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The Effect of the Addition of Citrus Fruits Juice on The Physical and Chemical Characteristics of Sapodilla (*Manikara zapota)* Sliced Jam

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A B S T R A C T

This study aims to determine the effect of various citrus fruit juices on the qualities of sliced sapodilla jam. Completely randomized design (CRD) with four treatments and four replications. A (2% citric acid) served as the control, B (26% lime juice), C (26% lemon juice), and D (26% kaffir lime juice) were the treatments. The data were statistically examined using ANOVA and Duncan's New Multiple Range Test (DNMRT) at the 5% significance level. The addition of citrus fruit juice had a substantial influence on the jam's folding test, total titrated acid, pH value, water content, ash content, total dissolved solids, total sugar, crude fiber, and vitamin C did not affect its water activity. According to the chemical features, the addition of lime juice as a source of citric acid resembles the characteristics of sheet jam made with pure citric acid more closely.

1. INTRODUCTION

1.1. Research Background

The production of Sapodilla fruit, that Indonesian named is *Sawo* fruit was high in West Sumatra, based on data from the Central Statistics Agency (BPS) in 2019 amounted to 5,600.00 tons per year, and in 2020 increased to 8,247.00 tons per year. Sapodilla fruit production knows no season, so it can bear fruit throughout the year and can grow in dry areas [1].

Sapodilla is one of the horticultural commodities, which is a climacteric fruit. After harvesting, it still experiences a spike in respiration, which causes the fruit to be easily damaged. [2], sapodilla fruit can only last for 3-5 days. Therefore, the processing of ripe sapodilla fruit needs to be done in order to extend the shelf life of sapodilla fruit. One option is to process the fruit into sliced jam [3]

Pectin, sugar and acid affect gel formation and viscosity of sliced jam. Pectin is a polysaccharide that makes up one-third of the plant cell wall. Pectin is located in the center of the lamellae in the cell wall. All photosynthetic plants contain pectin, but in different amounts depending on the type of plant and its level of maturity. Sapodilla fruit contains a small amount of pectin; therefore, pectin needs to be added so that the gel forms well. One of the gelling agents that has the same function as pectin is agar. Agar powder is a type of hydrocolloid that can form gels and as a texturizer in sliced jam [4].

Sugar has an important role in gelling, giving sweetness and also as a preservative for sliced jam. Sapodilla fruit has a sweet taste due to the sugar content in the fruit flesh, which is around 16-20% [5]. To maximize the amount of sugar in the manufacture of sheet jam, granulated sugar is added to complete it. Granulated sugar has the ability to bind water so that the firmness and elasticity of the jam can be maintained.

Acid is also important in the formation of gels in processing of sliced jam, because the acid content in ripe sapodilla fruit was relatively low. It was necessary to add acid to reach a certain pH in order to form good jam. It was usually added with synthetic citric acid. The addition of citrus fruit juice in the manufacture of the sliced jam was intended as a source of natural acid to replace the use of synthetic citric acid, which is commonly used. Adding various citrus fruit juices containing organic acids aims to regulate the pH to produce good sliced jam and prevent the formation of sugar crystals. The sour and fresh taste of sour citrus fruits juice can also give a distinctive jam taste. The juices used were lime, lemon, and kaffir lime. Lime, lemon and kaffir lime have different total acids. The addition of the amount of juice was stopped until it reached almost the same pH (3.3 to 3.6).

1.2. Literature Review

Jam is a food product that was intermediate moisture food (IMF), and modified into sheets that are compact, plastic and non-sticky [6]. A good sliced jam is a jam that is characterized by being able to lift the entire sliced jam without breaking and can also be rolled up, that is not easily torn [7]. Sliced jam was product that is more practical and easier to serve with bread. The main ingredient was rich in fiber content. Fruits with high fiber content can maintain the plastic structure of the sliced jam into a compact and non-sticky sheet. Sapodilla fruit contains 5.3% fiber, so it is suitable to be used as raw material in the manufacture of sliced jam.

In making jam, it takes 55% part of sugar and 45% part of fruit. Sugar can bind water, reducing the relative humidity (ERH) in the product and is usually used as a food preservative. The process of cooking jam with a high sugar concentration will increase the gel's viscosity [8]. The added sugar in the formation of jam functions as a dehydrating agent, which attracts water molecules bound to pectin molecules so that it will affect the balance of pectin and existing water so that the firmness and elasticity of the jam can be maintained [9].

In the manufactory of sliced jam, sugar, acid, hydrocolloid compound, and margarine were also needed. The acid plays a role in lowering the pH so that it reaches a gel formation condition. Lime, lemon, and kaffir lime contained citric acid. The citric acid (2-hydroxy-1,2,3-propanetricar-carboxylic acid) is a weak tricarboxylic acid naturally concentrated in citrus fruits. Lemon juice and lime juice are rich in citric acid, containing 1.44 and 1.38 g/oz, respectively. Lemon and lime juice concentrates contain 1.10, and 1.06 g/oz, respectively [10], and the citric acid content in lemons and limes (lime and kaffir limes) were about 8% of the wet weight [9].

Agar powder is a hydrocolloid soluble at high temperatures (80^{o}C), but its solubility in cold water is low. As much as 0.5-2% agar powder is put in water, it will form a gel after being heated to the gelatinization temperature and then cooled. At a concentration of 2%, agar powder can form a strong gel texture, but at lower concentrations it can form a soft gel. Agar powder has the same function as gelatin, accelerating the gelling process in jam [3]. Gels are formed because when heated, the gelatin and water molecules move freely when cooled, the gelatin molecules begin to close together, solidify and form a lattice that encloses the water molecules forming a solid-liquid colloidal system. [8].

In the manufacture of jam is usually used types of vegetable fat, that was margarine. Margarine had no distinctive taste and aroma of butter. In making jam, margarine is used so that the sliced jam is not sticky and the texture of the sheet jam becomes flexible. Margarine contains 80% fat, 18% water, table salt (NaCl) max 4% and several other substances. Margarine has a fairly high melting point, which is around 37-42^{o}C. This makes margarine safe to store at room temperature [11].

1.3. Research Objective

This study aims to learn the effect of adding citrus fruits juice to the physical and chemical haracteristics of Sapodilla sliced jam.

2. MATERIALS AND METHODS

2.1. The Materials

Ripe sapodilla fruit, limes, lemons and kaffir limes were obtained from community garden plants in the Solok area. Citric acid, sugar, agar powder, margarine, and plain bread were purchased from traditional markets in Padang. Chemicals for analysis include distilled water, filter paper, pp indicator (Merck, pa), 0.1 N NaOH (Merck, pa), buffer solution pH 7 and pH 4, $BaCl_2$ (Merck), H_2O (Merck), H_2SO_4 (Smart-lab, pa), HCl (Smart-lab, pa), KI (Merck), 1% starch solution, luff schoorl solution, boiling stone, thiosulfate solution ($Na_2S_2O_3$) (Merck), 10% K_2SO_4 (Merck), alcohol 95% (technical grade).

The tools used to manufacture sliced jam include scales, blender, knife, spoon, plastic basin, stirrer, filter, juicer, jam mold, stove and pan. While the tools used to analyze are analytical scales, oven, cup, desiccator, crucible pliers/tweezers, ash dish (porcelain), furnace/furnace, electric stove, beaker, funnel, measuring flask, erlenmeyer, dropper, burette. 25 mL, pH meter, aw meter, hand refractometer, upright cooler, heater, mortar, spatula, petri dish, water bath, incubator, colony counter, autoclave.

2.2. The Design

The research design was a completely randomized (CRD) with 4 treatments and 4 replications. The product observation data was analyzed using ANOVA and followed by Duncan's New Multiple Range Test (DNMRT) at a 5% significance level. The treatment was adding citrus juice to manufacture sapodilla fruit jam with citric acid treatment as a control. The treatments treatment was;

A = addition of 2% citric acid (control)
B = addition of 26% lime juice
C = addition of 26% lemon juice
D = addition of 26% kaffir lime juice

2.3. Research implementation

2.3.1. Formulation determination.

This sliced jam formulation is based on the formulation of another researcher [12] with modifications that was based on pre research that has been done. The formulation for making this sliced jam can be seen in Table 1.

Table. 1 Sapodilla fruit jam formulation

Parameters	Treatment			
	A	B	C	D
Sapodilla Puree (g)	100	100	100	100
Sucrose (g)	55	55	55	55
Margarine (g)	1	1	1	1
Agar Powder (g)	3	3	3	3
Acids (g)	2	26	26	26

2.3.2. Making of Sapodilla Puree

The sapodilla fruit is peeled, washed with water to remove the sap, drained, and seeds removed. Sapodilla fruit that has been

cleaned and seeds removed is then crushed using a blender until it becomes fruit puree. Then, the sapodilla puree is weighed according to the formulation.

2.3.3. Making of Citrus Fruit Juice

Lime, lemon, and kaffir lime are sorted and washed thoroughly. Then the citrus fruit is cut into two halves using a knife. After that, the fruits were squeezed using a juicer, then the juice was filtered.

2.3.4. Making of sliced Jam

100 g of puree sapodilla is put into a frying pan to be heated while stirring. Then, 3 g of agar powder was added, 55 g of granulated sugar, acid according to treatment, and 1 g of margarine. All ingredients were mixed and then cooked until a temperature of at least 80ºC. During cooking, stirring is carried out continuously and should not be too fast because it will cause bubbles which can damage the texture and final appearance. Then a spoon test is carried out to determine when the cooking is complete and if the jam does not fall easily when poured. Then the jam was poured into a mold measuring 8x8 cm with a thickness of 3 mm, then the jam was allowed to stand until it hardened.

2.4. Observations

2.4.1. Observation on the Raw Materials

Observations on the raw materials, namely sapodilla puree, lime juice, lemon juice, and kaffir lime juice. In the sapodilla puree was observed for water content, pH, total dissolved solids, crude fiber, and vitamin C. In lime, lemon and kaffir lime, water content, pH, and vitamin C levels were observed.

2.4.2. Observation of the Sliced Jam

Observations on the sliced jam included physical tests (folding power), chemical tests (total titrated acid, pH value, water content, ash content, water activity (aw), total dissolved solids, total sugar, crude fiber content, and vitamin C content).

3. RESULT AND DISCUSSION

3.1. Raw Materials Analysis

The analysis was carried out on the raw materials, namely sapodilla pulp, lime, lemon, and kaffir lime. The sapodilla pulp was analyzed for water content, pH, vitamin C, total dissolved solids, and crude fiber. Meanwhile, lime, lemon, and kaffir lime were analyzed for water content, pH, and vitamin C. The results of the analysis of raw materials can be seen in Table 2.

Table. 2 The Raw Materials Analysis

Variable	Raw Material			
	Sapodilla Puree	Lime Juice	Lemon Juice	Kaffir Lime Juice
Water Content (%)	77.21 ±0.9	93.67 ± 0	94.34 ± 0.01	89.35 ± 0.49
pH	5.60 ±0	2.45 ± 0.07	2.65 ± 2.65	2.60 ± 0.14
Vit. C (mg/100ml)	14.26 ± 0.25	27.11 ± 1	50.69 ± 1.99	20.24 ± 2.23
TDS (˚Brix)	16.88 ± 1.44	-	-	-
Fiber Dietary %)	2.25 ± 0.35	-	-	-

Note: (-) no test is carried out, TDS = Total Dissolved Solids

Table 2 shows the water content of sapodilla puree is 77.21% in lime juice, 93.67%, in lemon juice, 94.34%, and in kaffir lime juice, 89.35%. According to other reports, the moisture content of sapodilla pulp in this study was not much different from the composition of sapodilla as a whole, namely 78% [13]. Likewise, the water content of limes, lemons and kaffir limes juice in other reports is almost the same, namely 88.9%, 92.2% and 81.1%, respectively. The results of the analysis of these three citrus types are in line with the results of research conducted where the highest water content is found in lemons and the lowest is in kaffir limes[14].

The pH of the sapodilla puree obtained is 5.60 (table 2). The results of this analysis are not much different from the results of the other research which states that the pH of sapodilla fruit was 5 [12]. Table 2 shows that the pH of lime juice, 2.45, lemons 2.65 and kaffir lime, 2,60. in line with another study, pH of lime was 2.48 and kaffir lime was 2.60 [15] the pH of lemon was 2.57 [16].

The value of vitamin C of sapodilla puree is 14.26 mg/100ml. According to USDA, this result is in line with the value of vitamin C in sapodilla fruit, which is 14.7 mg/100ml [13]. The value of vitamin C in lemons is 50.69 mg/100ml (Table 2), which is in line with other reported 40-50 mg/100ml of vitamin C [17]. Table 2. also shows that vitamin C in kaffir lime juice is 20.24, lower than other reported 20.24 mg/100 ml [13] and the vitamin C in lime is 27.11 mg/100 ml (Table 2).

The results showed that the levels of vitamin C in the fruit juices of the three types of citruses differed quite a lot. 50.69% in lemons juice, 27.11% in limes juice, and 20.24 in kaffir limes juice. However, it is not in line with the pH of each juice, where the pH of lemon juice is 2.65, lime is 2.45, and kaffir lime is 2.60. Lemon juice which contains much higher vitamin C than the other types, actually has a pH that is close to the same as the pH of kaffir lime which has less than half the vitamin C content of lemon juice. This shows that kaffir lime juice and lime juice contain other organic acids which are high enough to affect the pH of the juice.

Total dissolved solid of sapodilla puree is 16.88 ^{0}Brix, and crude fiber is 2.25% (table 2). The results of the analysis of total dissolve solids from this study are in line with other reports, which are 16.6-17 ºBrix [13], while the crude fiber content in this study is slightly below other report.

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3.2. Folding Test of Sliced Jam (Physical Characteristic)

Folding test on sapodilla fruit jam with the addition of the several types of juice ranged from 3.00 to 4.00. The analysis results can be seen in fig 1 and table 3. The highest folding test was found in treatment A (2% citric acid) with an average value of 4.00 (cracked after two folds but not cracked after one old).

Fig 1. Sliced Jam

These results indicate that adding lime juice, lemon juice and kaffir lime juice resulted in a lower folding test when compared to the addition of citric acid as a control. This is thought to be associated with the high-water content of the juice, which ranges from 89.35 - 94.34% so that it can affect the water holding capacity to be low so that the jam will become softer and cause the jam to crack more easily.

Table 3. The value of Folding Test

Treatment	Value
A (2%, citric acid)	4.00 ± 0.00
B (26%, lime juice)	3.00 ± 0.00
C (26%, lemon juice)	3.00 ± 0.00
D (26%, kaffir lime)	3.00 ± 0.00
CV = 0%	

Note: : 1= broken when pressed with finger without folding,
2= cracked but still attached when folded once,
3= cracked after one fold,
4= cracked after two folds but not cracked after one fold,
5= not cracked after two folds.

In addition, it is also influenced by the concentration of citric acid, the addition of lime juice, lemon juice and kaffir lime juice, besides containing citric acid, it also contained other compounds, so that the concentration of citric acid in the juice decreases. This resulted in the gel's strength getting weaker [18]. So that when folded, the jam is easy to crack. Thus, if seen from Figure 5 the sliced jam with treatments B, C, and D is somewhat less attractive when folded, but before folding the appearance of the sheet jam from all treatments is not different.

3.3. Chemical Characteristics of Sliced Jam

3.3.1. Total Titrated Acid

The dominant organic acid content in citrus fruits is citric acid, so the target of this product analysis is citric acid. The total titrated acid analysis results measured in the sliced jam contain citric acid. Table 4 shows that the total titrated acid ranged from 0.75-1.45%. The results of the analysis can be seen in table 4.

Table 4. The Value of Total Titrated Acid

Treatment	Value (%)
A (2%, citric acid)	1.45 ± 0.64 d
B (26%, lime juice)	1.19 ± 0.64 c
C (26%, lemon juice)	0.75 ± 0.64 a
D (26%, kaffir lime)	1.01 ± 0.64 b
CV = 5.81%	

Note**:** Numbers in the same column, followed by different lowercase letters, show significant differences at the 5% Duncan's New Multiple Range Test (DNMRT) level.

The variance analysis shows that the addition of citrus fruits juice had a statistically significant effect (p = 0.002) on the total titrated acid value of sapodilla jam. The total acid calculated is the total citric acid. The highest total citric acid was found in treatment A (2% citric acid) which was 1.45% and the lowest was found in treatment C (26% lemon juice) which was 0.75%. Treatment A had high total citric acid because the added acid was pure citric acid. In contrast to sheet jam with the addition of lemon, the total citric acid is lower. This is related to pH, lemon has a higher pH, then followed by kaffir lime and lime.

The total measured titration acid is the citric acid level. The results showed that the levels of citric acid in jam with the addition of lime juice, lime juice, and kaffir lime resulted in lower levels of citric acid when compared to citric acid in jam with pure citric acid added (treatment A). The addition of orange juice in making jam has taken into account the citric acid content in each orange juice. Another interesting thing is that the citric acid content in each jam added to orange juice is not the same, even though the amount of fruit juice added has taken into account the citric acid content in each fruit according to another report that the citric acid content is 8% [18]. . From these findings, it is suspected that the citric acid content in lime juice, lemon juice and kaffir lime juice is not the same.

3.3.2. The Value of pH

The results of the pH analysis on sapodilla sliced jam with the addition of the juice ranged from 3.35 to 3.60. The results of the analysis can be seen in table 5. The analysis of variance shows that the addition of the juice has an effect on statistically significant (p = 0.018) on the pH value of sliced jam. The highest pH was found in treatment C (26% lemon juice) which was 3.60. Referring to the analysis of raw materials, the pH of lemon juice is 2.65 higher than that of kaffir lime juice, which is 2.60 and that of lime juice is 2.45. Research shows that the higher the total citric acid, the lower the pH value. Not so in treatment A (2% citric acid) which had the same pH as treatment B (26% lime juice). It is suspected that in the juice, both lime, lemon and kaffir lime, it is suspected that there are other acidic compounds such as oxalic acid, tartaric acid, malic acid, lactic acid, and ascorbic acid that can affect on the pH.

Table 5. The Value of pH

Treatment	Value	
A (2%, citric acid)	3.35 ± 0.07	a
B (26%, lime juice)	3.35 ± 0.07	a
C (26%, lemon juice)	3.60 ± 0.00	b
D (26%, kaffir lime)	3.50 ± 0.00	b
CV = 1.45%		

Note**:** Numbers in the same column followed by different lowercase letters, show significant differences at the 5% Duncan's New Multiple Range Test (DNMRT) level.

In measuring the pH of the raw materials, the basic pH of all ingredients before cooking is in the range of 3.3 - 3.6. Measurement of pH value is one of the parameters to determine the durability of a food product, especially in products that are processed with acid. The higher the concentration of citric acid used, the lower the pH value. This is because citric acid acts as an acidifying agent.

3.3.3. Water Content

The results of the analysis of the water content in sliced jam with the addition of juice ranged from 32.00 to 36.27%. The results of the analysis can be seen in table 6. Based on the results of the analysis of variance, it showed that the addition of the juice had a statistically significant effect (p = 0.000) on the moisture content of the sliced jam. The highest water content was found in treatment C (26% lemon juice) which was 36.27% and the lowest was in treatment A (2% citric acid) which was 32.00%. The difference in water content in sliced jam is influenced by the type and moisture content of the raw materials used. In the analysis of raw materials, the highest water content of lemon juice was obtained, which was 94.34% when compared to lime at 93.34% and kaffir lime 89.35%. Usually, intermediate food has a moisture content of 10-50% [19].

Table 6 . The Value of Water Content

Treatment	Value (%)	
A (2%. citric acid)	32.00 ± 0.98	a
B (26%. lime juice)	35.28 ± 0.61	c
C (26%. lemon juice)	36.27 ± 0.39	c
D (26%. kaffir lime)	33.03 ± 0.52	b
CV = 1.94%		

Note**:** Numbers in the same column followed by different lowercase letters, show significant differences at the 5% Duncan's New Multiple Range Test (DNMRT) level.

In this study, the product's water content was found to be in the range of intermediate moisture food, 10-50% [19]. Moisture content is one of the most important tests in food products to determine the quality and resistance of food to damage that may occur. The water content of treatment A was lower when compared to treatments B, C, and D. This was related to the water content of the raw materials. In treatment A, pure citric acid was added, while in treatments B, C and D, food containing citric acid was added. Because the citric acid in food is not pure, the amount of juice that must be added must be more to get the same concentration of citric acid as pure citric acid. Thus, not only citric acid enters the raw material, but also the water.

3.3.4. Ash Content

The results of the analysis of the ash content of the sapodilla fruit jam product with the addition of the juice ranged from 0.41 - 0.84% can be seen in table 7. The analysis of variance showed that the addition of the juice had a statistically significant effect (p = 0.013) on the ash content of sliced jam. The highest ash content was found in treatment C (26% lemon juice) which was 0.84% and the lowest was found in treatment A (2% citric acid) which was 0.41%.

Table 7 . The Value of Ash Content

Treatment	Value (%)	
A (2%, citric acid)	0.41 ± 0.17	a
B (26%, lime juice)	0.58 ± 0.17	ab
C (26%, lemon juice)	0.84 ± 0.19	b
D (26%, kaffir lime)	0.66 ± 0.01	bc
CV = 24.22%		

Note**:** Numbers in the same column followed by different lowercase letters, show significant differences at the 5% Duncan's New Multiple Range Test (DNMRT) level.

Table 7 shows that adding the juice resulted in higher ash content than adding citric acid. Ash content indicates mineral content derived from inorganic residues from the combustion of organic components contained in sliced jam. The ash content of this sliced jam is influenced by the characteristics of the raw materials, the additives used and the mineral content of the ingredients. The presence of minerals in sapodilla sliced jam is influenced by minerals found in sapodilla fruit and limes, lemons and kaffir limes juice, such as potassium, calcium, sodium, phosphorus, iron. The higher the ash content in a food ingredient, the higher the minerals contained in the food.

3.3.5. The activity of Water (Aw)

The results of the analysis of water activity in the sapodilla fruit jam with the addition of juice ranged from 0.80 to 0.83. The results of the analysis can be seen in table 8. Table 8. shows that the Aw value of sapodilla fruit jam with the addition of the juice ranged from 0.80 - 0.83. The aw of those jams meets the aw criteria of intermediate moisture food, ranging from 0.65-0.90. [19].

The highest Aw value was found in treatment C (26% lemon juice) which was 0.83, and the lowest was in treatment A, which was 0.80. The results obtained are in line with the water content of sliced jam where the addition of orange juice has a higher water content when compared to the addition of citric acid (control). The relationship between water content and the water activity of a food follows a typical pattern. In general, the higher the water activity, the greater the water content of the material, but the pattern of changes in water content with water activity is not linear. However, it is in the form of a sigmoid curve which is commonly called a moisture sorption isotherm (MSI) curve (Kusnandar, 2010). . The water sorption isotherm curve is

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generally sigmoid in shape and is typical for each food. So, not always with the higher water content of a material, the water activity is also high. Water activity in food products varies in different environments. When wet food is stored in an environment with low relative humidity (dry), then some water from the food gradually migrates to the environment until equilibrium conditions are reached (Aw = ERH/100) and vice versa.

Table 8. The Value of Activity of Water (aw)

Treatment	Value
A (2%, citric acid)	0.80 ± 0.01
B (26%, lime juice)	0.82 ± 0.00
C (26%, lemon juice)	0.83 ± 0.00
D (26%, kaffir lime)	0.82 ± 0.00
CV = 0.41%	

Water activity (Aw) is one of the parameters that can be used to explain how water affects food stability and durability, chemical reaction rate, enzyme activity, and microbial growth [20]. Water activity is most commonly used as a criterion for food safety and food quality. Free water can accelerate the process of damage to foodstuffs such as microbiological, chemical, enzymatic processes and even destructive insect activity [19] .

3.3.6. Total Dissolved Solid (TDS)

The results of the analysis of total dissolved solids in sapodilla sliced jam with the addition of the juice ranged from 28.50 – 40.50 ^{0}Brix. The results of the analysis can be seen in table 9. Based on the results of the analysis of variance, it showed that the addition of the juice had a statistically significant effect (p = 0.001) on the total dissolved solid. The highest total dissolved solids were found in treatment A (2% citric acid) which was 40.50 ^{0}Brix, significantly different from treatments B (26% lime juice), C (26% lemon juice), and D (26% lime juice). kaffir lime), where the total soluble solids in the treatment with the addition of its juice resulted in a lower total dissolved solids when compared to the treatment with the addition of pure citric acid.

Table 9. The Value of Total Dissolve Solid

Treatment	Value (^{0}Brix)	
A (2%, citric acid)	40.50 ± 5.74	b
B (26%, lime juice)	33.00 ± 2.45	a
C (26%, lemon juice)	28.50 ± 1.73	a
D (26%, kaffir lime)	30.75 ± 1.50	a
CV = 10.02%		

Note**:** Numbers in the same column, followed by different lowercase letters, show significant differences at the 5% Duncan's New Multiple Range Test (DNMRT) level.

Based on SNI 01-3746-2008, the value of total dissolved solid for fruit jam quality requirements is at least 65%. The value obtained in this study did not meet the standard of SNI 01-3746-2008 for the jam. Treatment A had higher total dissolved solid than treatments B, C and D. This is thought to be caused by the higher water content in treatments B, C and D, compared to water content in treatment A. The Higher water content can also cause the solids concentration to increase. It is in line with other reports which stated that the water content could affect the total dissolved solid content of the material.

3.3.7. Total Sugar

The analysis results of total sugar in sapodilla sliced jam ranged from 44.39 to 57.10%. The results of the analysis can be seen in table 10. The minimum total sugar content of jam is 55-65% wet weight [21]. In this study, the total sugar of sapodilla sliced jam was still below the minimum total sugar content of the jam applied.

Table 10. The Value of Total Sugar

Treatment	Value (%)	
A (2%, citric acid)	57.10 ± 2.62	b
B (26%, lime juice)	52.93 ± 2.23	b
C (26%, lemon juice)	44.39 ± 3.69	a
D (26%, kaffir lime)	49.96 ± 0.28	a b
CV = 11.02%		

Note**:** Numbers in the same column followed by different lowercase letters, show significant differences at the 5% Duncan's New Multiple Range Test (DNMRT) level.

Based on the results of the analysis of variance, it showed that the addition of juice had a statistically significant effect (p = 0.030) on the total sugar. Table 10. shows that the highest average total sugar value is found in treatment A (2% citric acid) which is 57.10%, higher than treatment B (26% lime juice), C (26% lemon juice)) and D (26% kaffir lime juice). This is because the higher the concentration of citric acid added, the total sugar tends to increase. This is thought to have something to do with the hydrolysis of complex carbohydrates (polysaccharides) into simple carbohydrates which are included in the sugar group.
Correlation analysis showed that glucose, fructose, and sucrose were positively correlated with total sugar content [22].

3.3.8. Crude Fiber

The results of the analysis of crude fiber in sapodilla sliced jam products with the addition of several types of juice ranged from 0.50 to 3.00%. The results of the analysis can be seen in table 11. Based on the results of the analysis of variance, it showed that the addition of the juice had a statistically significant effect (p = 0.009) on crude fiber. Table 11. shows that the highest average value of crude fiber is found in treatment C (26% lemon juice) which is 3.00% and the lowest is found in treatment A (2% citric acid) which is 0.50%. This is thought to be caused by the addition of juice. In treatment A, the acid used was pure citric acid, while in treatments B, C and D, citric acid was obtained from fruit juice. Of course, there are other compounds in fruit juices besides citric acid, one of which is crude fiber. The crude fiber in the jam likely comes from the added juice.

Table 11. The Value of Crude Fiber

Treatment	Value (%)	
A (2%, citric acid)	0.50 ± 0.00	a
B (26%, lime juice)	0.75 ± 0.35	a
C (26%, lemon juice)	3.00 ± 0.00	b
D (26%, kaffir lime)	2.00 ± 0.71	b
CV = 25.30 %		

Note**:** Numbers in the same column followed by different lowercase letters, show significant differences at the 5% Duncan's New Multiple Range Test (DNMRT) level.

3.3.9. Vitamin C

The results of the analysis of vitamin C in sapodilla fruit jam with the addition of several of types of juice ranged from 9.15 to 17.25%. The results of the analysis can be seen in table 12. The analysis of variance showed that the addition of the juice had a statistically significant effect (p = 0.016) on vitamin C in sliced jam. The highest vitamin C was found in treatment C (26% lemon juice) which was 17.25 mg/100ml, and the lowest was in treatment A (2% citric acid) which was 9.15 mg/100ml. The difference in vitamin C content is due to each juice's naturally different vitamin C content.

Table 12 . The Value of Vitamin C

Treatment	Value (mg/100ml)	
A (2%, citric acid)	9.15 ± 0.49	a
B (26%, lime juice)	12.32 ± 0.99	a
C (26%, lemon juice)	17.25 ± 0.00	b
D (26%, kaffir lime)	11.26 ± 2.49	a
CV = 10.90 %		

Note**:** Numbers in the same column followed by different lowercase letters, show significant differences at the 5% Duncan's New Multiple Range Test (DNMRT) level.

The higher the vitamin C content in the added juice product, the greater the vitamin C content in a sliced jam. From the results of the analysis of raw materials, the level of vitamin C in lime juice is 27.11 mg/100ml, the level of vitamin C in lemon juice is 50.69 mg/100ml, and vitamin C in kaffir lime juice is 20.24 mg/100ml. The vitamin C content in all products is in line with the vitamin C content in lime juice, lemon juice, and kaffir lime juice

4. CONCLUSION

The addition of citrus fruits juice significantly affected the folding test, total titrated acid, pH value, water content, ash content, total dissolved solids, total sugar, crude fiber and vitamin C of the sliced jam**,** but has no effect on water activity. Judging from the chemical characteristics, it shows that the addition of lime juice as a source of citric acid is closer to the characteristics of sheet jam using pure citric acid.

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