Vol. 11, No. 4 (2022) : 549 - 560
DOI : http://dx.doi.org/10.23960/jtep-l.v11i4.549-560

JURNAL TEKNIK PERTANIAN LAMPUNG

ISSN 2302-559X (print) / 2549-0818 (online)
Journal homepage : https://jurnal.fp.unila.ac.id/index.php/JTP

Physical, Chemical, and Organoleptic Characterization of Beetroot Leather (*Beta vulgaris* L.) with Additional CMC and Carrageenan

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Article History :

Received : 15 July 2022
Received in revised form : 27 August 2022
Accepted : 9 September 2022

Keywords :
Beetroot Leather,
Carrageenan,
Characterization,
CMC,
Organoleptic

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ABSTRACT

The beetroot leather with CMC (Carboxyl Methyl Cellulose) or carrageenan as a binder resulted in beetroot leather with a dense clay texture and a good level of plasticity. Based on the benefits and content of beetroot and the addition of CMC and carrageenan, this research tries to characterize beetroot leather's physicochemical and organoleptic characteristics from various concentrations and types of thickening agents. This study was arranged in RBD (Randomized Block Design) with 6 treatments and 4 repetitions. CMC was expressed as factor X and carrageenan as factor Y with each concentration level (0.1%; 0.3%; 0.5%). Beetroot leather was tested physically, chemically, shelf life, and organoleptically. Physical tests include color and texture tests. Chemical tests include moisture, ash, antioxidant capacity, and total sugar. The data from observing physical and chemical properties were processed using the ANOVA (Analysis of Variance) method, further tested using DMRT (α=5%) and organoleptic using the Likert scale. The best treatment was found in X1Y1 (CMC 0.1%), which has good physicochemical content with a hardness level of 173.13g, deformation 2.07mm, dark purplish gray color, moisture content 15.72%, ash content 5.23%, total sugar 67.82%, and antioxidants 42.06%. Beetroot leather is easy to consume and has the best hardness level with a moisture content that is not too high, so it is not easily damaged. The organoleptic test showed that the respondents could not distinguish the five treatments and expressed their liking for all beetroot leather products.

1. INTRODUCTION

Beetroot is one of the root crops that have good health benefits. Beets contain dietary fiber, and are rich in antioxidants, and various types of vitamins. One of the antioxidants contained in beets is betalain pigment which can be used as a natural coloring agent for food (Biancardi *et al*., 2010). Betalain pigments are a combination of betacyanin and betaxanthin pigments. Almost all beets are filled with betacyanin pigments 80% or more.

Beetroot is known to have various benefits, however, beetroot has a weakness, namely the level of public interest in consuming beetroot is very low because it has a strange taste and earthy taste (Chasparinda *et al*., 2014; Widyaningrum & Suhartiningsih, 2014). The consumption rate of beetroot in Indonesia is still less than 1% therefore, product developments are needed (Kementrian Kesehatan Republik Indonesia, 2010). Considering the advantages and the lack of interest in ingesting beets among the general public, it is required to process beetroot in order to produce goods that the public will accept. Beetroot processing is currently only used to create products that cannot be consumed directly, such as sugar beet (Biancardi *et al*., 2010), beetroot jam (Sofyan & Afida 2019), and beetroot flour (Amelia et al, 2016). This method of beetroot processing involves creating beetroot leather, which can be consumed immediately.

Beetroot leather or fruit leather is a dry confectionery in the form of a thin layer with a distinctive original taste of the fruit used (Puspasari *et al*., 2005). Beetroot leather is easy to produce and can increase sales value because it is a healthy snack. In addition, it can extend the shelf life compared to fresh fruit, and the nutritional content of fresh fruit does not change much (Raab & Oehler, 2000; Kwartiningsih & Mulyati 2005). Fruit leather can be made with various fruit mixtures which have been done by various previous researchers, namely fruit leather made from papaya (Raab & Ohler, 2000), guava (Babalola *et al*., 2002), cashew (Nurlaely, 2002), mango (Azeredo *et al*., 2006), a mixture of soursop and rosella (Historiarsih, 2010), jackfruit (Okilya *et al*., 2010), a mixture of mango and rosella (Safitri, 2012), jackfruit dami (Erni, 2019), and kenitu fruit (Herlina *et al*., 2020).

Although the raw materials used to make beetroot leather are high in fiber, it is likely that the finished product will have a thick and plastic texture. Therefore, add carrageenan and carboxymethyl cellulose (CMC) binder as a result (Kusbiantoro *et al*., 2005). The technique of making beetroot leather with CMC and carrageenan binders with certain types and concentrations results in beetroot leather which has a dense clay texture and a good level of plasticity (Fauziah *et al*., 2015; Herlina *et al*., 2020).

Herlina *et al*. (2020) reported that the fruit leather of the kenitu fruit used CMC and carrageenan concentrations of 0.1%-0.5%; yellow watermelon fruit leather used CMC concentrations of 0.5%-1.5% (Fitriana, 2021); and used carrageenan with a concentration of 0.3%-0.9% (Marzelly *et al*., 2017). From previous studies, the use of CMC carrageenan ranged from 0.1%-1.5% with the best treatment potential of 0,1%. Therefore, this study used CMC and carrageenan with the best potential concentration from previous fruit leather studies. Based on the benefits and content of beetroot as well as the addition of CMC and carrageenan, this research aimed to characterize the physicochemical and organoleptic characteristics of beetroot leather from various concentrations and types of binders.

2. MATERIALS AND METHODS

The research was conducted from August 2021 to January 2022 at the Agricultural Product Processing Laboratory, Faculty of Agriculture and Business, Satya Wacana Christian University. Research materials included: red beetroot var. Ayumi 04 harvested after 3 months of age from Sumberejo Village, Ngablak District, Magelang Regency; white crystal sugar (Sugar); citric acid (Elephant Stamp); CMC (Food grade);

carrageenan (Food grade); distilled water, DPPH (2,2-diphenyl-1-picrylhydrazyl), and alcohol. The research tools included a Royal Horticulture Society (RHS) color chart, Textur Analyzer (Brookfield CT), UV-Vis 1280 spectrophotometer (Shimadzu), gas stove (Hitachi), blender (ECC Hi-power blender), Teflon pan (Maxim®), Oven (Memmert), and a beaker.

Six treatment combinations with four replications were arranged in randomized block design (RBD). CMC and carrageenan addition was 0,25g; 0,75g; 1,25g which was equivalent to 0,1%; 0,3% and 0,5% (Table 1).

Table 1. Formulation beetroot leather

Treatment	Material (g)					Total (g)
	Sugar	Citric Acid	Puree Beet	CMC	Carrageenan	
X1Y1	25	0,25	224,5	0,25	-	250
X1Y2	25	0,25	224,0	0,75	-	250
X1Y3	25	0,25	223,5	1,25	-	250
X2Y1	25	0,25	224,5	-	0,25	250
X2Y2	25	0,25	224,0	-	0,75	250
X2Y3	25	0,25	223,5	-	1,25	250

Beetroot leather was prepared by washing red beetroot and washing them with running water. The beetroot was cleaned by peeling off the rind and was then split into pieces. As much as 750 g of clean material was mashed using a blender for ± 2 minutes with the addition of water in a ratio of 1:1. The blending process produced beet pulp or pure. The puree was then put into a tin and weighed according to the treatment formulation. Into the puree was then added CMC and carrageenan according to the treatment in Table 1. The puree was then mixed using a blender for ± 2 minutes. Each treatment that has been mixed was then heated using Teflon over medium heat until it boils. The fire was then reduced to a temperature 75^{o}C and heated for 2 minutes while stirring until the mixture is homogeneous. The dough was then poured on a baking sheet that has been lined with sulfate cloth with a thickness of about 2 mm. The dough was then dried in an oven at 70^{o}C for 17 hours. After 17 hours, the beetroot leather product was removed from the oven, separated from the adhesive cloth, then cut into pieces of 3x10 cm in size for easy consumption. The procedure for making beetroot leather is shown in Figure 1.

Beetroot leather was then tested for its physical, chemical, and organoleptic characteristics as well as its shelf-life. Physical tests include color testing using an RHS color chart and texture using a texture analyzer (Lutfi *et al.*, 2017). Chemical quality testing of beetroot leather included moisture content using the thermogravimetric method (AOAC, 2005), ash content refers to (Sudarmadji *et al.*, 1997), antioxidant capacity test using the DPPH method (Zakaria et al., 2008), total sugar test using the Luff Schoorl method, organoleptic and shelf-life with the use of LDPE plastic sack.

The organoleptic test was conducted using the 5-point scale with parameters including color, aroma, taste, and texture using 30 panelists aged 18-23 years. Panelists were asked to determine a product score between 1-5 with the following details: Very like (score 5); Likes (score 4); Slightly like (score 3); Neutral (score 2); Dislike (score 1). The data from the observation of physical and chemical properties were processed using the ANOVA (Analysis of Variance) method of variance (α = 5%), and further tested using DMRT (Duncan's Multiple Range Test), while organoleptic using a Likert scale (Sugiyono, 2013).

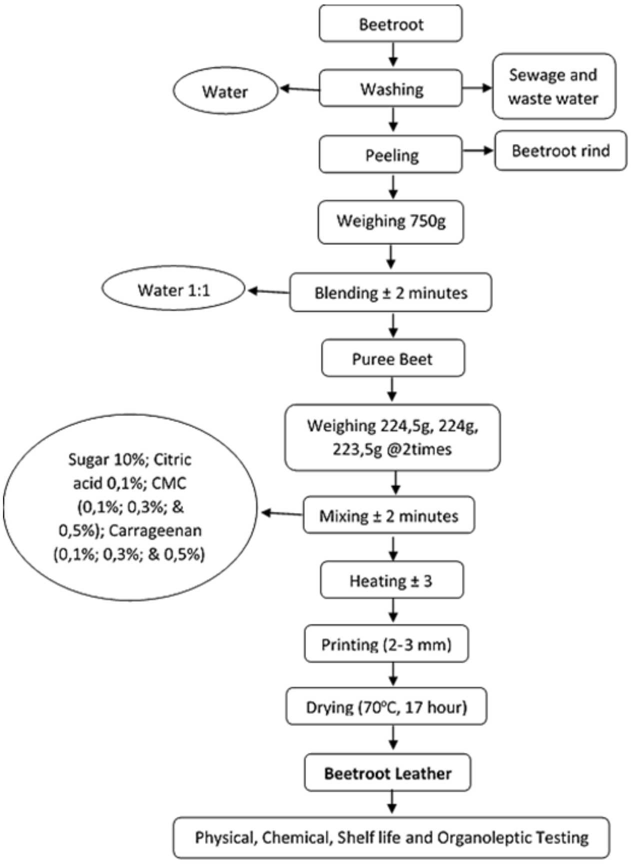

Figure 1.The procedure of making beetroot leather

3. RESULTS AND DISCUSSION

3.1. Physical Characteristics of Beetroot Leather

In this study, the physical characteristics tested included hardness at the level of hardness, deformation, and color. Hardness is the maximum peak at the first pressure or is used to describe the fineness of the crumb of the product. While deformation is a change in shape that occurs in the product after being subjected to violent pressure. The color of the product is one of the factors of consumer interest in buying a product. Table 2 shows the physical characteristics of beetroot leather products.

Table 2. Physical characteristics of beetroot leather

Treatment	Hardness (g)	Deformation (mm)	Color
X1Y1	173.13 ± 28.26^{b}	2.07 ± 0.13^{a}	*Dark purplish grey*
X1Y2	253.75 ± 78.36^{ab}	4.52 ± 5.05^{a}	*Dark purplish grey*
X1Y3	314.38 ± 79.64^{ab}	2.65 ± 0.31^{a}	*Dark purplish grey*
X2Y1	160.25 ± 39.93^{b}	1.75 ± 0.21^{a}	*Dark purplish grey*
X2Y2	199.75 ± 77.14^{ab}	1.60 ± 0.00^{a}	*Dark purplish grey*
X2Y3	271.25 ± 93.65^{ab}	1.52 ± 0.10^{a}	*Dark purplish grey*
F. Count	2.7	1.17	
CV	32.27	89.55	

Note: The numbers followed by different letters (in the same column) show a significant difference according to the DMRT test at the 5% level. F. Count (F value is the result of a comparison using F table on ANOVA), CV (comparison of standard deviation with the average calculation and expressed in proportion).

Hardness is the amount of force that is applied until there is a change in the shape of the sample (Indiarto *et al*., 2012). Table 2. shows the level of addition of concentrations in either CMC or carrageenan was significantly different on the hardness of beetroot leather and the interaction between the two was not significantly different in X1Y1 and X2Y1. CMC and carrageenan are potential hydrocolloids as thickening agents, because of their gel-forming, stable, elastic, and printable properties. This is thought to occur because the water bound in the hydrocolloid network (binding material) is increasing. This is in accordance with Herlina *et al*. (2020) who states that the higher the added hydrocolloid level, the more compact the gel matrix will be, so it can reduce the hollow structure which can reduce elasticity and increase hardness.

Deformation is a percentage of the number of pressings on a product that can change shape when a compressive force is applied (Asmoro *et al*., 2017). Table 2 depicts the hardness of beetroot leather with deformation that is not significantly different, indicating that customers can consume the product with a chewy texture, similar to candy leather in general, namely: solid, plastic, soft, can be chewed and sucked.

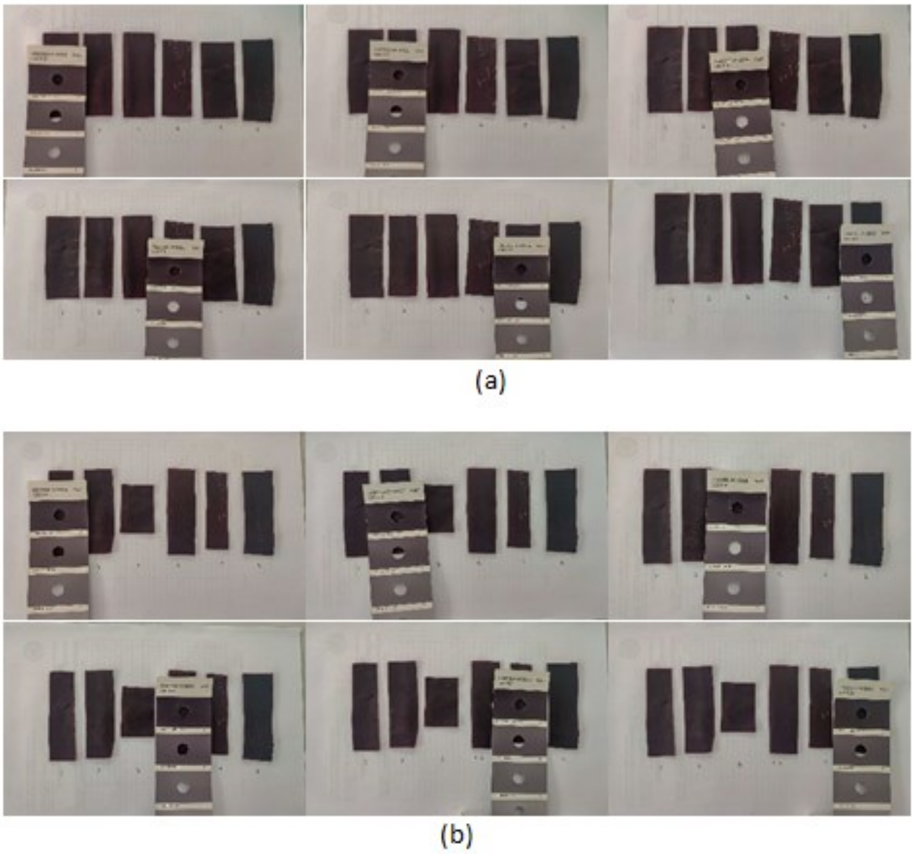

Figure 2. Beetroot Leather Color Parameters (a) Room temperature and (b) Refrigerator temperature

Color is one of the determining factors for the quality of a processed product and is a consumer preference. The color produced by both types of binder CMC and carrageenan produces the same color, namely dark purplish gray as shown in Figure 2.

The resulting color is the basic color of the beetroot used. After processing, there was no difference in color between the raw material and the beetroot leather product. Therefore, beetroot leather products do not experience food degradation, even though they have been cooked and dried. This is in accordance with the opinion of Khairunnisa *et al*. (2015) and Nurkaya et al. (2020) who state that the color of fruit leather products will be influenced by the color of the raw materials used.

3.2. Chemical Characteristics of Beetroot Leather

The chemical characteristics tested were moisture content, ash content, total sugar, and antioxidants. Analysis of chemical properties is intended to determine the shelf life of the product, the total content, and the suitability of the product with the provisions of the established Standard National Indonesia (BSN, 1996). The chemical characteristics of beetroot leather can be seen in Table 3.

Moisture content in food is an important component because it can affect the appearance, texture, taste, freshness, and shelf life (Zulkipli, 2016). Table 3. shows that the types and concentrations of the X1Y2 and X2Y2 treatments were not significantly different, while the other treatments were significantly different. The addition of carrageenan produced a higher moisture content than the addition of CMC because of the difference in the number of fibers in the binder used, so it can affect the ability to bind water. Carrageenan contains a higher total dietary fiber than CMC, which is 83.62 g/100g (Santoso et al., 2004, while the fiber content in CMC is 74 g. 100g (Muzafa, 2006). In line Santoso (2011) reported that high fiber content can increase the ability to absorb water due to the presence of free hydroxyl groups that are polar in sufficient quantities.

Moisture content is a factor that greatly affects the quality of food, so water is often removed or reduced in the food processing process by evaporation or drying (Yunita and Rahmawati, 2015). Table 2 shows that the level of moisture content affects the hardness of the product (hardness) which results in the treatment with the addition of carrageenan being softer than CMC. According to Nurlaely (2002), good fruit leather has a moisture content value of 10-20%, so the moisture content value in beetroot leather at all concentration levels has met the requirements.

Table 3. Chemical characteristics of beetroot leather

Treatment	Moisture Content (%)	Ash Content (%)	Total Sugar (%)	Antioxidant (%)
X1Y1	15.72 ± 0.00^{c}	5.23 ± 0.97^{b}	67.82 ± 21.02^{a}	42.0 ± 4.97^{a}
X1Y2	16.62 ± 0.01^{b}	6.44 ± 0.28^{b}	70.22 ± 8.30^{a}	42.58 ± 7.92^{a}
X1Y3	13.50 ± 0.00^{e}	7.74 ± 1.33^{a}	62.41 ± 19^{a}	43.58 ± 5.66^{a}
X2Y1	14.82 ± 0.00^{d}	6.19 ± 1.36^{b}	70.36 ± 5.20^{a}	45.19 ± 5.10^{a}
X2Y2	16.90 ± 0.00^{b}	5.96 ± 0.71^{b}	69.21 ± 12.73^{a}	44.33 ± 11.34^{a}
X2Y3	19.27 ± 0.00^{a}	5.92 ± 0.54^{b}	72.22 ± 5.26^{a}	42.27 ± 3.69^{a}
F. Count	113.94	4.99	0.34	0.16
CV (%)	2.3	11.96	17.11	14.35

Note: The numbers followed by different letters show a significant difference according to the DMRT test at the 5% level. F. Count (F value is the result of a comparison using F table on ANOVA), CV (comparison of standard deviation with the average calculation and expressed in proportion).

Table 3 shows the level of ash content in the X1Y1, X1Y2 and X2Y1, X2Y2, X2Y3 treatments whose results were not significantly different, while the X1Y3 treatment was significantly different from the other treatments. Khairunnisa *et al.* (2015), this happens because CMC contains mineral salts that are inorganic, so when burning, the inorganic content in it does not burn. According to Sudarmadji *et al.* (1997), the determination of ash content is closely related to the mineral content contained in a food ingredient. Furthermore, Winarno (2008) stated that the ash content is a mineral element or inorganic substance that does not burn during combustion. In line Sudarmadji *et al.* (1997) and Winarno (2008), the results of the burning or ashing process carried out on fruit leather cause organic substances to burn.

The total sugar contained in the beetroot leather product is shown in Table 3. All treatments were not significantly different. This is presumably because the concentration of sugar in each treatment was not different, so there was no difference in the results of the total sugar level of beetroot leather. The water activity of the food is reduced, so sugar is involved in the preservation or can extend the shelf life of beetroot leather. Panigoro *et al.* (2019) says the total yield of beetroot leather sugar has met the standard of SNI No. 1718 (BSN, 1996) which is at least 40%.

A compound's antioxidant activity is assessed by its capacity to scavenge free radicals. DPPH is a stable free radical compound that is used as a reagent in dissolved free radical scavenging assays and is often utilized as a model in assessing the scavenging power of free radicals (Amelia, 2011). The antioxidant content of fruit leather was examined using the DPPH method, the findings of the analysis were not significantly different in each treatment, and antioxidant content was only measured on the finished product. As a result, it is believed that the processing process and the inclusion of binders such as CMC and carrageenan have no effect on antioxidants.

3.3. Shelf-life

Storage of beetroot leather is done to determine the shelf life of the product (Sari *et al.*, 2015). The peels of the beetroot were separated into four portions for storage at room temperature and refrigerator temperature in each treatment. At room temperature, each treatment received two samples: one to quantify weight loss and the other to measure color changes and determine whether the product was microbial. Table 4 shows the increase in weight, it is suspected that beetroot leather absorbs moisture in the air around storage, so the longer the product is stored, the higher the moisture content of the product and has the potential to cause accelerated product damage and fungal and bacterial contamination. Table 4 shows a non-significant weight loss, it is suspected that the fruit peels absorb moisture from the surrounding air, so the longer the product is stored and can increase the risk of product damage and mold. and bacterial contamination.

The usage of packaging affects the shelf life of a product (Diamente *et al.*, 2014). The packaging is made of LDPE (Low-Density Polyethylene). LDPE is a plastic that can be used for storage because it cannot be destroyed while remaining safe for food (Setyowati *et al.*, 2017). The greatest fluctuations in humidity and water activity can be produced by LDPE. The texture of samples packaged in LDPE is also affected, with an increase in product hardness.

Figure 3 shows that there was no significant change in the storage from day 0 to day 24. The storage process was carried out for 24 days because on day 27 the product stored at room temperature was found to be moldy, therefore storage was not continued. The appearance of mold on the product is suspected because during the storage process, the product is often opened to measure the weight loss.

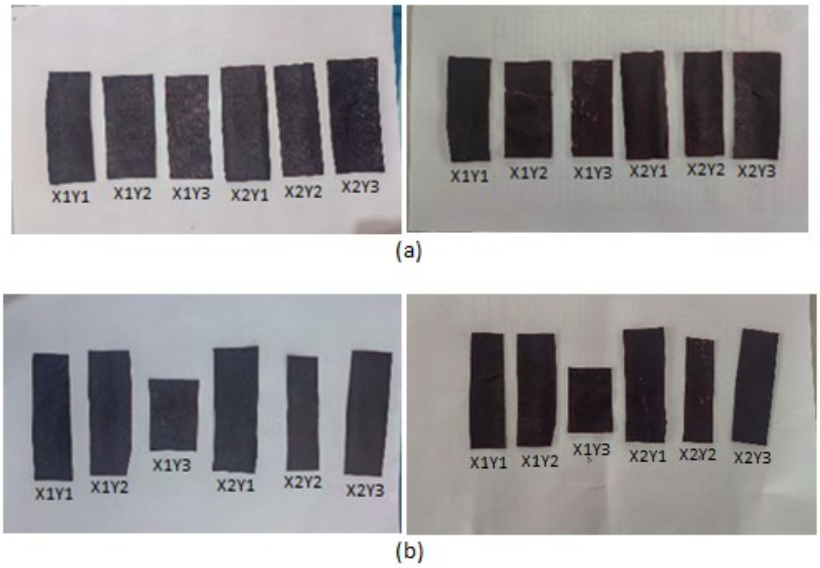

Figure 3. Initial and Final Storage of Beetroot Leather (a) Room Temperature and (b) Refrigerator Temperature (top left of day 0 room temperature storage, top right of 24th -day room temperature storage, bottom left of 0th-day refrigerator temperature storage, and bottom right of 24th-day refrigerator temperature storage

3.4. Organoleptic

Organoleptic test parameters include: color, texture, taste, and aroma. The levels of the hedonic scale used are very like, like, slightly like, neutral, and do not like (Soekarto, 2002). Panelists' responses to beetroot leather products are shown in Table 5.

Based on the Likert scale the results of the organoleptic test analysis on the color of the beetroot leather product showed that the value obtained was in the preferred category for each treatment. The resulting color is purplish red like the color of fresh beetroot. Glicksman (1983), stated that the stabilizer had no effect on the color and smell of fruit leather. Therefore, beetroot leather products do not experience food degradation, even though they have been cooked and dried. This is in accordance with the opinion of Khairunnisa *et al.* (2015) and Nurkaya *et al.* (2020), which states that the color of fruit leather products will be influenced by the color of the raw materials used.

Taste is an important factor in determining product acceptance. The results of the analysis obtained a favorable category for the treatment with CMC X1Y1; X1Y2; X1Y3 and carrageenan in the X2Y1 treatment, while in the X2Y2 and X2Y3 treatment, the analysis obtained a somewhat favorable category. This is in accordance with the research of Herlina *et al.* (2020) which states that CMC and carrageenan have no taste (bland) and have no effect on the taste of fruit leather. The taste of beetroot leather produced is a distinctive but weak beetroot taste and is sweet and slightly sour from the addition of sugar and citric acid.

The results of the analysis of the aroma of beetroot leather were obtained in the like category for each treatment except for the X2Y2 treatment, which was in the like category. The panelists were unable to detect a difference in aroma between treatments because of the use of pureed beet raw material, which is not significantly different for the concentration of use, making the aroma more dominant sweet and sour and a little distinctive beetroot aroma. This is likely because fruit leather is a dry candied sheet with a characteristic aroma from the raw material. This is due to the fact that CMC and carrageenan synthesized from seaweed do not have a recognizable scent (Nurkaya *et al*., 2020). According to Futeri *et al*., (2019), CMC is an anionic, colorless to yellowish, odorless, and tasteless cellulose polymer ether. Moreover, because it is non-toxic, beetroot leather is unaffected.

Table 5. The organoleptic score of beetroot leather produced with different carrageenan and CMC addition

Treatment	Color		Taste		Aroma		Texture	
	IV (%)	D	IV (%)	D	IV (%)	D	IV (%)	D
X1Y1	62.00	L	61.33	L	53.33	SL	63.33	L
X1Y2	62.66	L	68.66	L	53.33	SL	66.66	L
X1Y3	66.66	L	64.66	L	56.00	SL	59.33	SL
X2Y1	64.66	L	67.33	L	60.66	L	57.33	SL
X2Y2	62.66	L	54.66	SL	52.66	SL	53.33	SL
X2Y3	67.33	L	57.33	SL	56.00	SL	64.00	L

Description: IV (index value), D (Description), L (like) and SL (slightly like)

The texture produced by beetroot leather can be seen in Table 5. Based on this data, the results of the analysis were categorized as liking the X1Y1, X1Y2 and X2Y3 treatments, while the other treatments were categorized as slightly like. The resulting texture is not too tough and not too soft, because it may be influenced by the moisture content. While in the treatment of carrageenan, the more addition of carrageenan can increase the elasticity of the texture of beetroot leather, Pietrasik & Jarmolouk (2003) stated that the higher the hydrocolloid added, the texture will become softer because more water is added.

4. CONCLUSION

Based on the analysis results of beetroot leather with the type of variation and concentration of CMC binder and carrageenan were not significantly different in physical, chemical (total sugar and antioxidants), and organoleptic characteristics, but significantly different in chemical properties (moisture content and ash content). Storage of beetroot leather for 24 days did not change from day 0 to day 24. The comparison treatment of CMC and carrageenan were classified as favored by the panelists for the organoleptic values of color, taste, aroma and texture (slightly like to like). The best treatment and recommendation were found in X1Y1 which had good physicochemical content, was easy to consume, and the level of hardness was the best weight.

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