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RESEARCH PAPER

Effect of glucomannan and sugar concentration for physicochemical and organoleptic characteristics of dragon fruit skin slice jam

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Abstract

The high consumption of dragon fruit causes a high amount of dragon fruit skin waste produced that still has benefits and nutritional value. *Amorphophallus oncophyllus* contain high glucomannan. Glucomannan as a hydrocolloid has gelling agent properties. Water in food can also be reduced in the presence of sugar which has hygroscopic properties. The purpose of this research is to describe effect of glucomannan and sugar concentration for physicochemical and organoleptic dragon fruit skin slice jam. The treatments are glucomannan (1%, 1.5%, 2%), sugar (10%, 15%, 20%), and single control (glucomannan 1% with sugar 0%). Samples were analyzed by color, water activity, syneresis, total solid soluble (TSS), texture, and hedonic test. The result showed that the addition of glucomannan and sugar significantly affect decrease of water activity, syneresis and increase TSS and texture. Based on overall hedonic test, panelist preferred 1% glucomannan with 15% sugar formulation.

1. Introduction

Indonesia has a variety of thousands of types of flora that grow from Sumatra to Papua, one of them is the Porang tuber plant (*Amorphophallus oncophyllus*) (Pramula, 2015). This plant has an export increase of 174.7% from 11,721 tons in 2019 to 20,476 tons in 2022 [Kementerian Pertanian RI (Kementan RI), 2022]. Porang tubers contain glucomannan where the glucomannan content in glucomannan flour reaches 63.20% (Aryanti and Abidin, 2015). Glucomannan is used as a gelling agent, such as a thickener or water binder (Khasanah, 2017). Similar to glucomannan, sugar has water binding properties. The higher the concentration of added sugar, the texture is harder because the water content is reduced.

Slice jam is the result of a modification of jam in general which is plastic and has a semi-solid texture (Kurnia *et al.*, 2021). The characteristics of the jam are bright, clear, and have a real fruit taste. Dragon fruit is a red fruit that is widely found and used as a processed food (Sujatmiko, 2016). The high consumption of dragon fruit, increase the waste of dragon fruit skin that produced. However, dragon fruit skin is often thrown away because not many people know the content and benefits of dragon fruit skin. Therefore, it is necessary to develop research on dragon fruit peels that can still be processed into foods such as jam that reduce food waste (Wibowo, 2021). This research will study the changes in physicochemical and organoleptic characteristic of dragon fruit skin slice jam with the ratio of glucomannan and sugar concentration.

2. Materials and methods

2.1 Materials

Dragon fruit skin used from dragon fruit (*Hylocereus costaricensis*) were mashed using a blender with water added in a ratio of 1:1 to form a puree. Glucomannan concentration used was 1%, 1.5% and 2%, while sugar concentration used was 10%, 15% and 20%. Puree, glucomannan, and sugar were cooked at 80-90°C for 10 mins. After that, it was molded and cooled in the refrigerator for 24 hrs (for syneresis analysis). The control used was 1% glucomannan with 0% sugar.

2.2 Color and water activity analysis

Color analysis was determined using colorimeter (Portable Colorimeter 3nh NH310, China) with the results shown as CIE L*a*b*, CIE L*C*H*, and color difference (ΔE). Analysis of water activity was done using aw meter (Aqua Lab 4-TE, Decagon) by following instrument's guidelines.

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2.3 Syneresis analysis

The gravimetric method was used to determine syneresis. The sample was stored in the refrigerator (~4°C) for 24 hrs.

2.4 Total solid soluble measurement

The sample (slice jam) was measure using hand refractometer (<50%). Hand refractometer is held at an angle of 90°. The measurement results are read from the lenses of two refractometers, right at the border of the blue and white areas, expressed in °Brix units.

2.5 Texture analysis

Texture testing was carried out using a texture analyzer (rheotex) which measures the hardness of the slice jam with a size of 4×4 cm. The probe used is a cylindrical probe, with Triger Point of 0.005 gf, Test Speed of 1 mm/s, and Target Value adjusted to ½ of the sample depth (0.0025 m). The probe moves downwards to compress the sample and then return automatically. Texture measurement results are expressed in units of N (Newtons) in graph that was shown in the computer. The hardness level is seen from the peak value at the first pressure.

2.6 Organoleptic analysis

Hedonic test is conducted to determine the preference of the product. About thirty-five untrained panelists were asked for their preference of the dragon fruit skin slice jam. The scale range that used for the hedonic test is about 1-7, which is 1 represent very dislike and 7 represent very like.

2.7 Statistical analysis

Results of analysis were shown as mean ± standard deviation from 3 replications. The statistical method used were the One-Way ANOVA (analysis of variance) following Duncan's post hoc if there is a significant difference at $p<0.05$ through IBM SPSS application.

3. Results and discussion

3.1 Effect of glucomannan and sugar on color, water activity, syneresis, total solid soluble, and texture for slice jam

Color is an important parameter in food, because the first thing that will affect or attract attention is the physical. In addition, color can also be a factor to determine the quality of the food produced. Differences in ingredients, temperature, time, and the way food products are processed can determine different qualities and characteristics (Hartini, 2018). The data in Table 1 shows the results of the analysis carried out on the color parameters of dragon fruit skin slice jam, including L* (lightness), a* (redness), b* (yellowness), C* (chroma), H* (hue), and ΔE (color difference) from the addition of glucomannan and sugar concentrations. Increasing Mailard reaction can be caused by increasing sugar concentration. From the results below, it can be seen that the higher the concentration of added sugar, the value of L*, a*, and H* decrease. Decreasing L* value indicates that the jam is getting darker in color due to the formation of melanoidin compounds during the Mailard reaction (Waskita *et al.*, 2014). The value of C* also decreased which could be due to the fact that the sugar used was not pure and contained a lot of ash or mineral content, so that the addition of sugar could make the slice jam not clear/opaque (Hartini, 2018).

Meanwhile, the addition of glucomannan as a hydrocolloid can increase the value of L*, b*, and H*. Increasing L* value could be caused by the white color of glucomannan flour (90.05% whiteness) (Widjanarko *et.al.*, 2015). An increasing H* value means that the slice jam has an increasingly yellow hue of the corners. This can be caused by glucomannan flour derived from yellow porang tubers. However, the overall value of H* resulting from the addition of sugar and glucomannan is still included in the red corner hue (scale 0-60) (Nurlela, 2021). For the results of color differences (ΔE), there was no significant difference in the sugar concentration factor.

Water activity can indicate microbial growth. The lower the water activity, the smaller the chance of microbes to grow so that the shelf life of slice jam is longer. From tha data in Table 2, the addition of glucomannan and sugar affects the decrease in water activity significantly. This result is an expected result because it indicates the addition of glucomannan and sugar can extend the shelf life of slice jam. Glucomannan as a gelling agent and sugar which has hygroscopic properties are able to bind water very well, thereby reducing water activity (Yulistiani *et al.*, 2013).

Syneresis is the process of releasing water from food that can be associated with product storage. Based on the results in Table 3, the addition of glucomannan and sugar can significantly reduce the syneresis value of slice jam. The decrease in the syneresis value in slice jam is desirable because it means that the slice jam cannot release water during storage. Glucomannan, which is a gelling agent, is also capable of forming colloidal dispersion, also known as a double helix structure, and becomes stronger so as to maintain the release of water which causes syneresis (Anggreana *et al.*, 2019). Likewise, the addition of sugar can cause the double helix bond that is formed to be stronger so that the water molecule gets stronger and lowers the syneresis value

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Table 1. Effect of glucomannan and sugar on color for dragon fruit skin slice jam.

Color	Treatment	Glucomannan 1%	Glucomannan 1.5%	Glucomannan 2%
L*	Control	35.877±0.211^{A}	-	-
	Sugar 10%	35.763±0.287^{Aa}	35.823±0.227^{Aa}	36.063±0.232^{Aa}
	Sugar 15%	33.970±0.223^{Bb}	34.120±0.246^{Bb}	35.107±0.206^{Ba}
	Sugar 20%	32.187±0.303^{Cc}	33.990±0.121^{Bb}	34.977±0.208^{Ba}
a*	Control	15.487±0.310^{A}	-	-
	Sugar 10%	14.547±0.257^{Ba}	14.587±0.272^{Aa}	14.613±0.246^{Aa}
	Sugar 15%	13.893±0.221^{Ca}	13.940±0.270^{Ba}	14.073±0.254^{Ba}
	Sugar 20%	12.770±0.214^{Da}	12.820±0.248^{Ca}	12.993±0.247^{Ca}
b*	Control	0.553±0.135^{A}	-	-
	Sugar 10%	-0.153±0.124^{Bb}	0.003±0.105^{Aab}	0.130±0.148^{Aa}
	Sugar 15%	-0.200±0.147^{Ba}	-0.100±0.115^{Aa}	0.080±0.147^{Aa}
	Sugar 20%	-0.253±0.0923^{Ba}	-1.147±0.135^{Aa}	-0.080±0.154^{Aa}
C*	Control	15.860±0.276^{A}	-	-
	Sugar 10%	14.613±0.171^{Ba}	14.720±0.349^{Aa}	14.787±0.232^{Aa}
	Sugar 15%	13.680±0.193^{Ca}	13.753±0.282^{Ba}	13.867±0.247^{Ba}
	Sugar 20%	12.750±0.135^{Da}	12.803±0.215^{Ca}	12.847±0.288^{Ca}
H*	Control	35.547±0.300^{Ac}	-	-
	Sugar 10%	25.130±0.286^{Bc}	29.393±0.330^{Ab}	32.677±0.3837^{Aa}
	Sugar 15%	20.463±0.124^{Cc}	25.610±0.148^{Bb}	29.990±0.2800^{Ba}
	Sugar 20%	14.233±0.049^{Dc}	19.787±0.283^{Cb}	25.033±0.1893^{Ca}
ΔE	Control	-	-	-
	Sugar 10%	5.387±0.126^{A}	-	-
	Sugar 15%	5.410±0.106^{A}	-	-
	Sugar 20%	5.420±0.113^{A}	-	-

Values are presented as mean±SD. Values with different uppercase superscripts within the same column are statistically significantly different ($p<0.05$) between the sugar concentrations. Values with different lowercase superscripts within the same row are statistically significantly different ($p<0.05$) between the glucomannan concentrations.

Table 2. Effect of glucomannan and sugar on water activity for dragon fruit skin slice jam.

Treatment	Glucomannan 1%	Glucomannan 1.5%	Glucomannan 2%
Control	0.988±0.002^{A}	-	-
Sugar 10%	0.978±0.002^{Ba}	0.971±0.001^{Ab}	0.970±0.002^{Ab}
Sugar 15%	0.968±0.002^{Ca}	0.966±0.002^{Ba}	0.959±0.003^{Bb}
Sugar 20%	0.967±0.002^{Ca}	0.962±0.001^{Cb}	0.958±0.002^{Bc}

Values are presented as mean±SD. Values with different uppercase superscripts within the same column are statistically significantly different ($p<0.05$) between the sugar concentrations. Values with different lowercase superscripts within the same row are statistically significantly different ($p<0.05$) between the glucomannan concentrations.

Table 3. Effect of glucomannan and sugar on syneresis for dragon fruit skin slice jam.

Treatment	Glucomannan 1%	Glucomannan 1.5%	Glucomannan 2%
Control	2.153±0.080^{A}	-	-
Sugar 10%	1.663±0.081^{Ba}	1.184±0.045^{Ab}	1.017±0.050^{Ac}
Sugar 15%	1.303±0.109^{Ca}	0.947±0.106^{Bb}	0.742±0.097^{Bb}
Sugar 20%	0.907±0.765^{Da}	0.699±0.102^{Cb}	0.414±0.065^{Cc}

Values are presented as mean±SD. Values with different uppercase superscripts within the same column are statistically significantly different ($p<0.05$) between the sugar concentrations. Values with different lowercase superscripts within the same row are statistically significantly different ($p<0.05$) between the glucomannan concentrations.

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(Hartati and Djauhari, 2017).

Total solid soluble (TSS) measures all substances, both organic and inorganic substances contained in a food ingredient. TSS are affected by gelling agent and sugar content, this is because TSS are dominated by sugar content and a small amount of dissolved protein, amino acids, and other organic compounds. The results of the study on the TSS content of slice jam according with the literature where the addition of glucomannan and sugar concentrations can increase the TSS value of slice jam significantly (Table 4) (Kusumiyati *et al.*, 2020).

The results of the slice jam texture based on this study are in Table 5, showing that the higher the concentration of glucomannan added, the harder the slice jam texture. This is due to the increasing number of gels formed due to the number of hydrogen bonds so that the slice jam becomes harder and firmer (Suntoyo *et al.*, 2017). Beside glucomannan, another factor that causes the increase in the texture of glucomannan to become harder is the addition of sugar concentration. The hard texture of slice jam is caused by sugar which is able to bind water in the jam and form a harder texture due to the hygroscopic properties of sugar (Ardiansyah *et al.*, 2019).

3.2 Effect of glucomannan and sugar on slice jam organoleptic characteristic

The 15% sugar concentration formulation was chosen to produce slice jam where the concentrations of glucomannan used were 1%, 1.5% and 2% to be tested organoleptically based on the level of preference test. Organoleptic testing includes a hedonic test which is a test that aims to determine differences in quality and determine the level of preference for a product (Mardiah *et al.*, 2021). This study uses 7 rating scales where the scale is (1) very dislike, (2) dislike, (3) slightly dislike, (4) neutral, (5) slightly like, (6) like, and (7) very much like.

Based on the results of the study using 35 untrained panelists in Table 6, the addition of glucomannan only resulted in significant differences in texture attributes. The increasing concentration of glucomannan causes the level of preference for the texture of slice jam to decrease. This could be due to the large amount of gel formed so that the slice jam became harder, where the panelists did not like the texture of the slice jam that was too hard (Suntoyo *et al.*, 2017). While the addition of sugar significantly affects the taste attributes. The addition of sugar gives a sweet taste which tends to be preferred by the panelists (Marsigit *et al.*, 2019). For the overall attributes, only the addition of sugar that has a significant effect that the panelists prefer. obviously, the panelists gave their overall rate based on taste. This is because in the addition of sugar, only the taste attribute has a significant effect.

4. Conclusion

The addition of glucomannan and sugar has a significant effect on increasing the values of TPT and texture, and decreasing the value of water activity and syneresis of dragon fruit skin slice jam. From the overall hedonic test results (overall), the panelists slightly liked dragon fruit skin slice jam on 1% glucomannan and with 15% sugar formulation (5.2±1.324). The results of the physicochemical color analysis in this formulation were 33.97±0.2227 L* value; 13.89±0.2212 a* value; -0.20±0.1473 b* value; 13.68±0.1931 C* value; and

Table 4. Effect of glucomannan and sugar on TSS for dragon fruit skin slice jam.

Treatment	Glucomannan 1%	Glucomannan 1.5%	Glucomannan 2%
Control	$5.000±0.000^{D}$	-	-
Sugar 10%	$21.667±0.577^{Cc}$	$22.667±0.577^{Cb}$	$25.000±0.000^{Ca}$
Sugar 15%	$27.667±0.577^{Ba}$	$27.667±0.577^{Ba}$	$28.667±0.577^{Ba}$
Sugar 20%	$35.000±0.000^{Ac}$	$37.000±1.000^{Ab}$	$38.333±0.577^{Aa}$

Values are presented as mean±SD. Values with different uppercase superscripts within the same column are statistically significantly different ($p<0.05$) between the sugar concentrations. Values with different lowercase superscripts within the same row are statistically significantly different ($p<0.05$) between the glucomannan concentrations.

Table 5. Effect of glucomannan and sugar on texture (hardness) for dragon fruit skin slice jam.

Treatment	Glucomannan 1%	Glucomannan 1.5%	Glucomannan 2%
Control	$2.635±0.267^{B}$	-	-
Sugar 10%	$2.908±0.056^{ABc}$	$4.558±0.100^{Bb}$	$6.173±0.098^{Ca}$
Sugar 15%	$2.936±0.132^{ABc}$	$5.395±0.284^{Ab}$	$6.896±0.087^{Ba}$
Sugar 20%	$3.278±0.235^{Ac}$	$5.728±0.046^{Ab}$	$7.324±0.275^{Aa}$

Values are presented as mean±SD. Values with different uppercase superscripts within the same column are statistically significantly different ($p<0.05$) between the sugar concentrations. Values with different lowercase superscripts within the same row are statistically significantly different ($p<0.05$) between the glucomannan concentrations.

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Table 6. Effect of glucomannan and sugar on the level of preference for slice jam.

Attribute	Treatment	Glucomannan 1%	Glucomannan 1.5%	Glucomannan 2%
Color	Sugar 0%	5.543±1.291^{A}	-	-
	Sugar 15%	6.000±0.767^{Aa}	5.771±1.087^{a}	5.743±1.336^{a}
Odor	Sugar 0%	4.171±1.403^{A}	-	-
	Sugar 15%	4.600±1.143^{Aa}	4.314±1.367^{a}	4.296±1.384^{a}
Texture	Sugar 0%	4.543±1.686^{A}	-	-
	Sugar 15%	5.000±1.515^{Aa}	4.600±1.499^{ab}	3.943±1.136^{b}
Taste	Sugar 0%	2.600±1.786^{B}	-	-
	Sugar 15%	5.114±1.451^{Aa}	5.057±1.211^{a}	4.771±1.352^{a}
Overall	Sugar 0%	3.200±1.568^{B}	-	-
	Sugar 15%	5.200±1.324^{Aa}	5.000±1.306^{a}	4.743±1.197^{a}

Values are presented as mean±SD. Values with different uppercase superscripts within the same column are statistically significantly different ($p<0.05$) between the sugar concentrations. Values with different lowercase superscripts within the same row are statistically significantly different ($p<0.05$) between the glucomannan concentrations.

20.46±0.1242 H* value. Meanwhile, other physicochemical analysis of the formulation resulted in 0.968±0.0020 water activity; 1.303±0.1091% syneresis; 27.67±0.5770°Brix; and 2.936±0.1323N texture.

Conflict of interest

The authors declare no conflict of interest.

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