost.v1i1.1915.

Leal, A. R., Oliveira, L. de S., Farias, L. M., Alves, C. A. N., Costa, J. N. da, Mata, P., & Sousa, P. H. M. de. (2021). Elaboration of mixed structured fruit formulations with agar and gellan gum: Texture, physicochemical, and sensory properties. *International Journal of Gastronomy and Food Science*, *23*, 100294. https://doi.org/10.1016/j.ijgfs.2020.100294.

Mahajan, M., Bons, H. K., Dhillon, G. K., & Sachdeva, P. A. (2022). Unlocking the impact of drying methods on quality attributes of an unexploited fruit, karonda (Carissa carandas L.): A step towards food and nutritional security. *South African Journal of Botany*, *145*, 473–480. https://doi.org/10.1016/j.sajb.2022.03.008.

Milton-Laskibar, I., Martínez, J. A., & Portillo, M. P. (2021). Current Knowledge on Beetroot Bioactive Compounds: Role of Nitrate and Betalains in Health and Disease. *Foods*, *10*(6), 1314. https://doi.org/10.3390/foods10061314.

Mohammadi-Moghaddam, T., & Firoozzare, A. (2021). Investigating the effect of sensory properties of black plum peel marmalade on consumers acceptance by Discriminant Analysis. *Food Chemistry: X*, *11*, 100126. https://doi.org/10.1016/j.fochx.2021.100126.

Molyneux. (2004). The Use of The Stable Free Radical Diphenylpicryl-Hydrazyl (DPPH) for Estimating Antioxidant Activity. *Songklanakarin Journal of Science and Technology*, *50*, 211–219.

Nizamlioglu, N. M., Yasar, S., & Bulut, Y. (2022). Chemical versus infrared spectroscopic measurements of quality attributes of sun or oven dried fruit leathers from apple, plum and apple-plum mixture. *LWT*, *153*, 112420. https://doi.org/10.1016/j.lwt.2021.112420.

Pandeirot, B. N. K., & Handoko, Y. A. (2022). Physical, Chemical, and Organoleptic Characterization of Beetroot Leather (Beta vulgaris L.) with Additional CMC and Carrageenan. *Jurnal Teknik Pertanian Lampung (Journal of Agricultural Engineering)*, *11*(4), 549. https://doi.org/10.23960/jtep-l.v11i4.549-560.

Parn, O. J., Bhat, R., Yeoh, T. K., & Al-Hassan, A. A. (2015). Development of novel fruit bars by utilizing date paste. *Food Bioscience*, *9*, 20–27. https://doi.org/10.1016/j.fbio.2014.11.002.

Paula, L., Ana, J.-G., Hannu, P., Carlos, M. J., Eeva-Riikka, V., & Cristina, J. (2025). Role of red beetroot in bread for reducing mycotoxin risks: Bioavailability of beetroot polyphenols and betalains with ochratoxin a, aflatoxin B1 and zearalenone in Caco-2 cells. *Food Chemistry*, *465*, 142036. https://doi.org/10.1016/j.foodchem.2024.142036.

Putri, I. R., Basito, & Widowati, E. (2013). Pengaruh konsentrasi agar-agar dan karagenan terhadap karakteristik fisik, kimia, dan sensori selai lembaran pisang (Musa paradisiaca L.) varietas raja bulu. *Jurnal Teknosains Pangan*, *2*(3), 112–120.

Putri, P. Y. A., Pratiwi, I. D. P. K., & Puspawati, I. G. A. K. D. (2023). Pengaruh Lama Pengeringan Daun Cemcem (Spodiaz pinnata LF Kurz) Terhadap Aktivitas Antioksidan Dan Sifat Sensoris Teh Celup Herbal. *Jurnal Ilmu Dan Teknologi Pangan (ITEPA)*, *12*(1), 133. https://doi.org/10.24843/itepa.2023.v12.i01.p11.

Rahmadhia, S. N., Sidqi, A. A., & Saputra, Y. A. (2023). Physical Properties of Tapioca Starch-based Film Indicators with Anthocyanin Extract from Purple Sweet Potato (Ipomea batatas L.) and Response to pH Changes. *Sains Malaysiana*, *52*(6), 1685–1697. https://doi.org/10.17576/jsm-2023-5206.

Raj, G. B., & Dash, K. K. (2022). Development of Hydrocolloids Incorporated Dragon Fruit Leather by conductive hydro drying: Characterization and Sensory Evaluation. *Food Hydrocolloids for Health*, *2*, 100086. https://doi.org/10.1016/j.fhfh.2022.100086.

Raj, G. V. S. B., Dash, K. K., Shams, R., Mukarram, S. A., & Kovács, B. (2024). Development of kiwi fruit leather incorporated with hydrocolloids and betacyanin microcapsules: Rheological behaviour and release kinetics of betacyanin. *Applied Food Research*, *4*(2), 100596. https://doi.org/10.1016/j.afres.2024.100596.

Rajoriya, D., Bhavya, M. L., & Hebbar, H. U. (2021). Impact of process parameters on drying behaviour, mass transfer and quality profile of refractance window dried banana puree. *LWT*, *145*, 111330. https://doi.org/10.1016/j.lwt.2021.111330.

Rangani, S. C., & Ranaweera, K. K. D. S. (2023). Incorporation of natural antioxidants extracted from strawberry, cinnamon, beetroot, and ginger; into virgin coconut oil for expansion of its shelf life. *Applied Food Research*, *3*(2), 100325. https://doi.org/10.1016/j.afres.2023.100325.

Riansyah, A., Supriadi, A., & Nopianti, R. (2014). Pengaruh perbedaan suhu dan waktu pengeringan terhadap karakteristik ikan asin sepat siam (Trichogaster pectoralis) dengan menggunakan oven. *Jurnal*

FishtecH, *2*(1), 53–68. https://doi.org/10.36706/fishtech.v2i1.1103.

Samakradhamrongthai, R. S., Nortuy, N., Sangsee, O., Srichan, P., Sangpimpa, W., Jannu, T., Supawan, T., Chanakun, P., Yimkaew, Y., & Renaldi, G. (2024). Effect of stevia syrup, okra fruit powder, and Thai white chili on physicochemical properties and sensory qualities of confectionery jam. *LWT*, *194*, 115797. https://doi.org/10.1016/j.lwt.2024.115797.

Shinwari, K. J., & Rao, P. S. (2018). Stability of bioactive compounds in fruit jam and jelly during processing and storage: A review. *Trends in Food Science & Technology*, *75*, 181–193. https://doi.org/10.1016/j.tifs.2018.02.002.

Singh, L. J., & Tiwari, R. B. (2019). Development of Nutritious Fruit Leather by Blending Guava and Papaya. *International Journal of Current Microbiology and Applied Sciences*, *8*(07), 813–820. https://doi.org/10.20546/ijcmas.2019.807.098.

Sofyan, A., & Kusumawardani, T. P. (2022). Karakteristik fisikokimia selai umbi bit (Beta vulgaris) dengan penambahan variasi konsentrasi pure labu kuning (Cucurbita moschata). *Ilmu Gizi Indonesia*, *6*(1), 69. https://doi.org/10.35842/ilgi.v6i1.356.

Solichah, W., Utomo, D., & Utami, C. R. (2023). Pengaruh konsentrasi CMC (Carboxyl Methyl Cellulose) dan gula aren terhadap fisikokimia dan organoleptik selai umbi bit (Beta vulgaris L.) ekstrak jahe merah. *Teknologi Pangan : Media Informasi Dan Komunikasi Ilmiah Teknologi Pertanian*, *14*(1), 118–131. https://doi.org/10.35891/tp.v14i1.3784.

Suna, S., & Özkan-Karabacak, A. (2019). Investigation of drying kinetics and physicochemical properties of mulberry leather (pestil) dried with different methods. *Journal of Food Processing and Preservation*, *43*(8). https://doi.org/10.1111/jfpp.14051.

Tontul, I., & Topuz, A. (2017). Effects of different drying methods on the physicochemical properties of pomegranate leather (pestil). *LWT*, *80*, 294–303. https://doi.org/10.1016/j.lwt.2017.02.035.

Viola, E., Mannino, G., Serio, G., La Rosa, L., Garofalo, G., Schicchi, R., Settanni, L., Gentile, C., & Gaglio, R. (2024). Phytochemical profiling and investigation of antioxidant, anti-proliferative, and antibacterial properties in spontaneously grown Sicilian sumac (Rhus coriaria L.) fruits. *Food Bioscience*, *61*, 104704. https://doi.org/10.1016/j.fbio.2024.104704.

Wang, T., Liu, L., Rakhmanova, A., Wang, X., Shan, Y., Yi, Y., Liu, B., Zhou, Y., & Lü, X. (2020). Stability of bioactive compounds and in vitro gastrointestinal digestion of red beetroot jam: Effect of processing and storage. *Food Bioscience*, *38*, 100788. https://doi.org/10.1016/j.fbio.2020.100788.

Wang, Z., Wu, G., Shu, B., Huang, F., Dong, L., Zhang, R., & Su, D. (2020). Comparison of the phenolic profiles and physicochemical properties of different varieties of thermally processed canned lychee pulp. *RSC Advances*, *10*(12), 6743–6751. https://doi.org/10.1039/C9RA08393F.

Yılmaz, F. M., Yüksekkaya, S., Vardin, H., & Karaaslan, M. (2017). The effects of drying conditions on moisture transfer and quality of pomegranate fruit leather (pestil). *Journal of the Saudi Society of Agricultural Sciences*, *16*(1), 33–40. https://doi.org/10.1016/j.jssas.2015.01.003.

Yunita, M., & Rahmawati, R. (2015). Pengaruh lama pengeringan terhadap mutu manisan kering buah carica (Carica candamarcensis). *Jurnal Konversi*, *4*(2), 17. https://doi.org/10.24853/konversi.4.2.17-28.