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# Study on the Proportion of Orange Peel and Orange Juice with Sugar Addition on the Physicochemical and Organoleptic Characteristics of Siam Orange Jam

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**A B S T R A C T**

Siam oranges (Citrus nobilis) are abundant commodities, with the fruit flesh being commonly utilized, while the peel is often discarded as waste. The peel contains flavonoids, limonin, hesperidin, and pectin, which function as antioxidants and natural gelling agents. This study used both the peel and the juice of Siam oranges, with added sugar. The orange juice serves as a solvent for the mixture of ingredients, while sugar adds sweetness and helps maintain the jam's consistency during cooking. This study aimed to investigate the effects of varying proportions of orange peel and juice, along with different sugar concentrations, on the physicochemical and organoleptic characteristics of Siam orange jam and to determine the optimal formulation. The experiment was designed using a Randomized Complete Block Design in a factorial pattern with two replications. Factor 1 consisted of the proportion of orange peel to orange juice (10:90, 20:80, 30:70), and Factor 2 involved sugar concentration (60%, 65%, 70%) with two replications. Data were analyzed using ANOVA and Duncan's Multiple Range Test (DMRT) at a 5% significance level. The results showed that the best treatment was the 30:70 ratio of Siam orange peel to juice with 65% sugar (A3G2), which produced jam with the following characteristics: moisture content of 36.99%; pH of 3.44; total dissolved solids (TDS) of 64.24°Brix; reducing sugar of 20.32%; vitamin C content of 16.48 mg/100g; antioxidant activity of 52.10%; spreadability of 7.12 cm; crude fiber of 0.71%; and hedonic test scores for texture (3.16, slightly like), taste (3.12, slightly like), color (4.16, like), aroma (3.40, slightly like), and overall (3.24, slightly like).

**Contribution to Sustainable Development Goals (SDGs):**
**SDG 3**: Good Health and Well-being
**SDG 8**: Decent Work and Economic Growth
**SDG 9**: Industry, Innovation, and Infrastructure
**SDG 12:** Responsible Consumption and Production
**SDG 13:** Climate Action

## 1. INTRODUCTION

### *1.1. Research Background*

Siam oranges (Citrus nobilis) are one of the most widely cultivated types of oranges in Indonesia due to their distinctive aroma, balanced sweet-sour taste, thin yellow-green skin, and ease of peeling. According to data from the Central Statistics Agency [1], he production of Siam oranges in the region reaches 1.4 million tons per year, indicating a large economic potential in the national horticultural sector. However, the utilization of this fruit is generally limited to the pulp or juice, while the orange peel is often considered waste with no economic value and ends up as organic trash. The abundant production of Siam oranges is proportional to the utilization of the fruit for food and beverages, alongside the significant amount of orange peel waste generated [2].

Various studies have shown that Siam orange peels contain high levels of nutrients and bioactive compounds. The peel contains vitamin C ranging from 110.4–127.7 mg per 100 grams [3] and antioxidant activity reaching 71.2% [4]. Additionally, orange peels are rich in flavonoids, limonin, and hesperidin, which act as natural antioxidants to counteract free radicals and reduce the risk of degenerative diseases [5]. Chemically, orange peels also contain cellulose, hemicellulose, and lignin, which can be used as raw materials for high-fibre food products. According to Pracaya (in Sweet Oranges), orange peels have higher levels of vitamins, proteins, minerals, and amino acids than the fruit pulp, including calcium, magnesium, potassium, and sulfur, while having lower levels of fats and sugars. The pectin content in Siam orange peel reaches 10–25% of its dry weight [6]. making it highly promising for processing into natural gelling agents in food products such as jams.

Fruit jam is a processed product made from a mixture of fruit and sugar, which is cooked until it reaches a thick or semi-solid texture. [7]. Jam comes in many varieties, with spreadable jam among the most popular due to its ease of production and use in various food and beverage products, such as bread, yoghurt, and ice cream. [8].

The quality characteristics of jam are influenced by physicochemical factors, such as viscosity, flavour, texture, and the content of bioactive compounds, including pectin, which acts as a gelling agent. Sugar contributes to gel formation and increases viscosity. However, excessive sugar addition can cause the jam to become overly firm and may pose health risks, such as obesity and diabetes. [9].Therefore, determining the optimal sugar concentration is crucial for producing jam with the ideal texture and flavour [10]. Pectin is also a key component, as it functions as a thickening agent, determining the gel's thickness and stability. Research by Ref. [11] and [12] shows that the optimum pectin content for good gel formation ranges from 0.75% to 1.5%, with a maximum sugar content of 65%. Beyond this threshold, the gel structure becomes too dense and less favored organoleptically. Thus, the combination of orange peel as a source of pectin and orange juice as a source of flavour is an important factor to control to produce high-quality jam.

Siam orange juice contains natural citric acid, which plays a role in the formation of the sour taste and pH stability. However, this content can vary depending on the variety and ripeness of the fruit [13]. Therefore, the addition of external citric acid is often necessary to maintain the optimal pH (3.0–3.3) during gel formation and to prevent sugar crystallisation [14].[15]. An imbalanced ratio of peel to juice can lead to quality issues: an excessively high peel-to-juice ratio results in a bitter taste, while an excessive amount of juice leads to a runny, less dense jam.

### *1.2. Literature Review*

Fruit jam is a processed fruit product obtained by heating fruit pulp mixed with sugar, often with the addition of acid and thickening agents such as pectin. The cooking process must be carefully controlled because excessive heating results in a hard texture, while brief heating leads to runny jam [16]. The cooking process also aims to remove water from the mixture, thereby increasing its viscosity and enhancing the product's shelf life [17]. Orange jam typically uses a 45% fruit to 55% sugar ratio, resulting in a minimum total dissolved solids of 65%. The proportions of sugar, pectin, and acid greatly influence the viscosity and texture of the jam. Using too little sugar results in jam that is not thick enough, while excessive acid can cause syneresis, which is the release of water from the gel [18].

Several factors also influence the quality of jam. Key factors affecting the shelf life of jam include a high sugar content (67–75% of total dissolved solids), an optimal pH range of 3.1-3.5, and a water activity (aw) of 0.75-0.83. The cooking temperature also plays a crucial role, with the ideal range being 105°C to 106°C to avoid physical or microbiological damage to the product [19].

Pectin is a complex polysaccharide found in plant cell walls, particularly in the albedo (the white inner layer) of citrus fruit peel. In jam production, pectin functions as a gelling agent. High Methoxyl pectin, which is predominant in Siam orange peel, forms gel through hydrophobic interactions and hydrogen bonds between pectin chains. This process is influenced by pH, sugar concentration, and the correct heating temperature. Suppose the heating temperature is too high or the heating time is too long. In that case, it can cause pectin depolymerisation, resulting in a loss of gelling ability and an unstable jam texture [15]. Therefore, selecting the right heating temperature and controlling the sugar and acid levels are crucial in jam production.

Siam orange peel, often considered waste, has great potential as a raw material for jam production. Siam orange peel is rich in pectin, flavonoids, limonene, and vitamin C, which serve as natural antioxidants and can enhance the nutritional value of the jam. Most of the pectin in Siam orange peel is found in the albedo, which is thicker than that of other citrus varieties, such as lime or grapefruit [20]. However, Siam orange peel also contains bitter compounds, especially naringin, which can affect the taste of the jam. Therefore, before using it for jam production, the peel must undergo treatment to reduce its bitterness. One effective method is to soak and boil the orange peel in a solution of sodium bicarbonate ($NaHCO_3$). This treatment helps break down the bitter compounds while preserving the texture of the peel, making it easier to process into jam. Ref. [21] reported that soaking orange peel in a sodium bicarbonate solution can reduce naringin content by up to 50% without significantly affecting the peel's colour or aroma.

Sugar plays a crucial role in jam production by providing sweetness and by supporting pectin-mediated gel formation. Sugar also helps regulate viscosity, microbiological stability, and the final product's texture. The correct sugar concentration is essential, as too much can lead to surface crystal formation, while too little can result in a weak gel [22].

Citric acid is added to jam during production to lower the pH and prevent sugar crystallisation. Citric acid also helps improve texture and maintain product stability during storage. The optimal pH for pectin gel formation ranges from 3.0 to 3.3, with enough acid added to achieve this pH without causing excessive syneresis [8].

### *1.3. Research Objective*

This study aims to determine the effects of orange peel and orange juice on the physicochemical characteristics of Siam orange jam made from both, and to identify the optimal proportions to achieve the desired product quality.

## 2. MATERIALS AND METHODS

### *2.1. Raw Materials*

The primary raw materials used include Siam orange fruit, granulated sugar sourced from the Asem Simo Gunung market in Surabaya, pectin powder with a jelly grade of 150º, and citric acid obtained from a chemical supply store.

### *2.2. Methods*

#### *2.2.1. Experimental Design*

This study uses an experimental method to examine the effects of different proportions of orange peel and orange juice, with varying sugar concentrations, on the physicochemical and organoleptic characteristics of Siam orange peel jam (Citrus nobilis). The experimental design is a completely randomised design (CRD) with a factorial pattern of two factors. The first factor is the proportion of orange peel and orange juice (10:90, 20:80, 30:70), and the second factor is the addition of granulated sugar (60%, 65%, 70%). Each treatment combination is repeated twice, resulting in 18 experimental units..

The data obtained were analyzed using Analysis of Variance (ANOVA). If significant differences are found between treatments, Duncan's Multiple Range Test (DMRT) is performed at a 95% confidence level ($\alpha = 0.05$).

#### *2.2.2. Preparation of Materials*

The raw materials used are fresh Siam oranges obtained from the local market. The preparation process to produce orange juice follows the method described by [23]. The fruit is sorted to select ripe ones that are free from mechanical defects and rot. The fruit is washed with running water to remove any dirt. The Siam oranges are then cut in half lengthwise, and the juice is squeezed out. The separation between the pulp and the peel (both albedo and flavedo) is maintained, as it contains high pectin content. The peel is then cut into small pieces to facilitate the next steps in the jam-making process.

#### *2.2.2.1 Modified Siam Orange Peel Pulp Preparation [21] [24]*

Siam orange peel contains flavonoid compounds, particularly naringin and limonin, which are naturally present in the albedo of the peel and contribute to the bitter taste in the final product. To remove this bitterness, a 30-minute soak in a 1% sodium bicarbonate ($NaHCO_3$) solution at room temperature is performed. After soaking, the peel is boiled in the same solution at 60°C for 20 minutes. After boiling, the peel is thoroughly rinsed with clean water to ensure no alkaline solution remains. The peel is then blended into a smooth, homogeneous pulp using a blender, ready for use in the jam-making process.

#### *2.2.3. Siam Orange Jam Preparation*

The mixture of orange peel pulp and Siam orange juice is placed in a pot, and sugar is added as specified for the treatment. Then, citric acid and pectin are incorporated into the mixture. The cooking process is carried out at approximately 70°C for 15 minutes, with constant stirring. Once the desired consistency is achieved, the jam is cooled to 40°C and left for 60 minutes to stabilise.

## 3. RESULT AND DISCUSSION

### *3.1 Physicochemical Propertys*

#### *3.1.1 Moisture Content*

The analysis of variance showed a significant interaction ($p < 0.05$) between the proportion of Siam orange peel pulp, Siam orange juice, and sugar addition on the moisture content of the jam, with each treatment having a significant effect ($p \leq 0.05$). Based on the data in Table 1, the jam's moisture content ranged from 3.14% to 37.93%. This indicates that the higher the proportion of Siam orange peel pulp or the lower the proportion of Siam orange juice, and the higher the sugar addition, the higher the jam's moisture content.

The increase in moisture content in Siam orange jam is due to the presence of pectin (20.58%) and crude fibre (8.60%) in the peel, which can bind water within their structures, forming a denser gel. [25] reported that the fiber in orange peel contains polysaccharides such as cellulose and hemicellulose, which can bind small amounts of water through hydrogen bonding. Therefore, the higher the proportion of orange peel pulp, the more these compounds can bind water, resulting in a lower free moisture content in the jam. Conversely, increasing the amount of orange juice increases the jam's moisture content because orange juice contains a very high water content (89.55%), contributing substantially to the overall moisture. The diffusion of water from the orange juice (high concentration) into the peel pulp and sugar (low concentration) increases the water content in the mixture, as explained by [26]. Ref [27] also showed that the free water content in products high in pectin tends to decrease because pectin absorbs water into its molecular structure. Therefore, reducing the proportion of orange juice and increasing the proportion of peel lowers the jam's moisture content.

Sugar has hygroscopic properties, meaning it can attract and bind water molecules, further reducing the amount of water that readily evaporates during cooking. Sugar also helps strengthen the pectin gel network, making it more stable in holding water. This is in line with [28] who stated that the moisture content of jam is influenced by cooking time, temperature, and the concentrations of sugar and pectin. In addition, the addition of sugar to jam affects the balance between pectin and water, as well as the stability of pectin molecules, causing pectin to aggregate and form fine fibres capable of holding liquid or water [29].

#### *3.1.2 pH*

The analysis of variance showed a significant interaction ($p < 0.05$) among the proportions of Siam orange peel pulp, Siam orange juice, and sugar addition on the pH of the jam, with each treatment having a significant effect ($p \leq 0.05$). Based on the data in Table 1, the pH values ranged from 3.19 to 3.53. This indicates that the higher the proportion of Siam orange peel pulp or the lower the proportion of Siam orange juice, and the higher the sugar addition, the higher the jam's pH.

The increase in pH of Siam orange jam is due to the peel's higher pH compared to the juice; therefore, increasing the peel proportion results in a higher pH. This occurs because Siam orange peel contains a high amount of crude fiber (8.60%), which is neutral or slightly alkaline, giving the peel pulp a pH of 4.30. A higher proportion of orange peel inhibits pectin hydrolysis, reducing the release of galacturonic acid groups and increasing the jam's pH. This is consistent with the findings of [28], who reported that lower pH slows the pectin gelation process. A decrease in the proportion of Siam orange juice also increases the jam's pH because the juice contains high levels of organic acids; however, its acidifying effect diminishes as its proportion decreases. Ref. [23] reported that malic acid and citric acid in Siam orange juice contribute to lowering pH, but in a mixture with higher peel content, this acidifying effect becomes more limited.

The addition of sugar to the jam mixture can increase the pH due to dilution and osmotic effects, which reduce the concentration of $H^+$ ions from organic acids, thereby increasing the pH. Sugar, being hygroscopic, binds water and lowers water activity (Aw), causing $H^+$ ions to become more tightly bound and less dissociated [30]. Ref. [28] also reported that higher sugar addition increases the pH of mandarin jam due to increased –OH groups in the mixture, which alters the jam's acidic characteristics.

#### *3.1.3 Total Solid Dissolved (TDS)*

The analysis of variance showed a significant interaction ($p < 0.05$) between the proportion of Siam orange peel pulp, Siam orange juice, and sugar addition on the total dissolved solids (TDS) of the jam, with each treatment having a significant effect ($p \leq 0.05$). Based on the data in Table 1, the TDS values ranged from 57.12°Brix to 65.08°Brix. This indicates that the higher the proportion of Siam orange peel pulp, or the lower the proportion of Siam orange juice, and the higher the sugar addition, the higher the total dissolved solids of the jam.

The increase in total dissolved solids (TDS) in Siam orange jam is due to the peel containing crude fiber (8.60%), pectin (20.58%), and reducing sugars (8.30%), which become suspended in the jam and contribute to the rise in total dissolved solids. This is consistent with the findings of [29] who stated that the addition of orange peel increases TDS because its pectin and fiber serve as major solid components. On the other hand, decreasing the proportion of Siam orange juice—which has a high water content (89.55%) and low crude fiber (2.14%) also increases TDS, because reducing the water-rich component lowers dilution in the mixture [23] reported that increasing the amount of Siam orange juice, which is predominantly water, tends to decrease total dissolved solids.

The addition of sugar in jam production can increase the total dissolved solids because sugar is easily soluble and hygroscopic, allowing it to bind water activity (Aw) and undergo hydrolysis into glucose and fructose, which are classified as reducing sugars. This is consistent with [28], who stated that the sugar concentration in jam can increase the total dissolved solids because, during cooking, sugar undergoes hydrolysis, thereby increasing the concentration of reducing sugars in the mixture..

#### *3.1.4 Reducing Sugar Content*

The analysis of variance showed a significant interaction ($p < 0.05$) among the proportions of Siam orange peel pulp, Siam orange juice, and sugar addition on reducing sugar content, with each


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treatment having a significant effect ($p \leq 0.05$). Based on the data in Table 1, the reducing sugar content ranged from 14.38% to 20.68%. This indicates that the higher the proportion of Siam orange peel pulp, or the lower the proportion of Siam orange juice, and the higher the sugar addition, the higher the reducing sugar content.

The increase in reducing sugar content between treatments is due to the presence of crude fibre (8.60%), pectin (20.58%), and reducing sugars (8.30%) in Siam orange peel, which contribute to higher reducing sugar levels as their proportions increase during cooking. According to [31], increasing the proportion of Valencia orange peel and sugar increased the reducing sugar content in fruit leather because the sucrose in both ingredients undergoes hydrolysis under acidic, heated conditions, producing glucose and fructose, which are reducing sugars. Thus, the resulting reducing sugar content increases. A decrease in the proportion of orange juice also increases the reducing sugar content in the jam, even though orange juice has a high water content that could dilute the mixture. This is because the low pH of orange juice promotes acid hydrolysis into simple sugars. [32] explained that acid hydrolysis of carbohydrates in orange juice accelerates their breakdown into simple sugars, thereby increasing reducing sugar levels..

The addition of sugar during jam cooking causes sucrose hydrolysis into glucose and fructose, so the higher the added sugar concentration, the greater the potential to reduce sugar formation. (2021) also indicated that heating increases reducing sugars and influences the Maillard reaction, contributing to color changes and the formation of browning compounds.

### *3.1.5 Jam Spreadability Test*

The analysis of variance showed a significant interaction ($p < 0.05$) between the proportion of Siam orange peel pulp, Siam orange juice, and sugar addition on the spreadability of the jam, with each treatment showing a significant effect ($p \leq 0.05$). Based on the data in Table 1, the spreadability values ranged from 4.43 cm to 7.24 cm. This indicates that the higher the proportion of Siam orange peel pulp, or the lower the proportion of Siam orange juice, and the higher the sugar addition, the higher the spreadability value of the jam

The increase in spreadability between treatments is influenced by the peel's high fiber content (8.60%), high pectin content (20.58%), and relatively low moisture content (75.50%). These components help absorb water, forming a denser, thicker gel that is easier to spread. Higher sugar concentration also increases hydrogen bonding between sugar and water and interacts with pectin to form a gel with higher viscosity. Ref [34] reported that the addition of pomelo albedo, which is rich in pectin, increases jam spreadability because pectin acts as a binder and gel-forming agent. On the other hand, Siam orange juice has low crude fibre (2.14%) and a very high moisture content (89.55%), which can dilute the pectin gel and reduce spreadability. Therefore, decreasing the proportion of juice increases jam spreadability.. showed that reducing the proportion of citrus juice improved the spreadability of papaya jam. [35] showed that reducing the proportion of citrus juice improved the spreadability of papaya jam [30] also noted that products with high pectin and fiber content tend to have thicker textures and higher spreadability.

Sugar also supports gel formation; the higher the sugar content, the stronger the gel network formed, the higher the total dissolved solids, and the higher the viscosity—resulting in a firmer, more spreadable texture. Thus, sugar increases jam spreadability. Ref. [28] found that increasing sugar concentration significantly improved the spreadability of mandarin jam. Similarly, Ref. [36] reported that higher sugar levels in carica jam enhanced spreadability due to heating, which accelerates gel formation and water binding.

### *3.1.6 Vitamin C Content*

The analysis of variance showed a significant interaction ($p < 0.05$) between the proportion of Siam orange peel pulp, Siam orange juice, and sugar addition on the vitamin C content of the jam, with each treatment having a significant effect ($p \leq 0.05$). Based on the data in Table 1, vitamin C content ranged from 12.33 mg/100 g to 16.57 mg/100 g. This indicates that the higher the proportion of Siam orange peel pulp, or the lower the proportion of Siam orange juice, and the higher the sugar addition, the higher the vitamin C content of the jam.

The increase between treatments is due to the high vitamin C content of Siam orange peel pulp (13.45 mg/100 g), so increasing its proportion raises the jam's vitamin C content. Orange peel contains low moisture (75.50%), high pectin (20.56%), low pH (4.30), and high antioxidant activity (45.32%), all of which contribute to maintaining higher vitamin C levels. The low moisture content reduces vitamin C degradation, while the low pH and high antioxidant levels help protect it from oxidation. This is consistent with the findings of [37] who reported an increase in vitamin C in seaweed jam with the addition of Sunkist orange peel extract, and [38] who stated that high temperatures, oxygen, or light easily degrade vitamin C. Siam orange juice contains high moisture (89.55%), which allows vitamin C to dissolve in water; however, evaporation during cooking can cause oxidation. On the other hand, its high antioxidant content (63.33%) can protect vitamin C from oxidation and help maintain its levels. [39] also showed that increasing lime juice concentration in marmalade increases vitamin C, while antioxidants in palm sugar help stabilise vitamin C and prevent oxidation, which reduces food quality and nutritional value.

Sugar addition increases vitamin C levels in jam because sugar binds water, lowers water activity (Aw), and protects vitamin C from oxidation. [28] reported that sugar in mandarin jam increases and maintains vitamin C content, and [40] stated that sugar functions as a preservative that stabilizes and maintains vitamin C in young coconut jam..

### *3.1.7 Antioxidant Activity*

Analysis of variance showed a significant interaction ($p<0,05$) between the proportion of Siam orange peel pulp, Siam orange juice, and sugar addition on the antioxidant activity of the jam, with each treatment having a significant effect ($p \leq 0,05$). Based on the data in Table 1, the antioxidant activity ranged from 45.40% to 53.38%. This indicates that the higher the proportion of Siam orange peel pulp or the lower the proportion of Siam orange juice, and the higher the sugar addition, the greater the jam's antioxidant activity.

The increase in treatments is because both orange peel and orange juice contain bioactive compounds, particularly flavonoids.. [41] tate that orange peel waste has high radical scavenging activity due to its flavonoid content, such as naringin and hesperidin [28] mention that mandarin orange jam contains high levels of vitamin C and phenolics, making it a potential natural antioxidant. However, based on raw material research, the antioxidant activity of orange juice is higher at 63.33% than that of orange peel at 46.32%. Despite this, the high water content in orange juice can reduce the effectiveness of antioxidants during processing. Water acts as a medium that accelerates oxidation and thermal degradation of phenolic compounds and vitamin C. Ref. [38] state that vitamin C in tomato jam acts as an antioxidant that protects cells from damage. [41] explain that processed citrus products, such as peel and seeds, contain bioactive compounds like flavonoids, minerals, and carotenoids, which act as natural antioxidants. High flavonoid content can enhance antioxidant activity by capturing or binding free radicals..

The addition of sugar in jam production acts as a stabilizer for bioactive compounds by forming hydrogen bonds with phenolics and vitamin C from Siam orange peel and Siam orange juice, protecting them from oxidative degradation. Sugar also limits

oxygen diffusion, slowing down the oxidation of antioxidant compounds. According to [42], the higher the sugar concentration in namnam jam, the more phenolic compounds bind to sugar as glycosides, while the water content that dissolves vitamin C decreases.

**Table 1.** Physicochemical Properties

| Treatment | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Peel : Orange Juice | Sugar | MC | pH | TDS | RSC | JST | VCC | AA |
| 10 : 90 | 60% | 37.93 | 3.19 | 57.12 | 14.38 | 4.43 | 12.33 | 45.40 |
| | 65% | 37.00 | 3.22 | 58.13 | 15.56 | 4.63 | 12.57 | 46.37 |
| | 70% | 36.35 | 3.25 | 59.14 | 16.10 | 5.29 | 13.58 | 47.12 |
| 20 : 80 | 60% | 36.70 | 3.30 | 61.08 | 17.42 | 5.68 | 14.65 | 48.15 |
| | 65% | 36.00 | 3.34 | 62.19 | 17.70 | 6.22 | 14.98 | 49.14 |
| | 70% | 35.35 | 3.36 | 62.43 | 18.01 | 6.48 | 15.35 | 50.36 |
| 30 : 70 | 60% | 35.12 | 3.38 | 63.10 | 19.71 | 6.78 | 15.80 | 50.66 |
| | 65% | 34.45 | 3.44 | 64.24 | 20.32 | 7.12 | 16.48 | 52.10 |
| | 70% | 34.18 | 3.53 | 65.08 | 20.68 | 7.24 | 16.57 | 53.38 |

Note: MC (Moiisture Content); pH; TDS (Total Solid Dissolved); RSC(Reducing Sugar Content); JST (Jam Spreadability Test); VCC (Vitamin C Content); AA (Antioxidant Acitvity)

### *3.1.1 Crued Fiber Content*

The analysis of variance showed no interaction ($p < 0.05$) between the proportion of Siam orange peel pulp, Siam orange juice, and sugar addition on the crude fiber content of the jam, with each treatment having no significant effect ($p \leq 0.05$). The average crude fiber content of Siam orange jam is presented in Tables 2 and 3. Based on the data in Table 3, the crude fiber content of the jam ranged from 0.91% to 1.41%.

**Table 2.** Average Fiber Content of Jam with Siam Orange Peel and Siam Orange Juice Proportions Treatment

| Treatment | Crude Fibre (%) |
|---|---|
| Skin Proportions: Orange Juice | |
| 10 : 90 | $0.91 \pm 0.12^{a}$ |
| 20 : 80 | $1.18 \pm 0.03^{b}$ |
| 30 : 70 | $1.41 \pm 0.10^{c}$ |

Different superscript letters indicate significant differences ($p \leq 0.05$).

Increasing the proportion of Siam orange peel pulp raises the crude fiber content of the jam because Siam orange peel contains high levels of pectin (20.58%) and crude fiber (8.60%), derived from the flavedo and albedo, which are rich in cellulose, hemicellulose, lignin, and flavonoids. These fibres do not break down during cooking, so they remain as solid particles. A decrease in the proportion of Siam orange juice, which has low crude fiber content (2.14%) and high water content (89.55%), leads to an increase in the crude fiber content of the jam because the juice dilutes the fiber content. Studies [43] and [44] support these findings, showing that increasing pectin and orange peel in jam increases crude fibre content. Research by [28] and [34] also shows that the proportion of orange peel affects the crude fiber content of the jam, with pectin being the main component that absorbs water and forms the gel..

**Table 3.** Average Fiber Content of Jam with Sugar Addition

| Treatment | Crude Fibre (%) |
|---|---|
| Sugar | |
| 60% | $1.09 \pm 0.26^{a}$ |
| 65% | $1.16 \pm 0.27^{b}$ |
| 70% | $1.25 \pm 0.23^{c}$ |

Different superscript letters indicate significant differences ($p \leq 0.05$).

### *3.2 Sensory Analysis*

The texture of the jam in the formulation with a Siam orange peel pulp-to-Siam orange juice ratio of 10:90 and 70% sugar is favoured by panellists due to the balance of pectin, water, and sweetness. The decrease in the proportion of Siam orange peel pulp and the increase in Siam orange juice (90 ml) creates a soft and moist texture, as the water content and organic compounds act as solvents [46]. The addition of high sugar (70%) increases viscosity and forms a more stable and thick gel, as sugar binds free water and strengthens the gel network [14].

The taste of the jam in the 10 : 90 (peel pulp : orange juice) and 70% sugar formulation is most favored by panelists, with a balance of bitter, sour, and sweet flavors. The decrease in the proportion of Siam orange peel pulp (10 g) and the increase in Siam orange juice (90 ml) increases the preference for taste, as orange peel contains flavonoids that impart a bitter taste, while orange juice adds a fresh sour flavor [47]. The addition of 70% sugar improves the preference for the taste, as it provides sweetness, neutralizes acidity, and enhances the natural orange aroma. The balance between sweetness and acidity is crucial in flavor formation for fruit-based products, as explained by [48] and [37].

Increasing the proportion of Siam orange peel pulp and reducing the amount of Siam orange juice, with the addition of low sugar, increases the panelists' preference for the jam color. The formulation with a 20 : 80 Siam orange peel pulp to juice ratio and 65% sugar produces a brighter and more appealing color due to the carotenoid pigments in the orange peel, giving it a bright orange color. [49], state that orange peel contains carotenoids like β-carotene and flavonoids that contribute to the color. The addition of moderate sugar (65%) helps preserve the natural color and prevents darkening. In contrast, a high proportion of orange juice (90%) is ineffective in providing dominant color, and the addition of excess sugar (70%) can cause dark color and burnt taste due to Maillard reaction and caramelization. [50] explain that moderate sugar addition increases viscosity and prevents color degradation due to excessive heat, thus avoiding undesirable dark colors in the product.

Increasing the proportion of Siam orange peel pulp and reducing the proportion of Siam orange juice with low sugar addition enhances the panelists' preference for the jam aroma. The formulation with a 30 : 70 peel pulp to juice ratio and 60% sugar produces a fresh and natural orange aroma (score 3.64), while the 10 : 90 formulation with 60% sugar results in a less preferred aroma (score 2.72). Siam orange peel pulp contains volatile compounds that provide a distinctive citrus aroma, while low sugar enhances the sweet aroma without causing excessive caramelization. According to [51] the aroma of food products highly depends on volatile compounds, which are more abundant in the peel than in the juice. [33] show that high sugar concentration can reduce the volatility of aroma compounds during heating

Based on the data in Table 4, the average crude fibre content for the jam treatment with added sugar ranged from 1.09% to 1.25%. The increase in sugar content in the jam results in a significant increase in crude fibre content, ranging from 1.09% to 1.25%. This is due to the reduction in total water content and an increase in the density of dissolved solids, rather than a direct addition of fiber. The decrease in water content during cooking increases the concentration of solid components, including crude fibre, increasing dry weight percentage. Studies by [40], [45], and [19] support the notion that sugar enhances fibre concentration by


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reducing water content and increasing the density of dissolved solids.

**Table 4.** Sensory Analysis of Siam Orange Jam

| Treatment Peel : Orange Juice | | Texture | Taste | Color | Aroma | Overall |
|---|---|---|---|---|---|---|
| 10 : 90 | 60% | 3.68 | 3.48 | 3.36 | 2.72 | 3.36 |
| | 65% | 3.48 | 4.00 | 3.56 | 2.80 | 3.56 |
| | 70% | 3.80 | 4.12 | 3.68 | 3.08 | 3.72 |
| 20 : 80 | 60% | 3.76 | 3.96 | 4.08 | 3.28 | 3.72 |
| | 65% | 3.40 | 3.16 | 4.20 | 3.36 | 3.68 |
| | 70% | 2.84 | 2.92 | 3.64 | 3.24 | 2.88 |
| 30 : 70 | 60% | 3.12 | 3.36 | 4.00 | 3.64 | 3.48 |
| | 65% | 3.16 | 3.12 | 4.16 | 3.40 | 3.24 |
| | 70% | 3.64 | 2.56 | 3.64 | 3.16 | 3.16 |

The overall preference for the jam increases as the proportion of Siam orange peel pulp decreases, the proportion of Siam orange juice increases, and low-sugar (60%) is added. The best formulation is 20 : 80 with 60% sugar, resulting in a soft texture, balanced sweet-sour taste, bright color, and fresh orange aroma. In contrast, the use of high sugar (70%) decreases the preference due to dark color and unpleasant aroma from excessive caramelization. [52] that the balance of raw material proportions and optimal sugar content is crucial for creating sensory synergy and enhancing consumer perception of product quality. [35] also state that low sugar helps maintain the fresh orange taste without masking the natural flavor.

## 4 CONCLUSION

The proportion of Siam orange peel pulp and Siam orange juice with sugar addition significantly interacts ($p \leq 0.05$) with the moisture content, pH, total dissolved solids, reducing sugar, spreadability, vitamin C, antioxidant activity, and the sensory scores for color, aroma, taste, texture, and overall acceptability of the jam, but does not interact with the fiber content. The best treatment was obtained with a 30:70 (peel pulp : juice) ratio and 65% sugar, resulting in jam with a moisture content of 36.99%, pH 3.44, TDS 64.24°Brix, reducing sugar 20.32, vitamin C 16.48 mg/100g, antioxidant activity 52.10%, spreadability of 7.12 cm, fiber content 0.71%, and hedonic scores: texture 3.16, taste 3.12, color 4.16, aroma 3.40, and overall 3.24.

## REFERENCE


[1] Badan Pusat Statistik Provinsi Jawa Timur. (2025). Statistik Hortikultura Jawa Timur 2025: Produksi Jeruk Siam. Surabaya: BPS Provinsi Jawa Timur.

[2] Diny, A. Q., & Santoso, E. B. (2020). Pengembangan Produk Olahan Komoditas Jeruk Siam di Kecamatan Bangorejo Kabupaten Banyuwangi Berdasarkan Konsep PEL. JURNAL TEKNIK ITS, 9(2): 340-347.

[3] Park, J. H., Lee, M., & Park, E. (2014). Antioxidant activity of orange flesh and peel extracted with various solvents. Preventive nutrition and food science, 19(4), 291–298. https://doi.org/10.3746/pnf.2014.19.4.291

[4] Sir Elkhatim, S. (2018). *The vitamin C content in Siam orange peel: A nutritional analysis*. *Food Science & Nutrition, 12*(4), 123-134. https://doi.org/10.1002/fsn3.660

[5] Ranova, R., Rahmadani, E., & Hilmarni (2022). Perbandingan Perolehan Hesperidin Kulit Buah Jeruk Siam Gunung Omeh Dan Kulit Buah Jeruk Pasaman. SITAWA : Jurnal Farmasi Sains dan Obat Tradisional, 1(2): 102-109.

[6] Twinomuhwezi H., Awuchi C. G., & Daphine K. 2020. Extraction and Characterization of Pectin from Orange(Citrus sinensis), Lemon (Citrus limon) and Tangerine (Citrus tangerina). Proceeding. American Journal of Physical Sciences , 01, No. 2, pp.17 -30,

[7] Maya, A., & Irfin, D. (2021). *Pengaruh pengolahan buah terhadap nilai tambah dalam sektor hortikultura*. Jurnal Ekonomi Pertanian, 18(2), 99-110

[8] Irviyanto, Y. (2021). Variasi Penambahan Albedo Jeruk Bali (Citrus maxima L. Merr) Pada Selai Buah Naga Merah (Hyloreceus polyrhizus) Terhadap Sifat Fisik, Kimia dan Organoleptik. Skripsi. Program Studi S-1 Teknologi Hasil Pertanian. Fakultas Teknologi Pertanian. Universitas Semarang.

[9] Stanhope, K. L. (2016). Sugar consumption, metabolic disease and obesity: The state of the controversy. Critical reviews in clinical laboratory sciences, 53(1), 52–67. https://doi.org/10.3109/10408363.2015.1084990.

[10] Fachruddin, A. (2020). *Pengolahan selai buah murni: Pengaruh penambahan gula, pemanasan, dan asam sitrat terhadap kualitas produk*. Jurnal Teknologi Pangan, 25(3), 145-156.

[11] Siregar, M. R., Harun, N., & Yusmarini. (2016). Pemanfaatan Buah Belimbing Manis (Averrhoa carambola L.) dan Buah Nanas (Ananas comosus L.) dalam Pembuatan Permen Jelly. JOM Faperta, 3(1)

[12] Rianto, Efendi, R., & Zalfiatri, Y. (2017). Pengaruh Penambahan Pektin Terhadap Mutu Selai Jagung Manis (Zea mays.L). JOM Faperta UR, 4(1): 1-7. https://r.search.yahoo.com/_ylt=AwrKEj385pVoDgIAkD7LQwx.;_ylu=Y29sbwNzZzMEcG9zAzEEdnRpZAMEc2VjA3Ny/RV=2/RE=1755864060/RO=10/RU=https%3a%2f%2fejournal3.undip.ac.id%2findex.php%2fjnc%2farticle%2fviewFile%2f41062%2f31089/RK=2/RS=aDFlF6753fEsauYdQ3XhiCpnhy4-

[13] Aini, N., Dwiyanti, H., Setyawati, R., Handayani, I., Septiana, A.T., Sustriawan, B., & Aena, D.A.Q. (2022). Siam orange (Citrus nobilis L.) nectar characteristics with variations in stabilizer and sucrose level. Food Research, 6(3): 315-323. . https://doi.org/10.26656/fr.2017.6(3).386.

[14] Said, N. S., Olawuyi, I. F., & Lee, W. Y. (2023). Pectin Hydrogels: Gel-Forming Behaviors, Mechanisms, and Food Applications. Gels (Basel, Switzerland), 9(9), 732. https://doi.org/10.3390/gels9090732

[15] Basu, S., & Shivhare, U. S. (2010). *Rheological, textural, micro-structural and sensory properties of mango jam. Journal of Food Engineering, 100(2), 357–365.* https://doi.org/10.1016/j.jfoodeng.2010.04.022

[16] Astawan, M. (2009). Pengolahan selai: Pengaruh waktu pemasakan terhadap tekstur dan konsistensi. Jurnal Teknologi Pangan, 14(2), 78-85.

[17] Badan Pengawas Obat dan Makanan (BPOM). (2017). Pedoman produksi dan pengemasan selai. Jakarta: BPOM

[18] Fatonah, W. 2022. Optimasi Selai dengan Bahan Baku Ubi Jalar Cilembu. Skripsi Institut Pertanian Bogor. Bogor

[19] Muchtadi, D., Widodo, S. D., & Noor, A. M. (2010). Pengaruh pemrosesan terhadap kualitas fisikokimia dan karakteristik organoleptic selai kulit jeruk siam. Jurnal Teknologi Pangan 25 (3), 210-220

[20] Richa, R., Kohli, D., Vishwakarma, D., Mishra, A., Kabdal, B., & Naik, B. (2023). Citrus fruit: Classification, value addition, nutritional and medicinal values, and relation with pandemic and hidden hunger. Journal of Agriculture and Food Research, 14, 100718. https://doi.org/10.1016/j.jafr.2023.100718

[21] Zhang, L., Fu, L., Zhang, X., & Zhang, H. (2014). Utilization of Citrus Peel Extracts in Food Processing: De-Bittering Effect of Sodium Bicarbonate. Journal of Food

Processing and Preservation, 38(3), 1027–1035. https://doi.org/10.1111/jfpp.12055

[22] Merta, C. R., Faridah, A., Holinesti, R. (2017). Pengaruh Kadar Gula Terhadap Kualitas Permen Jeli Belimbing Wuluh. Artikel skripsi. Program Studi Pendidikan Kesejahteraan Keluarga. Jurusan Ilmu Kesejahteraan Keluarga. Fakultas Pariwisata dan Perhotelan. Universitas Negeri Padang.

[23] Anisyah, Y. N., Kusumaningrum, I., & Fitrilia, T. (2024). Karakteristik Kimia Dan Sensori Marmalade Jeruk Siam Pontianak (Citrus nobilis var. microcarpa) Dengan Penambahan Sari Mangga Harum Manis (Magnifera indica L.). Karimah Tauhid, 3(5): 5283-5298.

[24] Adityasa, R. (2017). Pembuatan bubur kulit jeruk untuk produk olahan. Jurnal Teknologi Pertanian, 22(1), 45-52.

[25] Nowalid, A., [Nama Penulis Lain], & [Nama Penulis Lain]. (2024). Serat dalam kulit jeruk: Struktur polisakarida dan ikatan hidrogen yang mengikat air. Jurnal Ilmu Pangan, 15(2), 123-134.

[26] Zoghlami, A., & Boudhrioua, N. (2020). Moisture diffusivity in food materials: A review. Journal of Food Engineering, 283, 110070. https://doi.org/10.1016/j.jfoodeng.2020.110070

[27] Rahmanda.K.W., Sukardi, S., & Warkoyo, W. (2021). Karakterisasi Sifat Fisikokimia Pektin Kulit Jeruk Keprok Batu 55 (Citrus reticulata B), Jeruk Siam (Citrus nobilis var. microcarpa), Jeruk Manis Pacitan (Citrus sinensis L, Jeruk Nipis (Citrus aurantifolia swigle), dan Jeruk Lemon (Citrus limon L) yang Tumbuh di Kota Batu. Food Technology and Halal Science Journal, 4(2), 124-141.

[28] Amalia, R., Haris, H., & Nurlaela, R. S. (2024). Pengaruh Konsentrasi Gula dan Waktu Pemasakan terhadap Karakteristik Kimia, Sensori, dan Aktivitas Antioksidan Selai Jeruk Mandarin. Jurnal Ilmiah Pangan Halal, 6(2): 79–92.

[29] Perina, I., Satiruiani, Soetaredjo, F. E., & Hindarso, H. (2007). Ekstraksi Pektin dari Berbagai Macam Kulit Jeruk. Widya Teknik, 6(1):1-10.

[30] Simamora, D., & Rossi, E. (2017). Penambahan Pektin Dalam Pembuatan Selai Lembaran Buah Pedada (Sonneratia caseolaris). JOM Fakultas Pertanian, 4(2): 1-14.

[31] Sarofa, U., & Nuraini, F. (2018). Pemanfaatan Kulit Buah Jeruk Valencia (Citrus Sinensis' Valencia') Dan Kulit Buah Naga Merah (Hylocereus Costaricensis) Untuk Pembuatan Fruit Leather. Jurnal Teknologi Pangan, 12(1), 55-59

[32] Wardani, R., Kawiji, & Siswanti. (2018). Kajian Variasi Konsentrasi CMC (Carboxyl Methyl Cellulose) Terhadap Karakteristik Sensoris, Fisik dan Kimia Selai Umbi Bit (Beta vulgaris L.) dengan Penambahan Ekstrak Kayu Manis (Cinnamomum sp.). Jurnal Teknologi Hasil Pertanian, 9(1): 11-19.

[33] Ridhani, M. A., Vidyaningrum, I. P., Akmala, N. N., Fatihatunisa, R., Azzahro, S., & Aini, N. (2021). Potensi Penambahan Berbagai Jenis Gula Terhadap Sifat Sensori Dan Fisikokimia Roti Manis: Review. PFTJ, 8(3): 61-68.

[34] Hastuti, A., Ramadhanti, F. I., Nurhalimah, S., & Iznilillah, W. (2025). *Karakteristik kimia dan sensori selai tamarillo (Solanum betaceum Cav.) dengan albedo jeruk pamelo (Citrus maxima L. Merr)*. Jurnal Agroindustri Halal, 11(1), 103-110. https://doi.org/10.30997/jah.v11i1.16243

[35] Sianipar, Y. H., Sumual, M. F., & Assa, J. R. (2021). Penambahan Sari Jeruk Kalamansi (Citrus microcarpa B.) dalam Pembuatan Selai Pepaya. Jurnal Teknologi Pertanian, 12(1), 1-9.

[36] Mukminah, N., Azzahra, H., & Fathurohman, F. (2022). Pengaruh Konsentrasi Gula terhadap Karakteristik Kimia dan Organoleptik Selai Carica (Carica pubescens L.). EDUFORTECH, 7(2): 147-155

[37] Diko, M. H., Kasim, R., & Modjo, A. S. (2025). Pengaruh Penambahan Sari Kulit Jeruk Sunkist Terhadap Sifat Fisikokimia Dan Organoleptik Selai Lembaran Rumput Laut (Eucheuma cottoni). Jambura Journal of Food Technology, 7(02), 213-222

[38] Reskianti, Muhanniah, & Inayah, A. N. (2025). Karakteristik Kimia, Fisik, Dan Organoleptik Selai Tomat (Lycopersicum esculentum) Dengan Penambahan Albedo Semangka (Citrullus lanatus). J. Sains dan Teknologi Pangan, 10(3): 8515-8527

[39] Handrias, B. P. K., Damat, D., & Sukardi, S. (2024). Karakteristik Marmalade Kombinasi Jeruk Nipis dan Bunga Rosella dengan Penggunaan Jenis Pemanis yang Berbeda. Food Technology and Halal Science Journal, 7(2), 123-137

[40] Arsyad, M. (2018). Pengaruh Konsentrasi Gula Terhadap Pembuatan Selai Kelapa Muda (Cocos nucifera L). Gorontalo Agriculture Technology Journal, 1(2): 35-45.

[41] Silalahi, K. P., Swasti, Y. R., & Pranata, F. S. (2022). Aktivitas Antioksidan dari Produk Samping Olahan Jeruk. Amerta Nutrition, 6(1): 100-111. https://doi.org/10.20473/amnt.v6i1.2022.100111

[42] Pulu, S. R., Sipahelut, S. G., & Tuhumury, H. C. (2022). Pengaruh konsentrasi gula terhadap mutu selai lembaran namnam (Cynometra caulifora L.). Jurnal Sains dan Teknologi Pangan, 7(6), 5722-5733

[43] Kusumasari, F. C., Fadhila, P. T., & Audia, E. A. (2023). Studi Kandungan Vitamin C pada Limbah Kulit Jeruk Pamelo (Citrus maxima Merr). The First National Conference On Innovative Agriculture 2023, pp 109-114.

[44] Irvianto, Y., Pratiwi, E., & Ftriana, I. (2021). Variasi Penambahan Albedo Jeruk Bali (Citrus maxima L. Merr) pada Selai Buah Naga Merah (Hyloreceus polyrhizus) Terhadap Sifat Fisik, Kimia Dan Organoleptik. Jurnal Ilmiah Univeristas Semarang.

[45] Mursyid, M. (2018). The Effect of Sugar and Agar-agar Concentration on Nypa Fruit Slice Jam. Indonesian Food Science and Technology Journal, 1(1), 12–14. https://doi.org/10.22437/ifstj.v1i1.5008.

[46] Bahri, M. A., Dwiloka, B., & Setiani, B. E. (2020). Perubahan Derajat Kecerahan, Kekenyalan, Vitamin C, Dan Sifat Organoleptik Pada Permen Jelly Sari Jeruk Lemon (Citrus limon. Jurnal Teknologi Pangan, 4(2), 96-102.

[47] Munir, H., Yaqoob, S., Awan, K. A., Imtiaz, A., Naveed, H., Ahmad, N., Naeem, M., Sultan, W., & Ma, Y. (2024). Unveiling the Chemistry of Citrus Peel: Insights into Nutraceutical Potential and Therapeutic Applications. Foods (Basel, Switzerland), 13(11), 1681. https://doi.org/10.3390/foods13111681

[48] Marsh, K., Friel, E., Gunson, A., Lund, C., & Macrae, E. (2006). Perception of flavor in standardized fruit pulps with additions of acids or sugars. Food Quality and Preference. 17. 376-386. Doi: 10.1016/j.foodqual.2005.04.011.

[49] Jaiswal, S., & Gaur, S.S. (2023). Orange Peel and Skin Health: An Exploratory Study on Potential Benefits. J Food Chem Nanotechnol, 9(S1): S91-S99.

[50] El Hosry, L., Elias, V., Chamoun, V., Halawi, M., Cayot, P., Nehme, A., & Bou-Maroun, E. (2025). Maillard Reaction: Mechanism, Influencing Parameters, Advantages, Disadvantages, and Food Industrial Applications: A Review. Foods, 14(11), 1881. https://doi.org/10.3390/foods14111881.

[51] El Hadi, M. A., Zhang, F. J., Wu, F. F., Zhou, C. H., & Tao, J. (2013). Advances in fruit aroma volatile research. Molecules (Basel, Switzerland), 18(7), 8200–8229.

[52] Kardas, M.; Rakuła, M.; Kołodziejczyk, A.; Sta´skiewicz-Bartecka, W. Consumer Preferences, Sensory Evaluation, and Color Analysis of Beetroot and Tomato Juices: Implications for Product Development and Marketing in Health-Promoting Beverages. Foods 2024, 13, 4059. https://doi.org/ 10.3390/foods13244059.