

Diversification of Tamarillo (*Solanum betaceum*) as a Jam Product on Different Ratios of Carrageenan as a Thickening Agent

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Abstract. Tamarillo (*Solanum betaceum*) is a fruit with good nutritional content for health, despite this, its processing as a functional food product such as jam as a practical form of diversification products, is still lacking. On the other hand, carrageenan is a thickening agent that is often used in the food industry besides pectin. The aims of this study were to examine (1) the effect of Tamarillo and carrageenan ratios on the Tamarillo jam and (2) the chemical and sensory characteristics of the Tamarillo jam. Four ratios of the Tamarillo and carrageenan were tested e.g. 100%:0%; 97.5%:2.5%; 95%:5%; and 92.5%:7.5%. Method used was a Completely Randomized Design. Observed data were analyzed using analysis of variance and Least Significant Difference test. Results of the recent study show that the use of different ratios of the Tamarillo and carrageenan affected the chemical and sensory characteristics of Tamarillo jam such as total sugar content, pH, color, aroma, taste, and spread ability. The best ratio for Tamarillo jam was 97.5% Tamarillo: 2.5% carrageenan which resulted in sugar content of 19.81% and pH of 4.04%, sensory parameters for color of 4.19, aroma of 3.40, flavor of 3.52, and spread ability of 3.65.

1 Introduction

Tamarillo (*Solanum betaceum*) is a type of fruit that grows in mountainous areas or highlands contain good nutrients for health, especially antioxidants ([1]. Tamarillo is rich in provitamin A which is good for eye on health and vitamin C to treat cancer sores and increases endurance. The fruit is also known for its mineral content such as potassium, phosphorus and magnesium when consumed can help to maintain body health and high fiber which is beneficial for preventing cancer and constipation [2]. Tamarillo fruit is rarely served as a table fruit due to its sour taste [3]. In addition, its utilization in food processing is still very

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lacking other than only being consumed directly. Thus, it is necessary to process Tamarillo into various types of processed products including jam.

Jam is one form of processed food products obtained from processing of fruit pulp, sugar, and added with thickening agents using a long cooking method until a thick texture is obtained. The optimum conditions for gel formation in jam are pectin (0.75- 1.5%), sugar (65-70%), and pH (3.2-3.4) [4,5]. Furthermore, to increase consumer acceptance of jam products with good texture, a thickening agent is needed [6]. One of the thickening agents that can be used in making jam other than pectin is carrageenan [7].

Carrageenan is seaweed extracts from the *Eucheuma cottonii* species and South Sulawesi province is one of its development centers in Indonesia, so it has the potential to be used as an additive in processed food [8]. Carrageenan used in the food industry because of its gel forming characteristics and thickening and stabilizing properties [9]. In addition, carrageenan is also one of the hydrocolloids which is colorless and can function as a texture, emulsifier, suspending agent and increasing the water absorption capacity of the product [10]. The characteristics of good carrageenan are that tasteless or has a neutral taste, colorless, and can increase the viscosity the product. Jam viscosity is one of the sensory quality determinants [11].

Sensory characteristics which determined the quality of food products are largely determined by several factors, namely: colour, taste, and aroma. In addition, the spread ability also determines the texture and thickness of the jam when spread on bread. The good quality jam must be brightly colored, chewy, real of fruit flavor, and good of spreading power that is not too watery and hard to spread on bread [12]. Thus, to determine the quality of the produced Tamarillo jam, it is necessary to test the sensory characteristics.

Utilization of Tamarillo into jam products with the addition of carrageenan as a thickening agent is a practical form of food diversification. It is also to introduce Tamarillo which is still rarely found and to increase its selling value other than only being consumed directly. Thus, this study aims to examine (1) the effect of the ratio of Tamarillo and carrageenan on Tamarillo jam and (2) the chemical and sensory characteristics of Tamarillo jam.

2 Materials and methods

2.1 Materials

Various ingredients used in the recent study were ripe Tamarillo fruit, marked with a purplish red skin, granulated sugar, carrageenan, water, and glass bottles for packaging.

2.2 Methods

One kilogram of Tamarillo ripe fruit and carrageenan with a concentration of 0%; 2.5%; 5%; and 7.5% was used in one treatment. The fruits were washed in running water previously to remove various impurities attached to the Tamarillo. Following the first step, the fruits were peeled, and the fruit flesh were cut before being crushed using a blender. Water then was added according to a predetermined ratio. The next stage is separating the pulp from the seeds or removing pulp that were not crushed during previous stage by filtering. Next, the Tamarillo pulp was mixed with sugar and carrageenan powder with various concentrations, then cooked over medium heat while stir continuously until it boils and Tamarillo jam is obtained. Furthermore, the Tamarillo jam is poured into glass jar bottles previously sterilized when it is still hot.

The treatments in this study were (1) 100% Tamarillo: 0% carrageenan; (2) Tamarillo 97.5%: Carrageenan 2.5%; (3) Tamarillo 95%: 5% carrageenan, and (4) Tamarillo 92.5%: 7.5% carrageenan.

Research parameters observed on the Tamarillo jam produced were Chemical characteristics: analysis of sugar content, acidity (pH) and sensory characteristics: organoleptic test using the hedonic method to test the panellists' preference for taste, colour, aroma, texture (oiling power).

2.3 Analysis

2.3.1 Total sugar content

Jam sample was weighed as much as five grams and dissolved with 100 ml of distilled water in a 500 ml Erlenmeyer, then homogenized. A 200 ml of 3% HCl solution was heated to boiling for three hours with upright coolant. The next stage was cooling and neutralization with 30% NaOH solution and the addition of a few drops of 3% CH₃COOH so that the solution is slightly acidic. The solution then transferred into a 500 ml volumetric flask. Pipetted 10 ml of the solution into a 500 ml Erlenmeyer and added 25 ml of Luff Schoorl's solution and some boiling stones and 15 ml of distilled water. Next, heat the solution on a constant flame and allow the solution to boil within three minutes. The solution was boiled continuously for 10 minutes. After the solution was cool then 15 ml of 20% KI and 25 ml of 25% H₂SO₄ were added slowly. Then titrated with 0.1N Na-thiosulfate solution using 0.5% starch indicator [13]. The formula for calculating the total sugar content analysis is:

$$\text{Total sugar content} = \frac{\text{sakarín weight (mg)} \times F_p}{\text{sample weight (mg)}} \times 0,95 \times 100\% \quad (1)$$

F_p = Dilution factor

2.3.2 Acidity

Determination of the degree of acidity (pH) was conducted using a pH meter. Prior to measurement, the pH meter was calibrated using a buffer solution of 7.0 and 4.0. One gram of Tamarillo jam was taken then added with 3 ml of distilled water, stirred until homogeneous. The pH meter electrode was immersed into the sample, until a stable reading is obtained. The pH value can be read directly on the pH meter scale [14].

2.3.3 Organoleptic test

Organoleptic tests are carried out based on the level of preference so that they can be accepted by the panelists. The test method used is the hedonic method (preferred test) including: colour, aroma, taste, and texture (oiling power) of the resulting Tamarillo jam product. The panellists used were 25 people. In this method, panellists were asked to provide an assessment based on a hedonic scale as presented in Table 1 [15].

Table 1. Organoleptic testing scale

Hedonic scale	Numerical scale
Like very much	5
Like moderately	4
Like slightly	3
Dislike moderately	2
Dislike very much	1

3 Results and discussion

3.1 Chemical characteristics

Analysis of the chemical characteristics of the Tamarillo jam product in the form of sugar content and pH analysis aims to assess the sugar content and pH of the Tamarillo jam with the comparison treatment of Tamarillo and carrageenan, as well as a basis for sensory testing of colour, aroma, taste and texture (oiling power).

3.1.1 Total sugar levels

Total sugar content in Tamarillo jam ranges from 19.40% - 20.44%, the lowest is produced from the comparison of 100% Tamarillo: 0% carrageenan, namely 19.40% and the highest is produced from the comparison of 92.5% Tamarillo: powdered carrageenan 7.5% which is 20.44%. The results are as seen in Fig. 1.

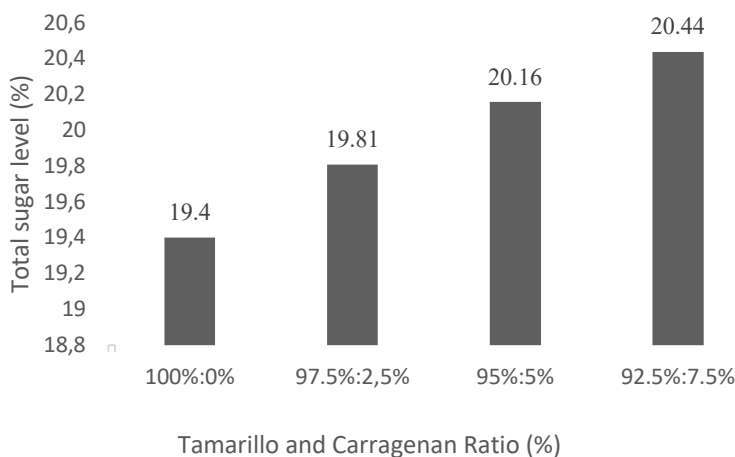


Fig 1. Total sugar content of Tamarillo jam on different ratios of Tamarillo and carrageenan

The highest sugar content with levels reaching >20% was obtained from a comparison of tamarillo and carrageenan of 92.5%: 7.5%, this was due to the carrageenan being added at a

high concentration compared to other treatments, which was 7.5%. This shows that the more addition of carrageenan the more of sugar content in the Tamarillo jam. This is because carrageenan can form a strong double helix structure so that it can capture sugar and bind it at the same time [16]. Carrageenan plays a role in forming a three-dimensional network together with water and sugar in synergistic conditions for the formation of the structure of food products [10]. Thus, the higher the concentration of carrageenan added, the more sugar will be trapped so that it is not easy to get out of the material network.

The results of the variance in sugar content of Tamarillo jam with the addition of carrageenan showed that the comparison of Tamarillo with carrageenan had a significant effect ($p < 0.05$), so that a further test of the Least Significant Difference (LSD) was carried out as presented in Table 2. Based on the LSD test results, sugar content of Tamarillo jam, were significantly different in all ratios of Tamarillo and carrageenan used. This shows that there is an effect of the ratio of Tamarillo and carrageenan on the sugar content of Tamarillo jam.

Table 2. Chemical characteristics of Tamarillo Jam

Chemical characteristics	Ratio (%)			
	100:0	97.5:2.5	95.5	92.5:5
Sugar content (%)	19.40 ± 0.0231	19.81 ± 0.1762*	20.16 ± 0.0451*	20.44 ± 0.0473
pH	3.65 ± 0.0153*	4.04 ± 0.0751*	4.45 ± 0.0231*	6.78 ± 0.0000*

ns= non-significant at 5% level of significance, * = Significant at 5% level of significance

Based on the quality requirements of fruit jam according to the Indonesian National standard SNI 01-3700:1995, it shows that the sugar content of the Tamarillo jam with the addition of carrageenan produced does not meet the quality criteria for the sugar content of fruit jam 55% [17]. This could be due to Tamarillo which is too acidic so that the sugar content produced is low. Malic acid is the main organic acid in Tamarillo and the main sugar compounds are fructose and glucose [18]. The high acid content in Tamarillo and the heating process causes a hydrolysis reaction by acid to sucrose to form fructose and glucose which causes a decrease in acid levels [19].

3.1.2 pH

The degree of acidity (pH) of Tamarillo jam produced on average ranged from 3.65% - 6.78%. The lowest pH was obtained in the 100% Tamarillo comparison treatment: 0% carrageenan (3.65); while the highest pH was obtained in the treatment with a comparison of 92.5% Tamarillo: 7.5% carrageenan (6.78). The results of pH measurements of Tamarillo jam produced from various ratios Tamarillo and carrageenan are presented in Fig. 2.

Testing the pH of Tamarillo jam showed that of Tamarillo:carrageenan had a significant effect ($p < 0.05$) on the jam, so further tests were carried out as presented in Table 2. Based on the results of the test, the pH of the Tamarillo jam with the addition of carrageenan were varied significantly between all treatments. This result shows that there is an effect of the ratio of Tamarillo and carrageenan on the pH of Tamarillo jam.

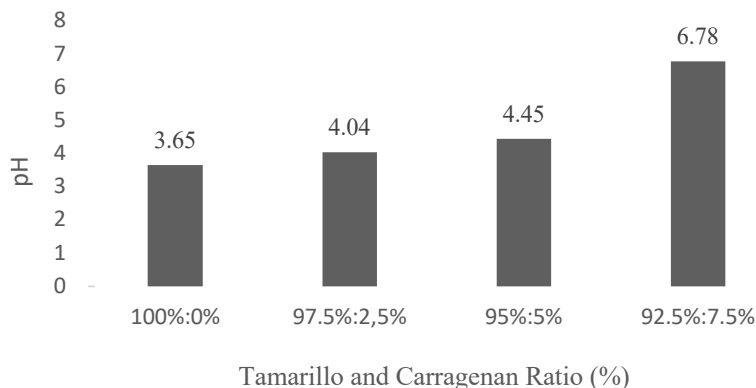


Fig 2. pH of Tamarillo jam with comparison of Tamarillo and carrageenan

Based on the research of Septiani *et al.* [20], the jam product with the addition of 1.5%-2.5% carrageenan produces a pH value of 3.60-4.00 and is also due to the fact that carrageenan has a pH of 8,64-9,59, so with the addition of carrageenan can cause an increase in pH and give a significantly different effect. The higher the concentration of carrageenan added, the pH in the Tamarillo jam will increase. This can happen because carrageenan contains potassium, calcium, magnesium, and sodium which react with acids to form salts. According to Agustín *et al.* [9], *Eucheuma cottonii* seaweed contains carrageenan from the polysaccharide group, namely galactose with sodium, magnesium, and calcium content with bonds to the galactose sulfate ester group and 3,6-anhydro-galactose copolymer and the salt formed is what will reduce acidity. According to Setyoprato and Sapei [21], carrageenan extracted with an alkaline solution tends to have a high degree of alkalinity. Hydrocolloids in carrageenan can bind with water due to the presence of relatively large OH groups, so they tend to provide an alkaline atmosphere and the pH of the gel will increase or tend to be neutral to alkaline as the concentration of the gelling agent added increases [22]. Thus, decreasing acid levels can increase pH.

3.2 Sensory characteristics

Sensory analysis of the Tamarillo jam product was carried out with the aim of assessing the panelists' preference for colour, aroma, taste, and texture (spread ability) of Tamarillo jam produced from different ratios of Tamarillo and carrageenan. The organoleptic test was carried out using the hedonic test method based on the level of panelists preference on four parameters, namely: colour, aroma, taste, and spread ability and was tested on 25 panelists who were asked to give a preference value by choosing between a hedonic scale of 1 (dislike very much) to 5 (like very much). The sensory value of Tamarillo jam is shown in Figure 3.

The appearance of colour is an attraction that influences consumer acceptance of a food product, even colour can be an indication of the quality of the food produced. Furthermore, colour also has a very important role and meaning in food commodities because it affects the degree of consumer acceptance of these commodities [23]. The colour of the Tamarillo jam on average ranges from 1.39-4.35. The lowest color score of 1.39 was obtained in the use of Tamarillo 92.5%: carrageenan 7.5%; while the highest score of 4.35 was obtained in the ratio of 100% Tamarillo: 0% carrageenan.

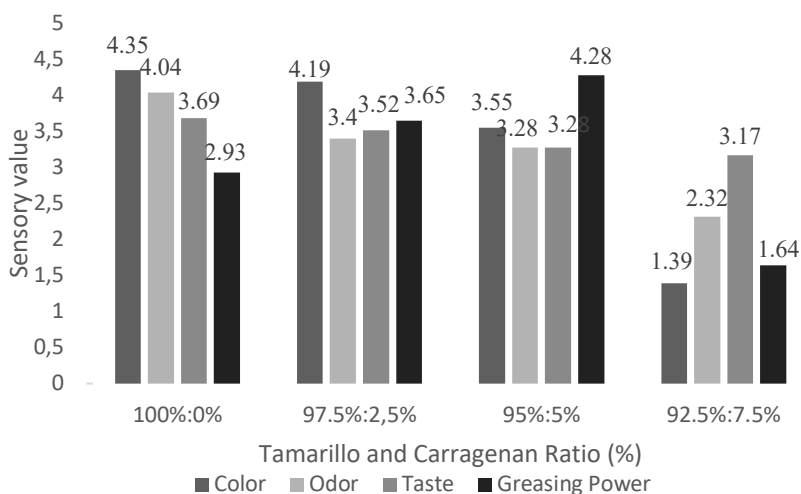


Fig 3. Sensory value of Tamarillo jam in different ratio of Tamarillo and carrageenan.

The colour test results showed that the panelists' favorite was the comparison of 100% Tamarillo: 0% carrageenan with a score of 4.35 from the assessment results of 23 panelists, while the lowest level of preference for panelists was found in the treatment of Tamarillo 92.5%: carrageenan 7.5% that is with a value of 1.3 by giving the results of a preference assessment as many as 20 panelists. Based on these results, the higher the concentration of carrageenan, the panelists' preference for the colour of Tamarillo jam will decrease. This is because the more addition of carrageenan will increase the total sugar content so that a Maillard reaction occurs causing changes in the Tamarillo jam colour from maroon to black [24]. Thus, the higher the concentration of carrageenan used, the more sugar is bound and the resulting jam will be darker (black).

The results of the analysis of variance in the treatment of Tamarillo and carrageenan ratio had a significant effect on colour ($p < 0.05$), hence the LSD test was carried out as presented in Table 3 showing the the all treatment of Tamarillo and carrageenan were significantly different. The color of Tamarillo jam with high carrageenan concentrations tends to be darker than those with lower carrageenan concentrations as shown in Figure 4.

Table 3. Chemical characteristics of Tamarillo jam

Sensory characteristics	Ratio (%)			
	100:0	97.5:2.5	95.5	92.5:7.5
Colour	4.35 ± 0.0611*	4.19 ± 0.0833*	3.55 ± 0.0889*	1.39 ± 0.0462*
Aroma	4.04 ± 0.0400*	3.40 ± 0.0400*	3.28 ± 0.0400*	2.32 ± 0.0400*
Taste	3.69 ± 0.0611*	3.52 ± 0.0400*	3.28 ± 0.0400*	3.17 ± 0.0231*
Spread ability	2.93 ± 0.0611*	3.65 ± 0.0231*	4.28 ± 0.0400*	1.64 ± 0.0400*

ns= non-significant at 5% level of significance, * = Significant at 5% level of significance



Fig 4. The colour of Tamarillo jam produced using different ratios of Tamarillo and carrageenan

Aroma is one of the organoleptic tests that often causes differences of opinion in assessing its quality. The reason is that there are differences in the sense of smell. Even though we can distinguish an aroma, each person has a different level of preference and the aroma parameter determines consumer acceptance because the aroma or odor stimulus becomes an impulse that will go to the olfactory nerve and describe the characteristics of a product [25]. This is what causes differences in the panelists' assessment of the aroma of Tamarillo jam.

The average aroma of Tamarillo jam ranges from 2.32-4.04. The lowest aroma score was obtained in the jam made from 92.5% Tamarillo and 7.5% carrageenan (2.32); while the highest score of 4.04 was obtained in jam made using 100% Tamarillo and 0% carrageenan.

Based on the results of the panelists' assessment of the highest level of aroma preference in Tamarillo 100%: 0% carrageenan with a score of 4.04 as many as 21 panelists, while the lowest was in Tamarillo jam ratio 92.5%: 7.5% carrageenan, with a score of 2, 32 given by 15 panelists on the hedonic test. It is suspected that the combination of raw materials and additives has a distinctive aroma. The formation of aroma in a final product is determined by the raw material of the product and greatly determines the quality of a product, whether the product can or cannot be accepted by consumers [26].

The results of the analysis of variance on aroma show that the use of different ratio of Tamarillo and carrageenan in making jam had a significant effect on the jam aroma ($p < 0.05$), hence a LSD test was carried out as presented in Table 3. Based on the LSD test results show that all treatments the ratio of Tamarillo and carrageenan was significantly different. This indicates that all treatments produced significantly different aromas. This is presumably because the higher the concentration of added carrageenan can affect the aroma of Tamarillo jam. According to Winarno [23], aroma usually arises as a result of a mixture of various odorous compounds. The effect of a combination of ingredients will create a taste that can differ from the aroma between one component and another [27]. Furthermore, the addition of optimal carrageenan can protect the distinctive aroma and taste of the resulting product.

Taste is a sensory attribute that cannot be separated from assessing the quality of food products and plays a very important role in producing delicious taste. The delicious taste of

food products cannot be produced without taste. Taste is a sensation felt in the oral cavity due to the presence of compounds that can interact with receptors on the tongue with four basic tastes, namely sweet, bitter, sour, and salty [28].

The average taste of the Tamarillo jam ranges from 3.17 to 3.69. The lowest taste score of 3.17 was obtained in the use of 92.5% Tamarillo and 7.5% carrageenan, while the highest score of 3.69 was obtained in the ratio of 100% Tamarillo with 0% carrageenan.

The results of the taste test showed that the panelists gave a very favorable rating to the ratio of 100% Tamarillo: 0% carrageenan, with a value of 3.69 given by 19 panelists, while the lowest level of panelists preference (2.32) was found in the ratio of Tamarillo 92.5%: carrageenan 7.5% given by 16 panelists. This shows that the addition of carrageenan has an effect in reducing the sour taste of Tamarillo. Carrageenan has a neutral effect on taste, because carrageenan has no taste. This is also in accordance with the pH value obtained, whereas the concentration of carrageenan increases, the pH value also increases, which means of Tamarillo jam will become more alkaline and lose its sour taste. Good carrageenan is carrageenan that does not have a striking taste and or no taste at all [22]. This is reinforced by Agustin and Putri [10], that carrageenan does not have a striking taste so that it can be used to avoid being affected by the taste of a product, which usually only food additives and given in limited quantities. In addition, the addition of sugar tends to neutralize the sour taste produced by Tamarillo [29]. Thus, the combination of sweet and sour taste is thought to be preferred by the panelists.

The average score for spread ability of the Tamarillo jam ranged from 1.64 to 4.28. The lowest greasing power score (1.64) was obtained in the use of 92.5% Tamarillo and 7.5% carrageenan, while the highest score (4.28) was obtained in the 95% Tamarillo with 5% carrageenan treatment. The higher the carrageenan concentration, the harder the texture of the Tamarillo jam, so that its spread ability on bread is lower (difficult to spread). The difference in the texture of the Tamarillo jam was due to the addition of different carrageenan concentrations. Carrageenan is a hydrocolloid that is commonly used as an additive in food processing which aims to form a solid and sturdy texture [5].

The test results on the jam's properties showed that the highest level of panelists' preference was for the use of Tamarillo 95% and 5% carrageenan for making jam with a score of 4.28 from the results of the assessment of 22 panelists. Furthermore, the lowest panelist assessment (1.64) was found in the treatment of tamarillo with 92.5% and carrageenan 7.5% and gave the results of a dislike rating of 15 panelists.

The results of the variance of the spread ability of Tamarillo jam with the addition of carrageenan show a significant effect ($p < 0.05$), so that an LSD test was carried out as presented in Table 3. Further test results show of spread ability of the Tamarillo jam with the addition of carrageenan were significantly different in all treatments. This shows that the addition of carrageenan as a thickening agent influences the spread ability of Tamarillo jam. The higher the concentration of carrageenan will cause the texture to be harder because the ability of carrageenan to form a gel is very strong, hence the Tamarillo jam will be difficult to apply. This is in line with the opinion Wati et al. [5], that the spread ability of the jam is influenced by the raw materials used including thickeners such as pectin and hydrocolloid materials such as carrageenan. Thus, the concentration of carrageenan added in the processing of Tamarillo jam can affect the resulting texture, hence it can affect the spread ability of the jam.

4 Conclusion

Carrageenan can be used as a thickening agent for Tamarillo jam. The comparison of Tamarillo and carrageenan has a real influence on Tamarillo jam products as indicated by

total sugar content, acidity (pH), colour, aroma, taste and spread ability. The best result of the Tamarillo jam with the addition of carrageenan was the ratio of 97.5% Tamarillo: 2.5% carrageenan.

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