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# Marmalade's formulation of Madu Susu Orange (*Citrus reticulata*) on multiple concentrations of sucrose

*[Formulasi marmalade jeruk Madu Susu (Citrus reticulata) pada berbagai konsentrasi sukrosa]*

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## ABSTRACT

*Generally, the type of orange used in marmalade production is Sunkist oranges. In this study, Madu Susu Oranges (Citrus reticulata), a local orange variety typically consumed fresh and rarely processed into products, were used as the raw material for making marmalade. Additionally, sucrose is a key ingredient that can influence the balance between pectin and water in marmalade, affecting its characteristics and making it a valuable topic for further research. The main objective of this research was to determine the best sucrose concentration in the Madu Susu Orange marmalade formulation based on its physicochemical and organoleptic characteristics. The research design used was a Randomized Block Design, one factor of the sucrose concentration level (75%, 80%, 85%, 90%, and 95%) in 5 repetitions. The data were analyzed using ANOVA and further tested with the HSD test at a 5% significance level. The determination of the best treatment was conducted using the effectiveness index method. The results showed that the best treatment was at a 95% sucrose concentration with a 0.77 treatment value (TTV). The physicochemical and sensory characteristics of the Madu Susu Orange marmalade at 95% sucrose concentration were: total acidity of 0.52%, pH 5.82, total soluble solids of 68.00%, moisture content of 20.87%, and color values L* 29.94, a* 9.87, b* 49.90. Sensory test results for the best treatment were color 3.80 (liked), texture 3.67 (liked), and taste 4.17 (very liked).*

*Keywords: Madu Susu Orange, sucrose, marmalade, organoleptic characteristic*

## ABSTRAK

*Marmalade* adalah produk pangan yang berbentuk hampir menyerupai selai yang terbuat dari sari buah-buahan dengan penambahan pektin, sukrosa dan asam sitrat serta potongan kulit jeruk. Pada umumnya bahan baku jenis jeruk yang dipakai pada pembuatan *marmalade* adalah jeruk sunkist. Pada penelitian ini bahan baku yang digunakan untuk membuat *marmalade* adalah jeruk madu susu *(Citrus reticulata)*, salah satu jeruk lokal yang hanya dikonsumsi secara langsung dan jarang diolah menjadi suatu produk. Selain itu gula atau sukrosa merupakan bahan baku yang dapat mempengaruhi keseimbangan pektin dan air pada marmalade, dan dapat mempengaruh karakteristik marmalade, sehingga perlu diteliti. Tujuan utama penelitian ini adalah untuk mendapatkan konsentrasi sukrosa pada formulasi *marmalade* jeruk madu susu terbaik berdasarkan karakteristik fisikokimia dan organoleptik. Rancangan penelitian yang digunakan adalah Rancangan Acak Kelompok (RAK) satu faktor yaitu taraf konsentrasi sukrosa (P) dengan 5 kali ulangan. Konsentrasi sukrosa *marmalade* jeruk madu susu yaitu 75%; 80%; 85%; 90%, dan 95%. Data dianalisis dengan menggunakan Analisis Ragam (ANOVA) dan uji lanjut Beda Nyata Jujur (BNJ) dengan taraf 5%. Penentuan perlakuan terbaik dilakukan menggunakan metode indeks efektivitas. Hasil penelitian menunjukkan perlakuan terbaik terdapat pada perlakuan konsentrasi sukrosa 95% yang memiliki nilai perlakuan *(Total Treatment Value* atau TTV) sebesar 0,77. Karakteristik fisikokimia dan sensori *marmalade* jeruk madu susu pada perlakuan 95% adalah total asam 0,52%, pH 5,82, total padatan terlarut 68,00%, kadar air 20,87%, dan warna L* 29,94, a* 9,87, b* 49,90. Hasil uji sensori pada perlakuan terbaik yaitu warna 3,80 (suka), tekstur 3,67 (suka), dan rasa 4,17 (sangat suka).

Kata kunci : Jeruk madu susu, sukrosa, *marmalade* , karakteristik organoleptik

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## Introduction

*Marmalade* is a food product similar to jam. Marmalade has a distinctive sweet and bitter orange flavor It is made from a combination of orange peel pieces, sucrose, pectin, citric acid, and fruit juice, which can be sourced from new local resources used as a gelling agent. The addition of fruit peel is a potential source of natural antimicrobials and antioxidants (Sartika et al., 2019) because it contains tannins, phenol, carboxylic components, and organic acids. Currently, marmalade is becoming popular among the public but is not widely available in the market; it is only found in select supermarkets.

Generally, marmalade is typically prepared using soursop, lime, and lemon (Rahayu et al., 2022). The acidic taste of citrus juice provides a refreshing and distinctive flavor (Septiana et al., 2023). According to Indrastuti & Aminah (2020), orange peel contains ascorbic acid, carotenoid pigments, and phenolic compounds (phenolics, flavonoids, and polymethoxylated). Phenolic compounds have various beneficial activities for the body, such as antibacterial, antimicrobial, antioxidant, anti-inflammatory, and antiviral properties (Liu et al., 2023). Alkaloid components and orange peel glycosides showed anticancer activity and contain many other ingredients that humans need (Liew et al., 2018). Orange peel also contains dietary fiber, making it useful in the food industry as a raw material for food or as medicine, an antimicrobial alternative, and a food supplement.

A significant issue is the high orange production, with the Central Statistics Agency (BPS) recording in 2018 that the District of Sambas produced 1,190,770 quintals of oranges, including "Madu Susu Oranges," during the harvest season. This overproduction leads to low selling prices and the potential for orange peels to become waste (Denata et al., 2021). This situation highlights opportunities for creating derivative orange products such as jam and marmalade. Marmalade is categorized into two types: with added sugar (gillified) and without added sugar during processing (non-gillified). The optimal gel formation in marmalade production occurs at a sugar content of about 65%-70% and a pH of 3.2-3.5 (Sipahelut, 2019). Marmalade characteristics are influenced by many factors, one of which is sugar. The quality requirements for marmalade, according to the Indonesian National Standard (SNI) 01-4467-1998, referenced in this study, include aroma, taste, color, texture, and a minimum soluble solids content of 65%. Sucrose, a disaccharide composed of two monosaccharides, naturally occurs in vegetables, seeds, and fruits and is often added to various food products (Ridhani et al., 2021).

Sucrose plays a critical role in marmalade production as it can significantly increase calorie content, and form fat leading to obesity. Its excessive consumption has adverse effects such as diabetes and damage to the heart, liver, and kidneys. To mitigate these risks, optimizing sucrose use in marmalade products is necessary. Nurani (2020) argues that sucrose balances pectin, water, and fiber density during marmalade production. The consistency and fiber density are influenced by the sucrose amount, higher sucrose content results in a thicker texture, making the precise sucrose concentration crucial for observation and exploration in this study. Previous studies on sucrose concentration in marmalade products include Sunkist orange-pineapple marmalade (Adityas et al., 2017), lime marmalade (Likumahua et al., 2022), and calamansi marmalade (Tutuarima et al., 2021). However, research using native West Kalimantan oranges has not yet been conducted. Based on this, the study focused on making marmalade using Madu Susu Oranges as the main ingredient and varying sucrose additions to determine the best formulation for marmalade. This research aimed to find the sucrose concentration that produces the best physicochemical and organoleptic characteristics in honey milk orange marmalade.

## Materials and Methods

### *Materials and Equipment*

The main ingredients used in this study were semi-ripe honey milk oranges obtained from the Flamboyan Market in Pontianak, sucrose, and salt. The materials used for analysis included distilled water

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(aquades) purchased from a local chemical store, phenolphthalein (PP) indicator, and NaOH from Merck (Darmstadt). The equipment used were knives, strainers, spoons, basins, cutting boards, a hotplate (Cimarec Thermofisher, USA), a stirrer, a thermometer, wooden clamps, a balance, and a stopwatch. The equipment used for chemical analysis included a volumetric flask, pH meter (AMT20, USA), dropper pipette, refractometer (Aichose, China), colorimeter (AMT-507, China), desiccator, porcelain dish, oven (B-One OV-30, Korea), measuring glass, stationery, and analytical balance (Mettler Toledo).

### *Research methodology*

This study utilized a Randomized Block Design (RBD) with a single factor, sucrose concentration (P), consisting of five levels: 75% (p1), 80% (p2), 85% (p3), 90% (p4), and 95% (p5). Each treatment was repeated five times, producing a total of 25 samples. Data were analyzed using Analysis of Variance (ANOVA), and if significant differences were found, further testing was carried out using the Honestly Significant Difference (HSD) test at a 5% significance level. Organoleptic test responses were evaluated using the Kruskal-Wallis method. The optimal treatment was identified based on the effectiveness index method (Zahrah et al., 2023).

### *Preparation of Madu Susu Orange marmalade*

The preparation of orange marmalade was adapted from Chundurwar & Mal (2022). The oranges were washed and cut into two halves. The juice was extracted and followed by scraping off the pulp attached to the peel. The orange peel was then cut lengthwise, soaked in warm water, with added salt to remove the bitterness, and stored for 14 days. After soaking, the peel was separated into the albedo and flavedo sections. The flavedo was washed thoroughly and then blended into a smooth paste. The juice and the blended peel were then boiled over medium heat. Once it began to boil, sucrose was added, and the mixture was stirred and allowed to cook for 25 minutes, then removed from the heat. The marmalade was poured into jars and left to cool to room temperature. The sugar concentration was based on the percentage of the total weight of the juice and peel used. The amount of orange ingredients is presented in Table 1, and the sugar formulation for the orange honey milk marmalade is presented in Table 2.

**Table 1.** Raw material formulation for the preparation of madu susu orange marmalade

| No | Ingredient | Amount |
|---|---|---|
| 1. | Orange Juice (g) | 56.25 |
| 2. | Orange Peel (g) | 6.25 |
| | Total orange ingridients (g) | 62.50 |

**Table 2.** Amount of orange ingredients and sugar in various formulations of madu susu orange marmalade

| Formula (% Sugar to Orange Ingredients) | Orange Ingredients (g) | Sugar (g) | Total (g) |
|---|---|---|---|
| p1 (75) | 62.5 | 46.88 | 109.83 |
| p2 (80) | 62.5 | 50.00 | 112.50 |
| p3 (85) | 62.5 | 53.12 | 115.62 |
| p4 (90) | 62.5 | 56.25 | 118.75 |
| p5 (95) | 62.5 | 59.37 | 121.87 |

### *Research parameters*

The observed parameters are as follows: a) total acid content test using the calculation for total acid content based on formula (1) (Poerwanty et al., 2020); b) pH measurement was conducted using a calibrated pH meter (Sulistijowati et al., 2020); c) total dissolved solids were tested using a handheld refractometer (Rahman et al., 2022); d) sample moisture content was measured gravimetrically based on the calculation formula (AOAC, 2005); e) color testing was performed using a colorimeter determined based on the International Commission on Illumination (CIE) system (Wang et al., 2019); f) organoleptic observations were conducted with 30 untrained panelists using an evaluation criterion of: 1 = dislike, 2 =

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slightly dislike, 3 = like, 4 = like more, 5 = strongly like (Triandini & Wangiyana, 2022). The formulas used for the observations are as follows :

$$\text{Total Acid (\%)} = \frac{\text{Volume of titrant (L)} \times N\, NaOH \times df \times \text{Eq of acid}}{\text{Sample Weight (g)}} \times 100\%$$

$$\text{The equivalent weight of citric acid} = 64.041 \text{ g/equiv.}$$

$$\text{Normal Weight } (NW_i) = \frac{\sum_{i=1}^{p} PW_i}{p}$$

$$\text{Effectiveness Value } (EI_{ij}) = \frac{MP_{ij}\text{-}WP_1}{BP_1\text{-}WP_1}$$

$$\text{Treatment Value for Each Parameter } (TV_{ij}) = EI_{ij} * NW_i$$

$$\text{Total treatment value } (TTV_j) = \sum_{i=1}^{p} TV_{ij}$$

Note:
$NW_i$ = Normalized weight of treatment-i
p = Number of parameters
$P_{wi}$ = Weight of parameter variable-i
$EI_{ij}$ = effectiveness value of parameter-i in treatment -j
$MP_{ij}$ = Average result of parameter-i in treatment -j
$W_{pi}$ = Lowest average result of parameter -i
$BP_i$ = Highest average result of parameter -i
$TV_{ij}$ = Treatment value of parameter-i in treatment -j
$TTV_j$ = Total treatment value in treatment -j

## Results and discussion

### *Physicochemical characteristics*

The physicochemical characteristics tested include total acid, pH, moisture content, total dissolved solids, and color. The total acid titration test (TAT) is used to determine the concentration of total acid present in a material or product. The results of the F test (ANOVA) for the total acid data indicate that the sucrose concentration in the various treatments for marmalade preparation had a significant effect. Therefore, a further test was conducted using the Honest Significant Difference (HSD) method at a 5% significance level (Table 3).

The highest total acid content is presented in Table 3, which is found in the treatment with 75% sucrose at 0.87 ± 0.04%, and the lowest total acid content is at 95% sucrose concentration, which is 0.52 ± 0.04%. The results of this study show that as the sucrose concentration increases, the total acid content decreases. A similar result was found in the study by Chalchisa et al. (2022), which investigated the effect of sugar, pectin, and temperature on pineapple jam quality. According to Siringoringo et al. (2018), sucrose has hygroscopic properties that can prevent changes in organic acids. The total acid content of a product is generally influenced by the natural acids found in the type of fruit used. The high natural acid content in the material can be used to increase the total acid value of marmalade. The acid content in honey milk oranges is not as high as in lime or sambal oranges. Therefore, it is suspected that the addition of high sucrose levels may reduce the total acid content in the marmalade. The decrease in total acid is believed to have an impact on the increase in pH.

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**Table 3.** Total acid content of madu susu orange marmalade at different sucrose concentrations

| Sucrose Concentration (%) | Total Acid Content (%) | pH | Total Dissolved Solids (% ) | Total Dissolved Solids (%) |
|---|---|---|---|---|
| 75 | 0.87 ± 0.04$^{e}$ | 3.95 ± 0.06$^{a}$ | 61.80 ± 2.68$^{a}$ | 28.16 ± 0.05$^{e}$ |
| 80 | 0.74 ± 0.03$^{d}$ | 4.12 ± 0.06$^{b}$ | 64.60 ± 1.52$^{b}$ | 27.65 ± 0.07$^{d}$ |
| 85 | 0.66 ± 0.04$^{c}$ | 4.25 ± 0.06$^{c}$ | 65.80 ± 0.84$^{bc}$ | 23.08 ± 0.05$^{c}$ |
| 90 | 0.59 ± 0.04$^{b}$ | 4.58 ± 0.06$^{d}$ | 66.80 ± 1.10$^{bc}$ | 21.46 ± 0.07$^{b}$ |
| 95 | 0.52 ± 0.04$^{a}$ | 5.82 ± 0.06$^{e}$ | 68.00 ± 1.41$^{c}$ | 20.88± 0.05$^{a}$ |
| | HSD 5% = 0.05 | HSD 5% = 0.004 | HSD 5% = 2.76 | HSD 5% = 0.12 |

Note: averages with the same letter notation are not significantly different by HSD test

### *pH*

pH measurement is carried out to determine the acidity level or neutrality of a product. The results of the pH data tested using ANOVA indicate that the sucrose concentration in the various treatments in this study significantly affected the marmalade production, as shown by the further test using the Honest Significant Difference (HSD) method at a 5% significance level presented in Table 3. The highest pH value was found at a sucrose concentration of 95%, which is 5.82 ± 0.06, and the lowest pH value was at a concentration of 75%, which is 3.93 ± 0.04. The pH value increases with the addition of sucrose concentration. Similar results were reported in the study by Likumahua et al. (2022), which examined the physicochemical properties of lime marmalade with various sucrose concentrations. That study revealed that high temperatures are believed to inhibit invertase enzyme activity and microorganism activity, thereby preventing significant sucrose degradation. This finding is supported by the report from Mujib et al. (2021), which explained that increased temperature corresponds with an increase in pH, where $H^+$ ions derived from organic acids evaporate, leading to a reduction in $H^+$ ions that cause acidic conditions, thus increasing the pH of the material.

The pH value of marmalade is concluded to be an important factor in achieving optimal gel conditions. Therefore, it is suspected that controlling pH during the marmalade production process is crucial to obtaining a high-quality product (Chalchisa et al., 2022).

### *Total dissolved solids*

Total dissolved solids (TDS) were measured based on the combined content of all organic and inorganic substances present in the product. Analysis of variance (ANOVA) was used to process the TDS data, and the results showed a significant effect. Therefore, a further test using the Honest Significant Difference (HSD) method at a 5% significance level was conducted, as presented in Table 3.

The results of the HSD test at 5% showed that honey milk orange marmalade at different sucrose concentrations significantly differed in terms of TDS. The highest TDS value was found at a sucrose concentration of 95%, which was 68.00 ± 1.41%, although it was not significantly different from the concentrations of 85% and 90%. The lowest TDS value was found at a sucrose concentration of 75%, which was 61.80 ± 2.68%. Total dissolved solids are thought to indicate the amount of dissolved substances in the solution, including water-soluble components such as fructose, glucose, sucrose, water-soluble proteins, or pectin contained in the fruit (Ginting et al., 2019).

Based on Table 3, it can be concluded that the total dissolved solids (TDS) value increases as more sucrose is added. This is consistent with the findings of Tutuarima et al. (2021), which stated that when sucrose is dissolved in water and heated, it breaks down into fructose and glucose. Consequently, the more sucrose is added, the higher the TDS value, as sucrose decomposition during heating leads to increased formation of glucose and fructose.

According to the research by Likumahua et al. (2022), it is suspected that the largest contribution to the increase in TDS comes from sugar. This increase occurs because free water is bound by sucrose, thereby

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increasing the concentration of dissolved substances. The TDS value rises as more particles are bound by sucrose, reducing the sediment formed. Novita et al. (2017) reported that differences in TDS values are influenced by the pectin and sucrose content, which are components of total dissolved solids. Furthermore, Aini et al. (2023) stated that dissolved solids are composed of reducing sugars (glucose and fructose), non-reducing sugars (sucrose), organic acids, pectin, and proteins. According to SNI 01-4467-1998, the minimum total dissolved solids in marmalade should be 65%.

### *Moisture Content*

The moisture content was tested to assess the quality and shelf life of the food product, considering the potential for product spoilage. The ANOVA (F-test) results for moisture content data indicated a significant effect of the treatments, followed by a further test using the Honest Significant Difference (HSD) method at a 5% significance level (Table 3).

The results of the HSD test at 5% showed that honey milk orange marmalade at different sucrose concentrations had significantly different moisture content. The highest moisture content was found at a sucrose concentration of 75%, at 28.16 ± 0.05%, while the lowest was found at a sucrose concentration of 95%, at 20.88 ± 0.05%. Based on Table 3, it is suggested that the lower the moisture content of marmalade, the higher the sucrose concentration added. This phenomenon occurs because sucrose has a stronger hygroscopic property compared to other sweeteners, allowing it to bind water more effectively. The higher the sucrose concentration in a food product, the lower its moisture content (Ridhani et al., 2021).

Moisture content in marmalade is also influenced by sucrose levels (Mustofa, 2017). Sucrose plays a crucial role in marmalade production by attracting water molecules bound to pectin molecules until a balance is achieved between water and pectin, forming the gel structure. Additionally, water content in the material can evaporate during the heating process in marmalade production. High sucrose concentrations may lead to crystallization on the surface of the marmalade. Conversely, adding sucrose at lower concentrations results in a more liquid structure and increases the moisture content of the marmalade.

### *Color*

The analysis of variance (F-test) results for color data is presented in Table 4. The data indicates that the treatment had a significant effect, which was followed by further testing using the Honest Significant Difference (HSD) method at a 5% significance level. The results can be seen in Table 4.

**Table 4.** Color performance of Honey Milk Orange marmalade at various sucrose concentrations

| Sucrose Concentration | Color Parameters | | |
|---|---|---|---|
| | L* | a* | b* |
| 75 | $53.38 \pm 1.37^{c}$ | $10.26 \pm 0.67^{c}$ | 41.53 ± 0.23 |
| 80 | $47.53 \pm 1.21^{b}$ | $9.69 \pm 0.94^{c}$ | 42.89 ± 2.51 |
| 85 | $37.64 \pm 1.43^{ab}$ | $7.60 \pm 1.37^{c}$ | 45.38 ± 16.16 |
| 90 | $36.75 \pm 1.38^{b}$ | $4.02 \pm 0.98^{b}$ | 52.65 ± 2.64 |
| 95 | $29.94 \pm 6.51^{a}$ | $9.87 \pm 0.10^{a}$ | 49.90 ± 5.02 |
| BNJ 5% = | 5.48 | 1.55 | |

Note: * Means followed by the same letter notation are not significantly different (p > 0.05)

The data processed using the HSD test (5% significance level) showed that honey milk orange marmalade at various sucrose concentrations exhibited significant differences in all treatments. The *L value** reflects the brightness of a product, ranging from 0 (dark) to 100 (bright). The highest L* value was observed at 75% sucrose concentration, with 53.38 ± 1.37, indicating that the marmalade color was neither too dark nor too bright. The L* values across treatments ranged from 29.94 ± 6.51 to 53.38 ± 1.37. The a* values (indicating redness) ranged between 4.02 ± 0.98 and 10.26 ± 0.67, while the b* values (indicating yellowness) ranged from 41.53 ± 0.23 to 52.65 ± 2.64. The b* values were not subjected to the HSD test, as

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there were no significant differences between treatments. As sucrose concentration increased, the marmalade became darker (lower brightness), attributed to non-enzymatic browning reactions (caramelization and Maillard reaction) at high cooking temperatures. These reactions darken the marmalade color, with sucrose caramelizing at around 160°C. This aligns with Legowo et al. (2024), who suggested that Maillard reactions could be mitigated by citric acid addition. However, for honey milk orange marmalade, citric acid addition was unnecessary due to the inherent citric acid content of the fruit.

### *The sensory characteristics*

In this study, sensory attributes assessed included color, texture, taste, and overall acceptability. The sensory evaluation results for Madu Susu Orange marmalade with varying sucrose concentrations are presented in Table 5.

**Table 5.** Hedonic test of Madu Susu Orange marmalade with different sucrose concentrations

| Konsentrasi Sukrosa (%) | Color | Texture | Taste | Overall Acceptability |
|---|---|---|---|---|
| 75 | 3.73 ± 0.74 | 4.43 ± 0.68 | 3.33 ± 0.48 | 3.57 ± 0.73 |
| 80 | 3.50 ± 0.63 | 3.57 ± 0.68 | 3.37 ± 0.49 | 3.57 ± 0.63 |
| 85 | 3.50 ± 0.57 | 3.70 ± 0.75 | 3.80 ± 0.61 | 3.87 ± 0.57 |
| 90 | 3.57 ± 0.63 | 3.93 ± 0.69 | 3.83 ± 0.65 | 3.83 ± 0.70 |
| 95 | 3.80 ± 0.76 | 4.17 ± 0.79 | 3.67 ± 0.76 | 3.97 ± 0.72 |
| Chi = 9.488 | $K_w$ 3.36 | $K_w$ 15.58 | $K_w$ 13.53 | $K_w$ 7.76 |

Note: If $Kw<\chi$, the effect is considered insignificant, whereas if $Kw>\chi$, the effect is deemed significant.

The panelists' average scores for the color characteristic of marmalade made from honey orange with varying sucrose concentrations ranged from 3.50 to 3.80. The result of Kruskal-Wallis ($K_w$ = 3.36806) was less than the Chi-square value (Chi = 9.488), indicating that the treatment did not significantly affect the color. The highest hedonic score for color was found in the 95% sucrose concentration (3.80), and the lowest was found in the 80% and 85% sucrose concentrations (3.50). This lack of significant difference is likely because the sucrose concentration differences were not large enough to cause noticeable changes in the color attributes of the marmalade. The panelists' preference for color improved as the sucrose concentration increased. The caramelization reaction during heating caused the marmalade to develop a brown color. As noted by Likumahua et al. (2022), when sugar is heated continuously until its melting point, it undergoes caramelization, which contributes to a darker brown color in the marmalade.

For the texture characteristic, panelists' average scores ranged from 3.57 to 4.43. The Kruskal-Wallis value (Kw = 15.58958) was greater than the Chi-square value (Chi = 9.488), indicating a significant effect of sucrose concentration on the texture. As shown in Table 5, the marmalade with the highest panelist preference was the 75% sucrose concentration. The texture of the marmalade became thicker as the sucrose concentration increased. This result aligns with the water content analysis, which showed that as more sucrose was added, the water content decreased, leading to a thicker texture.

Regarding the taste characteristic, the panelists' average scores ranged from 3.33 to 3.83, and the Kruskal-Wallis value ($K_w$ = 13.53645) was greater than the Chi-square value (Chi = 9.488), indicating a significant effect of sucrose concentration on taste. The most preferred taste was found in the 90% sucrose concentration, as higher sucrose concentrations (above 90%) resulted in an overly sweet flavor. The sweetness in the marmalade is attributed to the monosaccharides fructose and glucose from the orange fruit, as well as the added sucrose. Oranges also contain organic acids like oxalate, malate, and others. According to Likumahua et al. (2022), the acid content in oranges has a negative correlation with temperature increase during processing. High temperatures accelerate respiration, leading to evaporation and a decrease in acid content. Finally, the overall preference scores for the marmalade ranged from 3.57 to 3.97. The Kruskal-Wallis value ($K_w$ = 7.762) was less than the Chi-square value (Chi = 9.488), meaning that the treatment did not significantly affect overall preference. Overall preference is subjective, as each

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panelist evaluates the product based on personal taste. This variation is why overall preferences can differ between panelists. The overall preference in a hedonic test evaluates how much the panelists accept the product across all attributes, helping to identify the optimal formulation of the food product (Nurcahyani et al., 2021).

### *Effectiveness index*

The effectiveness test for honey orange marmalade at various sucrose concentrations was determined using the effectiveness index method (Zahrah et al., 2023). This test was performed to identify the best treatment for the honey orange marmalade formulation at different sucrose concentrations. The best formulation of the marmalade was determined by assigning weights to each parameter (Table 6) based on its role in achieving the objectives of the treatments applied.

**Table 6.** Parameter weights

| Variabel | Parameter Weight |
|---|---|
| Total Soluble Solids | 0.9 |
| Taste | 0.9 |
| Total acidity | 0.8 |
| pH | 0.8 |
| Texture | 0.7 |
| Moisture Content | 0.6 |
| Color | 0.5 |
| L* | 0.5 |
| a* | 0.5 |
| b* | 0.5 |

The results of the effectiveness index test in Table 7 show that the best treatment for honey orange marmalade with various sucrose concentrations was obtained at a 95% concentration, which had a treatment value (TTV) of 0.84.

**Table 7.** Best treatment value for Madu Susu Orange marmalade at various sucrose concentrations

| Parameter | WP | NW | Sucrose Concentration (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 75 | | 80 | | 85 | | 90 | | 95 | |
| | | | EI | TV | EI | TV | EI | TV | EI | TV | EI | TV |
| TSS | 0.9 | 0.13 | 0.00 | 0.00 | 0.45 | 0.06 | 0.65 | 0.09 | 0.81 | 0.11 | 1.00 | 0.13 |
| Taste | 0.9 | 0.13 | 0.00 | 0.00 | 0.18 | 0.02 | 0.36 | 0.05 | 1.00 | 0.13 | 0.68 | 0.09 |
| Total Acid | 0.8 | 0.12 | 0.00 | 0.00 | 0.20 | 0.02 | 0.40 | 0.05 | 0.63 | 0.08 | 1.00 | 0.12 |
| pH | 0.8 | 0.12 | 0.00 | 0.00 | 0.30 | 0.04 | 0.35 | 0.04 | 0.49 | 0.06 | 1.00 | 0.12 |
| Texture | 0.7 | 0.10 | 0.00 | 0.00 | 0.07 | 0.01 | 0.93 | 0.10 | 1.00 | 0.10 | 0.67 | 0.07 |
| MoistureConcent | 0.6 | 0.09 | 1.00 | 0.09 | 0.93 | 0.08 | 0.30 | 0.03 | 0.08 | 0.01 | 0.00 | 0.00 |
| Color | 0.5 | 0.07 | 0.78 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.22 | 0.02 | 1.00 | 0.07 |
| L* | 0.5 | 0.07 | 0.00 | 0.00 | 0.31 | 0.02 | 0.94 | 0.07 | 1.00 | 0.07 | 1.44 | 0.11 |
| a* | 0.5 | 0.07 | 1.00 | 0.07 | 0.91 | 0.07 | 0.57 | 0.04 | 0.00 | 0.00 | 0.94 | 0.07 |
| b* | 0.5 | 0.07 | 0.00 | 0.00 | 0.12 | 0.01 | 0.35 | 0.03 | 1.00 | 0.07 | 0.75 | 0.06 |
| TTV | 6.7 | | | 0.22 | | 0.34 | | 0.49 | | 0.65 | | 0.84 |

Note: Numbers in bold indicate the best treatment value based on the effectiveness index test

The chemical and sensory characteristics of the honey orange marmalade at the 95% treatment were found to be: total acid 0.52%, pH 5.82, total dissolved solids 68.00 °Brix, and moisture content of 20.87%. The best sensory test results were obtained with a color score of 3.80 (like), texture 3.67 (like), and taste 4.17 (like), with an overall preference score of 3.97 (like), color L* 29.94, a* 9.87, b* 49.90. Amalia et al. (2024) state that the microbiological, chemical, and sensory characteristics of jam are also influenced by the addition of oranges.

## Conclusion

The best treatment for making honey orange marmalade was obtained from the formulation of 56.25g orange juice, 6.25g orange peel, and 59.37g sugar, equivalent to 95% sugar, which produced the following chemical characteristics: total acid 0.52%, total dissolved solids 68%, pH 5.82%, moisture content 20.876%, color L* 29.94, a* 9.87, b* 49.90, and sensory characteristics: color (3.80), taste (4.17), texture (3.67), overall preference (3.97).

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