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PHYSICOCHEMICAL CHARACTERIZATION OF PEDADA FRUIT (*Sonneratia caseolaris*) SLICE JAM WITH THE ADDITION OF CARAGEENAN

Karakterisasi Fisikokimia Selai Lembaran Buah Pedada (*Sonneratia Caseolaris*) Dengan Penambahan Karagenan

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ABSTRACT

This study aims to evaluate the effect of carrageenan addition on the physicochemical properties of fruit slice jam made from *Sonneratia caseolaris*. This mangrove fruit contains 0.32% pectin, making it a potential raw material for jam production. However, conventional jam has limitations in practicality, leading to the development of fruit slice jam, which has a compact, non-sticky, and plastic-like texture. The study employed a Completely Randomized Design (CRD) with four treatments: P0 (control, 2% pectin), P1 (1.25% carrageenan), P2 (1.50% carrageenan), and P3 (1.75% carrageenan), each replicated five times. The physical parameters analyzed included hardness, cohesiveness, adhesiveness, and springiness, while the chemical parameters consisted of moisture content, ash content, reducing sugar, and pH. Data were analyzed using one-way ANOVA at a 95% confidence level, followed by Duncan's Multiple Range Test (DMRT). The results indicated that increasing carrageenan concentration significantly ($P<0.05$) decreased adhesiveness, springiness, and moisture content, while hardness, cohesiveness, ash content, reducing sugar, and pH increased. Thus, carrageenan addition significantly influences the physicochemical properties of fruit slice jam made from *S. caseolaris*, offering a promising innovation for fruit-based jam products.

Key words: Carrageenan, Physicochemical Characteristics, Pedada Fruit Slice Jam.

ABSTRAK

Penelitian ini bertujuan untuk menganalisis pengaruh penambahan karagenan terhadap karakteristik fisikokimia selai lembaran buah pedada (*Sonneratia caseolaris*). Buah pedada memiliki kandungan pektin sebesar 0,32%, sehingga berpotensi digunakan dalam pembuatan selai. Namun, selai konvensional memiliki keterbatasan dalam aspek kepraktisan, sehingga diperlukan inovasi dalam bentuk selai lembaran dengan tekstur yang lebih kompak, tidak lengket, dan plastis. Penelitian ini menggunakan Rancangan Acak Lengkap (RAL) dengan empat perlakuan, yaitu P0 (kontrol, pektin 2%), P1 (karagenan 1,25%), P2 (karagenan 1,50%), dan P3 (karagenan 1,75%), dengan lima kali ulangan. Parameter fisik yang dianalisis meliputi *hardness*, *cohesiveness*, *adhesiveness*, dan *springiness*, sedangkan parameter kimia mencakup kadar air, kadar abu, gula reduksi, dan pH. Data dianalisis menggunakan uji One-Way ANOVA dengan taraf kepercayaan 95% dan dilanjutkan dengan uji Duncan Multiple Range Test (DMRT). Hasil penelitian menunjukkan bahwa peningkatan konsentrasi karagenan secara signifikan (P<0,05) menurunkan nilai *adhesiveness*, *springiness*, dan kadar air, sementara nilai *hardness*, *cohesiveness*, kadar abu, gula reduksi, dan pH mengalami peningkatan. Dengan demikian, penambahan karagenan berpengaruh nyata terhadap karakteristik fisikokimia selai lembaran buah pedada, sehingga dapat menjadi alternatif inovasi dalam pengembangan produk selai berbasis buah pedada.

Kata Kunci: Karagenan, Karakteristik fisikokimia, Selai Lembaran Buah Pedada

INTRODUCTION

Sonneratia caseolaris, or what is known as pedada fruit, is a type of mangrove plant which is characterized by round leaves arranged in pairs on its branches, flowers which are located in the leaf axils and hang down, and fruit which is in the shape of a circular spiral with a size of around 2-2.5 cm (Pursetyo, 2013). This fruit has a distinctive aroma when it is ripe and is rich in vitamins such as vitamins A, B, B2, and C. However, there is a weakness in pedada fruit, namely that the taste tends to be astringent and sour if eaten directly. In addition, the water content of pedada fruit reaches 79%, making it rot quickly, so processing this fruit is very important to extend its shelf life (Rahman *et al*., 2016). One of the innovations in processing pedada fruit is making sheet jam, which is a variation of spreadable jam with a dense, non-sticky texture and good elasticity (Kurnia *et al*., 2021). Jam is generally made from fruit that contains pectin to help form gels, and because pedada fruit contains 0.32% pectin, this fruit is very suitable as a raw material for making sheet jam (Simamora & Rossi, 2017).

Hydrocolloids are important to add to making sheet jam to make the texture stronger. Carrageenan is one type of the many hydrocolloids that can be used to strengthen the texture of jam. The main function of carrageenan is as a thickener, emulsifier, and stabilizer, which can regulate the water content in the product and produce a denser and more plastic sheet jam texture (Harsyam *et al*., 2020). This study aims to analyze the physicochemical characteristics of pedada fruit sheet jam and determine the most optimal carrageenan concentration. It is hoped that the results of this study can provide useful insights into the description of the physicochemical characterization of pedada fruit sheet jam with the addition of carrageenan, so as to produce a more practical and quality product for consumption. This study is also expected to contribute to further studies to improve the quality of pedada fruit sheet jam.

METHODS

This research was conducted from January to March 2024 at the Food Laboratory and Chemistry Laboratory, located at the Faculty of Fisheries and Marine Sciences, Airlangga University, Surabaya. The tools used in this study included a stove, mold pan, sieve, pan, stirrer, plastic basin, spoon, knife, digital scale, pH meter, oven, desiccator, porcelain cup, cup clamp, CT3 texture analyzer, analytical scale, measuring flask, and Erlenmeyer. The materials used included pedada fruit, commercial carrageenan, pectin, granulated sugar, water, distilled water, margarine, 95% alcohol, lead acetate solution, Luff-Schrool solution, 0.1 N sodium thiosulfate, 20% KI, 25% H2SO4, sodium oxalate, and starch indicator.

The method used in this study was a Completely Randomized Design (CRD), consisting of four treatments with five replications, resulting in a total of 20 experiments. Each sample is given the code P0, P1, P2, and P3, according to the treatment given. The samples will be given the code P0, P1, P2, and P3 with the following descriptions:

P0 : Control (Pedada fruit sheet jam with a pectin concentration of 2% of the total ingredients used (3 grams)).

P1 : Pedada fruit sheet jam with the addition of 1.25% carrageenan from the total ingredients used (1.8 grams)).

P2 : Pedada fruit sheet jam with the addition of 1.5% carrageenan from the total ingredients used (2.2 grams)).

P3 : Pedada fruit sheet jam with the addition of 1.75% carrageenan from the total ingredients used (2.6 grams)).

The process of making pedada fruit sheet jam follows a method which is a modification of Simamora & Rossi (2017). The process begins by peeling the skin on the pedada fruit, removing the seeds, then cleaning. The flesh of the pedada fruit is crushed by adding water in a 1:1 ratio to produce pedada fruit pulp. This fruit pulp is then filtered twice. A total of 100 grams of pedada fruit pulp was weighed for each treatment. Other additional ingredients were also weighed, namely 44 grams of granulated sugar and 3 grams of margarine. Carrageenan was weighed according to each treatment, while pectin for the control was weighed at 3 grams. All ingredients are mixed and heated for 3 minutes at 60ºC. The jam is then put into a mold and left to harden, then cut into pieces measuring 8 cm × 8 cm. The addition of carrageenan in pedada fruit sheet jam can be seen in the table 1.

Table 1. Formulation of Pedada Fruit Jam

Ingredients (Grams)	Treatment			
	P0	P1	P2	P3
Fruit pulp	100	100	100	100
Sugar	44	44	44	44
Margarine	3	3	3	3
Pectin	3	0	0	0
Carrageenan	0	1,8	2,2	2,6
Total (Gram)	150	148,8	149,2	149,6

Quantitative data covering parameters such as water content, ash content, reducing sugar, and pH were analyzed using the One-way ANOVA (Analysis of Variance) test at a 95% confidence level. If the analysis results show a significant difference (P<0.05), the next step is to carry out the Duncan Multiple Range Test (DMRT) to determine the differences between treatments in more detail. For hedonic data including organoleptic evaluation, the Kruskal-Wallis test was used which was also applied with a 95% confidence level. If the Kruskal-Wallis test results show a significant difference (P<0.05), then the analysis will be continued with the Mann-Whitney test to compare the values between different groups and determine which differences have a significant effect on the parameters measured.

RESULT

The results of the physical characteristics in the form of texture tests include the level of hardness, level of cohesiveness, level of adhesiveness, and level of elasticity (springiness).

Table 1. Results of Testing the Physical Characteristics of Pedada Fruit Sheet Jam

No	Component	Mean Percentage of Physical Characteristics ± SD			
		P0 (Control)	P1 (1,25%)	P2 (1,5%)	P3 (1,75%)
1	*Hardness* (gf)	$205{,}39^{a} \pm 0{,}91$	$238{,}73^{b} \pm 0{,}98$	$267{,}68^{c} \pm 0{,}85$	$317{,}96^{d} \pm 0{,}92$

2	*Cohesiveness*	$0{,}23^{a} \pm 0{,}01$	$0{,}26^{b} \pm 0{,}01$	$0{,}35^{c} \pm 0{,}02$	$0{,}39^{d} \pm 0{,}01$
3	*Adhesiveness* (mJ)	$0{,}15^{c} \pm 0{,}01$	$0{,}12^{b} \pm 0{,}01$	$0{,}11^{b} \pm 0{,}01$	$0{,}09^{a} \pm 0{,}01$
4	*Springiness* (mm)	$0{,}63^{d} \pm 0{,}01$	$0{,}45^{c} \pm 0{,}01$	$0{,}42^{b} \pm 0{,}01$	$0{,}38^{a} \pm 0{,}01$

Source: Data Processing Results (2024)

The results of the physical characteristics test of pedada fruit sheet jam showed that the addition of carrageenan concentration had a significant effect on the parameters of hardness, cohesiveness, adhesiveness, and springiness. The hardness value increased with the increase in carrageenan concentration, where P0 (control) had the lowest value of 205.39±0.91 gf, while P3 had the highest value of 317.96±0.92 gf. Cohesiveness also increased, from 0.23±0.01 at P0 to 0.39±0.01 at P3, indicating that jam with carrageenan was more cohesive. Conversely, adhesiveness decreased, with the highest value at P0 (0.15±0.01 mJ) and the lowest at P3 (0.09±0.01 mJ), indicating that the jam became less sticky with the increase in carrageenan. Meanwhile, springiness showed a decreasing trend, from 0.63±0.01 mm at P0 to 0.38±0.01 mm at P3, which means the jam becomes less elastic as the carrageenan content increases. Overall, increasing the concentration of carrageenan in the jam formulation increases the hardness and cohesiveness but reduces the adhesiveness and elasticity of the product

The results of the chemical characteristics in this study, namely water content, ash content, reducing sugar, and acidity (pH) are presented in Table 2.

Table 2. Results of Testing the Chemical Characteristics of Pedada Fruit Sheet Jam

No.	Components	Mean Percentage of Chemical Characteristics ± SD			
		P0 (Control)	P1 (1,25%)	P2 (1,5%)	P3 (1,75%)
1.	Water Content (%)	$47{,}97^{d}\pm0{,}675$	$46{,}51^{c}\pm0{,}558$	$44{,}89^{b}\pm0{,}015$	$43{,}44^{a}\pm0{,}087$
2.	Ash Content (%)	$1{,}85^{d}\pm0{,}025$	$1{,}44^{a}\pm0{,}019$	$1{,}54^{b}\pm0{,}027$	$1{,}62^{c}\pm0{,}154$
3.	Reducing Sugar (%)	$40{,}39^{d}\pm0{,}582$	$35{,}48^{a}\pm0{,}023$	$36{,}86^{b}\pm0{,}319$	$37{,}68^{c}\pm0{,}020$
4.	pH Value	$2{,}87^{a}\pm0{,}018$	$2{,}94^{b}\pm0{,}011$	$2{,}96^{b}\pm0{,}008$	$3{,}08^{c}\pm0{,}078$

Source: Data Processing Results (2024)

The results showed that the control treatment (P0) and variations in carrageenan concentration in P1, P2, and P3 had a significant effect on the water content, ash content, reducing sugar, and acidity level (pH) of pedada fruit sheet jam ($P<0.05$), as confirmed by further Duncan Multiple Range Test (DMRT). The highest water content was found in P0 at 47.97±0.675%, while the lowest water content was found in P3 at 43.44±0.087%. The ash content ranged from 1.44% to 1.85%, with the highest value in P0 (1.85±0.025%) and the lowest in P1 (1.44±0.019%). Meanwhile, the highest reducing sugar was found in P0 at 40.39±0.582% and the lowest in P1 at 35.48±0.023%. In terms of pH, the highest value was found in P3 at 3.08±0.078, while the lowest value was found in P0 at 2.87±0.018. Overall, increasing the concentration of carrageenan in the jam formulation contributed to a decrease in water content and reducing sugar, as well as an increase in pH, which indicates that the use of carrageenan can affect the stability and chemical characteristics of pedada fruit sheet jam.

DISCUSSION

Hardness describes the value of the load required to deform a food product (Rochmah *et al.*, 2019). The results of the hardness level analysis showed that the addition of carrageenan to pedada fruit sheet jam (P1, P2, and P3) resulted in a significant increase, compared to the control treatment, namely 238.73 gf - 317.96 gf. This is because the cross-linking between polymers forms a three-dimensional mesh bond. The hydroxyl group in the bond has the ability to bind water and form a gel together with the sulfate ester group. The three-dimensional mesh formed from this bond will form a double helix matrix structure. With increasing concentration of added carrageenan, the amount of double helix matrix formed will also increase, which in turn will increase the amount of water bound in the structure. (Febriyanti *et al*., 2015). This is what causes the hardness value of pedada fruit sheet jam with the addition of carrageenan to increase. This is supported by the explanation of Marzelly *et al*., (2018) who stated that the polymer chain will form a three-dimensional network that is interconnected, which will then capture or immobilize water in the gel. This process produces a strong and rigid structure, which is able to withstand external pressure or force. As the concentration of added carrageenan increases, the amount of free water and adsorbed water in the material will decrease during the drying process. This causes the gel structure formed to become stronger and more stable.

Cohesiveness describes the internal strength present in a food ingredient, which shows the extent of the compactness or strength of the interaction between the parts of the material in maintaining its structure or shape (Puspaningrum *et al*., 2018). The results of the analysis of the level of compactness (cohesiveness) showed that the addition of carrageenan to pedada fruit sheet jam (P1, P2, and P3) resulted in a significant increase, compared to the control treatment, which was 0.26 - 0.39. Based on the research conducted, it shows that there is an increase in the compactness value as the concentration of carrageenan increases because the three-dimensional mesh bond that is connected has a high absorption capacity, causing the amount of water bound in the product gel matrix to increase. Other studies report that the kappa carrageenan cell wall is dominated by pophyran content, compared to pectin or other cellulose components. Porphyran is a polysaccharide with rare sulfate groups that makes the water holding capacity high compared to other types of carrageenan (Wahlstrom, 2020). This is in line with research conducted by Dipowaseso *et al.,* (2018) which states that increasing the amount of water bound in a product will reduce the distance between particles, which causes an increase in the attractive force between the particles. As a result, the particles will be bound more tightly together in the network, strengthening the overall structure of the product.

Adhesiveness is the amount of effort required to overcome the pulling force that occurs between the surface of a food product and the surface of another material. (Bahramparvar *et al*., 2013). The results of the adhesiveness analysis showed that the addition of carrageenan to the pedada fruit sheet jam (P1, P2, and P3) resulted in a significant decrease, compared to the control treatment, which was 0.12 - 0.09 mJ. This is because the more three-dimensional mesh bonds that are formed, the stronger the bonds between molecules to water and are retained in the gel due to the presence of a double helix matrix. The strong water binding capacity of carrageenan results in a lower adhesiveness value (Ma'arif *et al*., 2021).

Springiness describes the elasticity value of a food product (Ma'arif *et al*., 2021). The results of the springiness analysis showed that the addition of carrageenan to the pedada fruit sheet jam (P1, P2, and P3) resulted in a significant decrease, compared to the control treatment, which was 0.45 - 0.38 mm. The springiness value decreased along with the increasing hardness value. This decrease in value is due to the use of kappa carrageenan as a gelling agent which has hard and rigid properties. This is in accordance with the statement of Puspaningrum *et al.,* (2018) Puspaningrum where the harder the product produced, the lower the ability of the product to return to its original shape after compression (less elastic).

The results of the water content analysis showed that the addition of carrageenan to the pedada fruit sheet jam (P1, P2, and P3) resulted in a significant decrease in water content, compared to the control treatment, namely 46.51 ± 0.558 to 43.44 ± 0.087. This value does not meet the standards set in SNI 3547.02-2008 which requires a water content below 20%. This decrease can be explained due to the ability of carrageenan to bind water through its sulfate groups. The negatively charged sulfate group on the carrageenan molecule allows hydrogen bonds to form with water molecules, accelerating the formation of a gel matrix in jam

(Samantha *et al*., 2019). Carrageenan studies can form a stable gel matrix thanks to its chemical properties that support water binding. This mechanism illustrates that carrageenan at high temperatures tends to be a random polymer, but when the temperature decreases, this polymer forms a double helix structure, and at low temperatures, cross-linking occurs which produces a more stable gel (Ma'arif *et al*., 2021).

Information that can be obtained from the experimental results shows that carrageenan provides a significant advantage in controlling water content in products such as sheet jam. This is different from pectin, which although it can form a gel, is not as strong or stable as carrageenan at the same concentration. Recent studies indicate that carrageenan is able to absorb and bind more water in the jam matrix than pectin, which may explain why the addition of carrageenan results in a greater decrease in water content compared to the pectin control (Putri *et al*., 2017). Therefore, in food formulation, especially for products such as sheet jam, the selection of hydrocolloids such as carrageenan can be a more effective choice to meet product quality standards and optimize desired physical and sensory characteristics. (Ma'arif *et al*., 2021).

The results of the ash content test showed that the addition of carrageenan to the pedada fruit sheet jam (P1, P2, and P3) resulted in a significant increase, compared to the control treatment, namely 1.44 ± 0.019 to 1.62 ± 0.154. This value has met the standards set in SNI 3547.02-2008 in the jelly group which requires a maximum ash content of 3%. This increase is due to the mineral content in carrageenan. The more carrageenan is added, the higher the mineral content so that the ash content of the sheet jam will increase (Pratiwi *et al*., 2016)

Reducing sugar is an invert sugar found in food ingredients. Factors that can affect the reducing sugar value of sheet jam are the raw materials used (Parwatiningsih & Batubara, 2020). The control treatment gave a higher reducing sugar value compared to the treatment variation, namely the addition of carrageenan to the pedada fruit sheet jam product, namely 35.48 ± 0.023 to 37.68 ± 0.020. This value has not met the standards set in SNI 3547.02-2008 in the jelly group which requires a maximum reducing sugar content of 25%. This increase is because the addition of carrageenan concentration produces higher reducing groups. In addition, the presence of heat and acid during the cooking of sheet jam causes sucrose hydrolysis to produce fructose and glucose (Megawati *et al*., 2017). The information that can be obtained from the results of the study shows that carrageenan provides a significant advantage in controlling the reducing sugar value in products such as sheet jam. This is different from pectin which provides a higher reducing sugar value due to its nature which can bind water so that sucrose which is easily soluble in water will be bound more (Simamora & Rossi, 2017)

Acidity or pH is determined by the concentration of hydrogen ions in the solution or product being measured. The control treatment provided a lower acidity (pH) value compared to the treatment variation, namely the addition of carrageenan to the pedada fruit sheet jam product, namely 2.94 ± 0.011 to 3.08 ± 0.078. This increase is because carrageenan has a basic acidity (pH) so that the higher the concentration of carrageenan, the more acid can be balanced (Apriliany *et al.*, 2024). The results of the study obtained showed that carrageenan provides a significant advantage in controlling the acidity (pH) in products such as sheet jam, because the acidity (pH) of sheet jam ranges from 3.10 - 3.46. This is different from pectin, which in the making of sheet jam undergoes hydrolysis into pectic acid and pectinic acid, thus producing more acid which ultimately lowers the pH. (Septiani *et al*., 2013).

CONCLUSION

The results of the study on the physicochemical characteristics showed that pedada fruit sheet jam added with carrageenan had adhesiveness, springiness, and water content values that decreased with increasing carrageenan concentration and hardness, cohesiveness, ash content, reducing sugar, and acidity (pH) values that increased with increasing carrageenan concentration. The addition of 1.75% carrageenan is the optimal concentration in making pedada fruit sheet jam. This is indicated by the results of the physicochemical characteristic test which is more optimal in making pedada fruit sheet jam and the ash content is still sufficient for the requirements in SNI 3547.02-2008 jelly group.

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