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Characteristics of Slice Jam Produced by Ratio of Cocoa Fruit Juice and Mulberry and Carrageenan Addition

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A B S T R A C T

Slice jam is a modification of jam from a spreadable form to a jam in the form of slice, shiny and non-sticky. The slice jam has been shaped into the surface of the bread to make it more practical. The Main ingredient for this study's slice jam is cocoa flesh with mulberry added to increase its color. Hydrocolloids in the form of carrageenan are added to make the slice jam firm. Other ingredients added are sugar, CMC, and citric acid. The goal of this study is to analyze the effect of the ratio of cocoa fruit juice and mulberry with the addition of carrageenan on the characteristics of slice jam and to determine the best treatment combination from these variations. The method used was a Completely Randomized Design (CRD) factorial pattern with Factor I, the ratio of cocoa juice: mulberry (95:5, 90:10, 85:15) and Factor II, the addition of carrageenan (3%, 4%, and 5%). The data obtained were analyzed using ANOVA followed by a DMRT further test at the 5% level. The study's results showed a significant interaction ($p \leq 0.05$). Slice jam using the ratio of cocoa fruit juice: mulberry (85:15) with the addition of 5% carrageenan is the best treatment with the characteristics of water content 33.87%; total sugar 43.94%; pH 3.61; antioxidant activity DPPH 74.04%; vitamin C 14.58 mg/100 g; water activity 0.736; hardness 83.39 gf. The resulting organoleptic properties, including color, aroma, taste, and texture, are 4.08 (like), 2.84 (dislike), 4.12 (like), 3.6 (like).

Contribution to Sustainable Development Goals (SDGs):
SDG 2: Zero Hunger
SDG 3: Good Health and Well-being
SDG 9: Industry, Innovation, and Infrastructure
SDG 12: Responsible Consumption and Production
SDG 15: Life on Land

1. INTRODUCTION

1.1. Research Background

Jam demand in Indonesia until the end of 2014 reached 1728,72 tons. Jam is a processed food product popular in public and usually consumed with bread. Generally, the jam sold in the spreadable jam is considered less practical. One of the processing developments is to make spreadable jam into slice jam. The slice jam is shaped as the surface of the bread, making the serving method more practical.

The essential ingredient that is commonly used for jam is fruit. One of the fruits that can be used is cocoa. Cocoa is usually used by its seeds to make chocolate, while the flesh is considered waste by farmers or plantation companies. Cocoa flesh has various nutritional contents, one high in antioxidants. Cocoa flesh is white and wrapped like mucus around the cocoa beans. The white color is considered less attractive when made into jam, so to make it more appealing, mulberries are added to improve the color of the jam. Mulberries have anthocyanin, which makes them reddish-black. Mulberries also contain various nutritional

contents, one of which is high in vitamin C, so they can complement the vitamin in slice jam.

Aside from fruits, making slice jam requires additional ingredients like hydrocolloids. Adding carrageenan is an essential factor that can affect the final result of slice jam, especially the texture. Carrageenan can protect phenolic compounds during heating by forming a double helix structure that binds the molecular chain into a three-dimensional network or gel, so the more carrageenan there is, the stronger the gel texture becomes. It also inhibits the oxidation of phenolic compounds.

1.2. Literature Review

Slice jam is a modified product of spreadable jam that does not yet have a specific quality standard. A good slice jam product is shaped like a slice according to the surface of the bread is not liquid or stiff [1]. Generally, good quality slice jam is when the texture is firm and consistent and has a natural fruit flavor and color [2]. The main components of making jam are pectin, sugar, and acid. The ideal fruit for making jam must contain sufficient pectin and acid to produce the right characteristics [3].

In general, jam is made from a mixture of 45 parts of weight of crushed fruit while the other 55 parts are sugar, which thicken later and forms a semi-solid structure [4]. There is a slight difference in making slice jam, which is an additional process after cooking in molding, baking, and cutting [5].

Cocoa fruit consists of three parts: skin, fruit flesh, and seeds [6]. The part of the cocoa often used is the cocoa bean for making chocolate. However, cocoa fruit flesh also has the potential to be used as a processed product because it has beneficial nutritional content, one of which is 56% of antioxidants [7]. The white cocoa fruit flesh, which looks like mucus wrapped around the cocoa beans, has a 2-3% pectin content, a pH of 3.66-3.75 [8], and a sugar content of 10-15% [9].

Mulberry has many benefits and uses. Mulberry contains antioxidants, anthocyanins, and vitamin C [10]. From its physical characteristics, mulberry is red to blackish because it has an anthocyanin pigment of 30.8 - 83 mg / 100 g [11]. Mulberry contains relatively high vitamin C of 36.4 mg [12]. Mulberry is a juicy berry fruit and tastes sour because of its pH of 3-3.8 [8].

The types of hydrocolloids used for jam-making products include carrageenan, gelatine, pectin, and alginate [13]. Carrageenan is a polysaccharide, a galactan molecule with galactose as its central unit. Carrageenan is used in making slice jam because it is a gelling agent with a sulfate content of 17.83%. Low sulfate levels indicate higher gel strength in the material [14]. Low sulfate levels in kappa-carrageenan can cause cross-linking to form an aggregate or floc, forming a stronger and more elastic gel phase [13]. The gel produced by kappa carrageenan has a solid and reversible texture [15]. However, the weakness of kappa carrageenan is syneresis [16]. Thus, another hydrocolloid, namely CMC, is added. [17] stated that CMC's function is to prevent syneresis.

1.3. Research Objective

This study aims to analyze the effect of the cocoa fruit juice mulberry ratio with the addition of carrageenan on the characteristics of slice jam and to determine the best treatment combination from these variations.

2. MATERIALS AND METHODS

2.1. Material

The materials used for this study are cocoa fruit, mulberry, kappa carrageenan, granulated sugar, citric acid, CMC. The materials for analysis include equates, 0.1% anthrone, methanol, DPPH solution, 1 N NaOH, 1 N acetic acid, 1 N CaCl2, $AgNO_3$, 1% starch, and iodine.

2.2. Research Procedures

This research was conducted experimentally using a completely randomized design (CRD) factorial pattern consisting of 2 factors: Factor I is the ratio of cocoa juice: mulberry (95:5, 90:10, 85:15), and Factor II is the addition of carrageenan (3%, 4%, 5%). ANOVA analyzed the data obtained to determine the effect of treatment with 2 replications. If there is a significant difference, further testing is carried out using the DMRT (Duncan Multiple Range Test) method at a level of 5%.

2.3. Making Cocoa Juice

Cocoa fruit is sorted to get the good ones. After sorting, the fruit is crushed to get the inside. Then the flesh is taken from the beans by adding water with ratio of 1:1 and then blended using a mixer for 40 minutes.

2.4. Making Mulberry Juice

Mulberries are sorted to get the good ones. After sorting, they are washed to remove dirt. Then they are blended using a blender with the addition of water with ratio of 1:1 for 1 minute.

2.5. Making Slice Jam

The mixing of cocoa flesh juice and mulberry juice is done with ratio of (95:5), (90:10), (85:15), with the addition of carrageenan of 3%, 4%, and 5%. Other ingredients are granulated sugar (w/w) 50%, citric acid (w/w) 0.2%, CMC (w/w) 1%. The dough is cooked for 2.5 minutes at a temperature of 900C. The dough is poured into a baking pan with a thickness of 3 mm and then dried in a food dehydrator for 4 hours at a temperature of 70°C.

3. RESULT AND DISCUSSION

3.1. Physicochemical Characteristics of Slice Jam

Table 1. Analysis results of water content, antioxidant activity, pH, total sugar of slice jam

Formulation	w\Water content	Antioxidant	pH	Total Sugar
A1B1	25.91	74.41	3.59	43.83
A1B2	27.76	74.46	3.65	44.99
A1B3	27.92	75.62	3.73	45.65
A2B1	30.48	73.36	3.53	41.93
A2B2	32.93	74.45	3.64	43.54
A2B3	33.70	74.85	3.70	44.20
A3B1	33.07	73.32	3.36	40.92
A3B2	33.48	73.94	3.57	42.57
A3B3	33.87	74.04	3.61	43.94

Water content showed an increasing ratio of mulberry juice; the higher the carrageenan addition, the higher the water content. The water content of mulberry causes this is relatively high, which is 98.25% compared to cocoa fruit, which is 96.50%, while

carrageenan has hydrophilic characteristics due to the presence of hydroxyl groups and sulfate esters that can bind water [16]. Hydrocolloids can bind and retain water in food, thus affecting the water content [18].

Antioxidant Activity showed that the higher the ratio of cocoa fruit juice and the lower the ratio of mulberry juice, the more carrageenan added, the higher the antioxidant activity. The increase in antioxidant activity is influenced by the cocoa and mulberry juice used. Cocoa fruit contains chemical compounds such as polyphenols, lignin, theobromine [19], and catechins [20]. Mulberries contain main compounds such as flavonoids, tannins, polyphenols, and anthocyanins [21], which are antioxidants. Adding carrageenan can inhibit and protect antioxidant compounds because it has a hydroxyl group and can form a double helix structure, which prevents antioxidant damage due to heating [22].

The pH showed that the higher the ratio of mulberry juice, the lower the pH, while the higher the addition of carrageenan, the higher the pH. This is due to the cocoa and mulberry juice used. Each raw material tends to have an acidic pH, affecting the pH decrease. The addition of citric acid can lower the pH. [23] states that the addition of acid can lower the pH. On the contrary, the higher the addition of carrageenan, the pH will increase because carrageenan has a basic pH of 8-11 [24].

Total Sugar showed the higher the ratio of cocoa fruit juice, the lower the ratio of mulberry juice, the higher the addition of carrageenan, causing the higher total sugar. This is because the fruit contains sugar in the form of fructose, glucose, and sucrose so the total sugar will increase with the increasing amount of fruit pulp [25]. The addition of carrageenan can increase the total sugar because carrageenan contains a sugar component of 36-90% [26].

Table 2. Analysis results of vitamin C, activity water, texture of slice jam

Formulation	Vitamin C	Activity water	Hardness
A1B1	8.51	0.746	68.68
A1B2	10.62	0.743	77.1
A1B3	12.62	0.728	92.92
A2B1	11.35	0.74	66.64
A2B2	13.46	0.733	73.55
A2B3	13.85	0.726	89.67
A3B1	12.32	0.739	64.24
A3B2	14.51	0.732	71.01
A3B3	14.58	0.721	83.39

Vitamin C showed the increasing ratio of mulberry juice; the higher the carrageenan addition. the higher the vitamin C level. The increase in vitamin C is influenced by the fruit juice used. Mulberry contains quite high vitamin C compared to cocoa fruit, which still lacks vitamin C [27], so the mulberry ratio can increase slice jam's nutritional content. The addition of carrageenan forms a double helix structure, so the oxygen or cofactors that accelerate the oxidation of vitamin C can be inhibited [22].

Activity water showed that adding carrageenan reduces the water amount [28]. Carrageenan binds water, which is called bound water. As a result, water will decrease and evaporate when heated. Ref. [29] states that the water content is bound water in the carrageenan matrix, and carrageenan has bound water in the system so that the space for free water binding to the system is getting smaller. The ratio of cocoa and mulberry juice does not significantly affect water activity, and it is suspected that each fruit has a relatively low sugar content. Sugar can bind water.

Hardness showed that the higher the ratio of cocoa fruit juice, the lower the ratio of mulberry juice; the higher the carrageenan addition, the higher the hardness value. This is because cocoa fruit has a pectin content of 1.84% higher than mulberry at 0.45%. In addition, each fruit also has sugar and acid content, which is a texture-forming agent (gel) used to make jam. Ref. [4] stated that ideal jam-making fruits must contain enough pectin and acid to produce the appropriate characteristics. The addition of carrageenan makes the texture of the slice jam firmer. The high sulfate content in carrageenan polymers increases its viscosity value. The higher the sulfate content, the repulsive force between negatively charged sulfate esters along the polymer chain becomes stiff and attracted so that water molecules are bound to carrageenan and increase viscosity. Also, adding other hydrocolloids, namely CMC, can strengthen the texture and prevent syneresis [17].

3.2. Organoleptic Characteristics of Slice Jam

Table 3. The organoleptic test result of slice jam

Formulation	Color (%)	Aroma (%)	Flavor (%)	Texture (%)
A1B1	2.48	2.96	3.64	3.2
A1B2	2.52	2.8	3.32	2.96
A1B3	2.44	3.04	3.36	3.16
A2B1	4.2	2.92	3.76	3.92
A2B2	4.04	2.76	3.64	3.84
A2B3	3.8	2.84	4.08	3.72
A3B1	4.08	2.92	4.28	3.68
A3B2	4.04	2.6	3.96	3.76
A3B3	4.08	2.84	4.12	3.6

The results of organoleptic test of the color of the slice jam showed a significant difference. ($p \leq 0.05$). It can be seen that the panelists' preference level for the color of the slice jam obtained the highest rating, with an average of 4.2. The highest rating was found in the ratio of cocoa fruit juice: mulberry (90:10) with the addition of 3% carrageenan while the lowest value was 2.44 in the ratio of cocoa fruit juice: mulberry (95:5) with the addition of 5% carrageenan. The less addition of mulberry juice tends to produce a low score. This is because the color of the cocoa fruit juice is not attractive, so the panelists liked the color of the slice jam with the addition of mulberry fruit juice because mulberries have anthocyanin pigments [30].

The results of an organoleptic test of the aroma of slice jam showed no significant difference ($p \geq 0.05$). It can be seen that the panellists' preference for the aroma of slice jam obtained the highest rating, with an average of 3.04. The highest rating was found in the ratio of cocoa fruit juice: mulberry (95:5) with the addition of 5% carrageenan, while the lowest value was 2.6 in the ratio of cocoa fruit juice: mulberry (85:15) with the addition of 4% carrageenan. The aroma of cocoa fruit juice, mulberry and the addition of carrageenan did not show a significant difference because the ratio of the same ingredients tend to have almost the same aroma.

The results of an organoleptic test of the taste of the slice jam showed a real difference ($p \leq 0.05$). It can be seen that the panelists' preference for the taste of slice jam obtained the highest rating with an average of 4.28. The highest rating was found in the ratio of cocoa fruit juice: mulberry (85:15) with the addition

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of 3% carrageenan, while the lowest value was 3.32 in the ratio of cocoa fruit juice: mulberry (95:5) with the addition of 4% carrageenan. The taste found in slice jam is sour and sweet. The sweet taste is caused by the natural fruits used and the addition of sucrose. Sucrose can enhance the taste [31]. Aside from that, the addition of carrageenan provides a more pungent sweet taste [32]. The ability of carrageenan to form a gel when heated causes the taste components to reach the tongue because the food forms a gel [33]. As for the sour taste caused by the fruits used, they tend to have high acid levels and citric acid addition.

The results of organoleptic tests on the texture of slice jam showed a significant difference ($p \leq 0.05$). It can be seen that the panelists' preference for the texture of slice jam obtained the highest rating with an average of 3.92. The highest rating was found in the ratio of cocoa fruit juice: mulberry (95:5) with the addition of 3% carrageenan while the lowest value was 2.96 in the ratio of cocoa fruit juice: mulberry (95:5) with the addition of 4% carrageenan. The treatment of fruit ratios produced a good texture because the fruits used were ideal for making jam, containing pectin, sugar and acid. [34] stated that the texture of slice jam is influenced by pectin, sugar and acid. Furthermore, adding carrageenan will improve the texture of slice jam to be firmer. The higher the carrageenan, the more elastic and less brittle the gel tends to form.

4. CONCLUSION

The ratio of cocoa fruit juice: mulberry and the addition of carrageenan to the slice jam showed a significant effect ($p \leq 0.05$) on water content, antioxidant activity, pH, total sugar, vitamin C, hardness, and color, taste, and texture scores. However, it did not provide a significant effect ($p \geq 0.05$) on water activity and aroma scores. Slice jam produced by ratio of cocoa fruit juice: mulberry (85:15) with the addition of 5% carrageenan is the best treatment with water content value 33.87%, total sugar 43.94%, pH 3.61, antioxidant activity 74.04%, vitamin C 14.58 mg/100g, water activity 0.721, and hardness 83.39 gf. The organoleptic characteristics are color 4.08 (like), aroma 2.84 (dislike), taste 4.12 (like), and texture 3.6 (rather like).

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