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Analysis of Betacarotene, Total Sugar, and Organoleptic Jam of Purple Sweet Potato (Ipomoea Batatas L. Poir) Variation with Cassava Sugar (Manihot Esculenta)

Analisis Betakaroten, Gula Total, dan Organoleptik Selai Variasi Ubi Ungu (Ipomoea Batatas L. Poir) *dengan Gula Singkong* (Manihot Esculenta)

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ABSTRACT

Background: Purple sweet potato productivity in Indonesia is notably high, particularly in Bondowoso at 213.84 quintals/ha. This variant of sweet potato is rich in beta-carotene, with a content of 4237 µg/100 g, known for its ability to protect cells from free radicals and reduce the risk of diabetes mellitus. Notably, Indonesia ranks third globally in the prevalence of prediabetes, affecting 27.7 million people. In 2022, in Tapen District, Bondowoso, the prevalence of prediabetes, based on Tapen Health Center data, was recorded at 12.36%.
Objectives: Analyzing betacarotene, total sugar, and organoleptic propeties of purple sweet potato jam as a prediabetes distraction food.
Methods: A quasi-experimental design with a post-test-only control group was employed. The research involved producing purple sweet potato jam with varying ratios of cassava sugar and purple sweet potato (X0: 0% cassava sugar; 100% purple sweet potato; X1: 15% cassava sugar; 85% purple sweet potato; X2: 30% cassava sugar; 70% purple sweet potato; X3: 45% cassava sugar; 55% purple sweet potato). Analysis included determining betacarotene content using the UV-Visible Spectrophotometry method, total sugar using the Luff Schoorl method, and organoleptic evaluation through the hedonic test method. Data were subjected to statistical analysis using the One-Way ANOVA test for betacarotene and total sugar levels, followed by Duncan's post-hoc test. Organoleptic test data were analyzed using the Kruskall Wallis test and Dunn's post-hoc test.
Results: The average betacarotene content in treatments X0, X1, X2, and X3 were 4230.3 µg/100 g; 3464 µg/100 g; 2955.6 µg/100 g; and 2257.3 µg/100 g, respectively. Total sugar content averages for treatments X0, X1, X2, and X3 were 2.2%; 13.7%; 27.5%; and 39.2%, respectively. The panelists' preference indicated that sample X3 (45% cassava sugar and 55% purple sweet potato) was the most favored jam.
Conclusions: Significant differences were observed in beta-carotene, total sugar, and organoleptic levels of purple sweet potato jam, suggesting that the variation in purple sweet potato and cassava sugar ratios influenced the beta-carotene and total sugar levels in the jam.

INTRODUCTION

Prediabetes is a condition characterized by elevated blood glucose levels, not yet reaching the diagnostic threshold for diabetes[1]. According to the diagnostic criteria outlined by the Indonesian Endocrinology Society (PERKENI), an individual is considered to have prediabetes if their fasting blood glucose falls within the range of 100-125 mg/dL, and their plasma glucose 2 hours after the Oral Glucose Tolerance Test (OGTT) is in the range of 140-199 mg/dL[2]. In Indonesia, the prevalence of prediabetes ranks third globally, affecting approximately 27.7 million individuals[3]. As per the data from the Puskesmas Tapen application in Bondowoso, there was a 14.55% prevalence of prediabetes in 2022, derived from the early detection of non-communicable diseases in Tapen District. This involved 1.615 participants, of whom 235 were identified with prediabetes. Notably, individuals in early adulthood, spanning the age range of 18-40 years[4], are particularly susceptible to prediabetes. Research indicates that within this age group, 71.4% exhibit uncontrolled HbA1c levels, and 86.4% maintain a suboptimal diet[5].

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Prediabetes, when left unaddressed over an extended period, can progress to diabetes mellitus. The occurrence of oxidation reactions in the body is heavily influenced by free radicals; an imbalance, where the quantity of free radicals surpasses the antioxidant effect, results in oxidative damage. To avert the progression from prediabetes to diabetes mellitus and its associated complications, one viable solution is to ensure a sufficient daily intake of betacarotene. Betacarotene, as an antioxidant, plays a crucial role in shielding cells from the adverse effects of free radicals, thereby reducing the risk of diabetes mellitus among individuals with prediabetes[6]. Studies indicate that inadequate betacarotene intake may lead to insulin resistance and the eventual onset of diabetes mellitus[7]. Additionally, beyond beta-carotene, there exists a positive association between sugar consumption and elevated fasting blood glucose levels. The consumption of sugar-rich foods heightens the risk of developing prediabetes due to glucose intolerance[2].

One of the food ingredients rich in beta-carotene and complex carbohydrates is purple sweet potato, containing 4237 µg/100 g of beta-carotene. This beta-carotene content surpasses that found in carrots, which stands at 3784 µg/100 g. The productivity of purple sweet potato, particularly the Antin 2 and Antin 3 varieties, is substantial in Indonesia. Antin 2 has the potential to yield 37.1 t/ha, while Antin 3 can produce 30.6 t/ha[8]. Notably, Bondowoso District in East Java is a significant producer of purple sweet potatoes, with a total production reaching 213.84 quintals/ha[9]. These figures underscore the potential for value addition and processing of purple sweet potato commodities in Bondowoso Regency. Given the substantial production, further processing is essential to prevent new shoots or a decline in shelf life during storage. An innovative approach is transforming purple sweet potatoes into jam—a product commonly consumed by Indonesians, often paired with bread. According to BPOM data in 2018, the average jam consumption rate in Indonesia is reported to be 10 g per day.

Jam processing necessitates careful consideration of the sweetener employed. An appropriate sweetener for purple sweet potato jam products is fructose sugar, derived from cassava starch, known for its suitability in consumption to control blood sugar levels. Numerous studies have explored the creation of jam products with health benefits, such as beetroot jam designed for individuals dealing with diabetes and hypertension[10]. Additionally, similar studies involve the production of beetroot jam with varying proportions of added pumpkin (0%, 15%, 30%, and 45%). The innovation of purple sweet potato jam stands out as a healthy food option for those with prediabetes.

In light of this, the development of health-conscious snack innovations, such as purple sweet potato jam with cassava sugar, is essential for managing blood sugar levels effectively. Beyond the potential health benefits of purple sweet potato jam, gauging product acceptance through organoleptic tests with panelists is crucial for determining public reception. Consequently, the objective of this study is to analyze the levels of betacarotene, total sugar, and organoleptic qualities in jam variations of purple sweet potato with cassava sugar.

METHODS

This study adopts a quantitative research approach with a quasi-experimental design employing a Post-Test Only Control Group Design. Each treatment, involving variations in the composition of cassava sugar and purple sweet potato, was conducted three times. The percentage ratios for the formulations between cassava sugar and purple sweet potato are denoted as X0 (0%:100%); X1 (15%:85%); X2 (30%:70%); and X3 (45%:55%). The formulations were specifically tailored for prediabetic individuals, considering that the sugar concentration in purple sweet potato jam is below 60%, in contrast to other jams that may reach a 60% sugar concentration. These percentages were converted into 300 g of total ingredients without pectin, as outlined in Table 1.

Table 1. Formulation Conversion of Purple Sweet Potato Jam Varieties with Cassava Sugar

Formulation	Ingredients (g)			
	Cassava Sugar	Purple Sweet Potato	Pectin	Total
X0	0	300	3	303
X1	45	255	3	303
X2	90	210	3	303
X3	135	165	3	303

X0 = 0% cassava sugar and 100% purple sweet potato, X1 = 15% cassava sugar and 85% purple sweet potato, X2 = 30% cassava sugar and 70% purple sweet potato, X3 = 45% cassava sugar and 55% purple sweet potato.

In this study, validity was ensured through the adjustment of procedures and laboratory testing tools. Meanwhile, reliability was established by conducting three tests on each product sample, with each test performed twice. The process flowchart for creating variations of purple sweet potato and cassava sugar jam is illustrated in Figure 1.

This research was conducted from January to March 2023. Laboratory testing for betacarotene and total sugar levels in purple sweet potato jam was conducted at the Food Analysis Laboratory of Jember State Polytechnic, chosen for its appropriate facilities and methods, as determined by the researcher. The organoleptic test involved 25 moderately trained panelists who had received relevant materials and practiced related panelist testing, ensuring the validity of the results. Panelists conducted the organoleptic test by completing the hedonic test form, which employed a 5-point scale: 1 (very much like), 2 (much like), 3 (like), 4 (somewhat like), and 5 (dislike). In this study, validity and reliability were ensured through two rounds of testing for the analysis of betacarotene and total sugar levels, as well as organoleptic testing for the four formulations of purple sweet potato jam.

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The inclusion criteria for research subjects or panelists in this study encompass individuals aged 18-40 years, in good health, and with prior exposure to materials or practical training related to panelist and organoleptic tests. Exclusion criteria for panelists include a strong preference or aversion to purple sweet potatoes and allergies to purple sweet potatoes. Criteria for selecting purple sweet potatoes for jam production involve their being unbroken, displaying a fresh purple color, maintaining an intact shape, and having no sprouts.

The laboratory test for betacarotene content utilized the UV-Visible Spectrophotometric method, chosen for its high accuracy and precision in betacarotene analysis. The Luff Schoorl method was employed for the total sugar test on purple sweet potato jam due to its applicability in analyzing food products containing sugars with low molecular weights and natural or modified starch. Laboratory tests were conducted by the staff at the Jember State Polytechnic Laboratory, and the organoleptic test of jam was obtained through a hedonic test. The validity and reliability of this test were ensured by following laboratory procedures and the test method twice for betacarotene and total sugar levels in purple sweet potato jam to achieve accurate results.

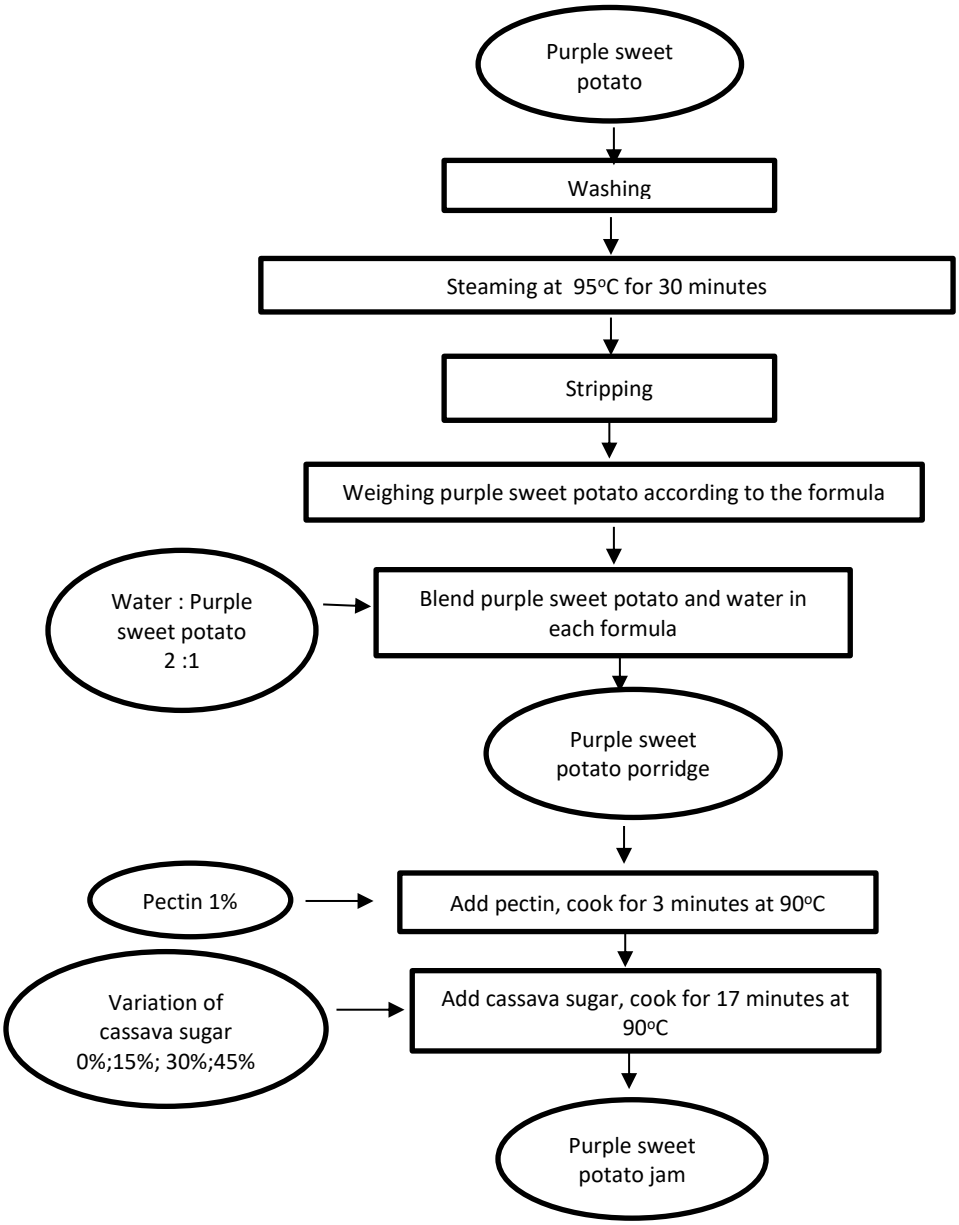

Figure 1. Flowchart for the Production of Purple Sweet Potato and Cassava Sugar Jam Varieties

The research instrument employed for data measurement is the SPSS Statistics 26 application. Betacarotene and total sugar levels were analyzed using the One-Way ANOVA test and the Duncan Post Hoc test with a p-value of 0.000 (α≤0.05). Meanwhile, the organoleptic test was analyzed using the Kruskall Wallis test with the Dunn Post Hoc test, setting a p-value of α≤0.05. This research received approval from the Health Research Ethics Commission of FKM UNEJ, certified with No. 303/KEPK/FKM-UNEJ/II/2023.

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Production of Purple Sweet Potato Jam

The tools and materials employed included a Miyako BL 102 PL blender, knife, container, pot, plate, spoon, cassava sugar, and purple sweet potato. Purple sweet potatoes for this study were obtained from the Bondowoso wholesale market, easily accessible to the community. The process of producing purple sweet potato jam begins with steaming purple sweet potatoes at 95°C for 30 minutes, followed by blending with water in a 2:1 ratio. The resulting purple sweet potato pulp is then mixed with 1% pectin, heated at 90°C for 3 minutes, and combined with cassava sugar. The mixture is cooked at 90°C for an additional 17 minutes[12].

Betacarotene Measurement

Tools and Materials

The instruments employed included an analytical balance, Erlenmeyer flask, measuring cup, glass funnel, goblet, and burette. The materials utilized comprised filter paper, measuring pipettes, KOH reagents, C2H5OH, absolute ethanol, diethyl ether, petroleum benzene, 92% methanol, distilled water, and Na2SO4 anhydride[13].

Procedure

The sample material was weighed to approximately ±5 g, refluxed in an Erlenmeyer flask, and treated with a 10% C2H5OH solution and KOH. The Erlenmeyer flask was covered with carbon paper and heated for 30 minutes. The mixture was then filtered through a Buchner funnel and rinsed with 20 ml of pre-heated absolute C2H5OH. The resulting precipitate was washed three times with 25 ml of diethyl ether.

The filtered material was transferred into a separatory funnel, followed by the addition of 200 ml of distilled water. After gently swirling the funnel to mix, the upper ether layer was separated. The C2H5OH layer was then extracted by adding 25 ml of petroleum benzene, and the upper ether layer was combined with the original ether layer. The resulting ether solution was washed approximately five times with 50 ml of distilled water until free of betacarotene.

The ether solution containing betacarotene was evaporated on a water bath at 40-50°C until the residue reached approximately ±5 ml. To the residue, 25 ml of petroleum benzene was added and transferred to a separatory funnel. Subsequently, 25 ml of 92% CH3OH was added and the mixture was shaken. After standing for approximately 2 minutes until two layers formed, the layers were separated.

Next, the layer containing betacarotene was extracted with 25 ml of 92% CH3OH until the bottom layer became colorless. The petroleum ether layer was then washed three times with distilled water. The betacarotene extract was filtered through a Na2SO4 anhydride filter into a 50 ml volumetric flask, diluted with petroleum benzene to the calibration mark. A 20 ml aliquot of the solution was pipetted into a cuvette or Coleman tube. Simultaneously, 10 ml of a blank solution (petroleum benzene) was placed into another cuvette. Both materials were examined using a Coleman UV-Visible Spectrophotometer at 436-450 MU, and the sample was compared with the blank.

Calculation of Betacarotene Content in 100 g =

$$\frac{100}{B}\ x\ f.p\ x\ \frac{Pc.b}{P.std} x\ K.std$$

Description:

B = weight of material
f.p = dilution factor = 50/20
Pc.b = solution reading on the Spectrophotometer
P. std = standard solution reading = 0.324
K. std = concentration of betacarotene standard solution = 10 ə

Total Sugar Measurement

Tools and Materials

The instruments used include an analytical balance, weighing bottle, 100 ml volumetric flask, funnel, 100 ml Erlenmeyer flask, 250-300 ml Erlenmeyer flask, counter cooler, gauze, Bunsen burner, 50 ml burette, 25 ml pipette, 10 ml pipette, and 100 ml beaker. The materials used consist of distilled water, Pb acetate solution, 8% sodium phosphate, 20% potassium iodide, 26.5% sulfuric acid, 1% amylum, 0.1 N sodium thiosulfate, 30% HCl, 45% NaOH, phenolphthalein, Na2CO3, and CuSO4[14].

Procedure

First, prepare the Luff Schoorl solution by dissolving 25 g of CuSO4·5H2O in 100 ml of distilled water, and then dissolve 50 g of citric acid in another 100 ml of distilled water. Dissolve Na2CO3 (388 g and 10 H2O) in 400-500 ml of hot distilled water, then allow it to cool. Agitate the Na2CO3 solution and add the CuSO4 and citric acid solutions by spraying them. Subsequently, dilute the solution to 1000 ml. If cloudiness occurs, let it settle and then filter.

Second, analyze the sugar before inversion in the sample. Weigh 5-10 g of pulverized material, place it into a 100 ml volumetric flask, and add approximately 2 flasks of distilled water. Gradually add 2 drops of base Pb acetate solution until it becomes clear, then dilute to the calibration mark and filter into an Erlenmeyer flask with filter paper. Pipette 50 ml of the filtrate into a 200 ml volumetric flask, add 8% sodium phosphate solution until no turbidity is observed, dilute to the calibration mark, shake, and filter in an Erlenmeyer flask with filter paper.

Third, analyze the sugar after inversion in the sample. Pipette 25 ml of the Pb-free filtrate, add 25 ml of Luff Schoorl solution to a 100 ml volumetric flask. Incorporate 10 ml of 30% HCl, heat in a water bath at a flask temperature of 60-70˚C for 10 minutes, and then cool. Introduce 2-3 drops of phenolphthalein and add 45% NaOH until a pink color is achieved. Cool and dilute to the calibration mark. Pipette 25 ml of the solution, add 25 ml of Luff Schoorl solution, and include 2-3 boiling stones. Place it in a counter cooler, heat for 2 minutes, reflux for 10 minutes, cool rapidly with running water. Gradually add 25 ml of 26.5% H2SO4, and then add 15 ml of 20% KI. Titrate the thiosulfate solution until a yellow color is observed. Introduce 2-3 ml of 1% amylum and continue titration until the blue color disappears. Conduct a blank titration with 25 ml of distilled water in

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a 250-300 ml Erlenmeyer flask and add 25 ml of Luff Schoorl.

Organoleptic Testing

Organoleptic testing in this study involved 25 moderately trained panelists. Moderately trained panelists, comprising 15-25 individuals, were selected from a limited pool based on their sensitivity, which was initially tested. The sensitivity of the panelists was honed through the provision of material about organoleptic testing, followed by practical exercises on various food products.

The steps of organoleptic testing in this study included determining the panelists' category, establishing inclusion and exclusion criteria for panelists, and selecting panelists based on these criteria. Informed consent was then obtained from the panelists, signifying their willingness to participate in the organoleptic test. An organoleptic testing site was designated, taking into account the appropriate distance between panelists, and the tested products were presented with different and randomly assigned sample codes. Subsequently, an explanation about organoleptic testing was provided to the panelists, allowing them an opportunity to ask questions. The actual organoleptic testing was conducted simultaneously, with panelists filling out a hedonic form using a 5-point scale: 1 (very much like), 2 (much like), 3 (like), 4 (somewhat like), 5 (dislike).

RESULTS AND DISCUSSION

Betacarotene Content of Purple Sweet Potato Variety Jam with Cassava Sugar

Betacarotene levels were measured using the UV-Vis spectrovotometric method. Samples were extracted using petroleum ether and then saponified with 15% KOH solvent in methanol. The average betacarotene content in the four samples of purple sweet potato jam variation with cassava sugar is shown in Table 2.

Table 2. Betacarotene Content of Purple Sweet Potato Variety Jam with Cassava Sugar

Parameter	Betacarotene Content of Jam (µg /100 g)			
	X0	X1	X2	X3
Becarotene	4230.3 ± 4.04[a]	3464.0 ± 7.00[b]	2955.6 ± 11.06[c]	2257.3 ± 4.16[d]

X0 = 0% cassava sugar and 100% purple sweet potato; X1 = 15% cassava sugar and 85% purple sweet potato; X2 = 30% cassava sugar and 70% purple sweet potato; X3 = 45% cassava sugar and 55% purple sweet potato; a,b = similar letter notation means not significantly different.

The laboratory analysis results of total sugar content in purple sweet potato jam variations with cassava sugar revealed that the highest total sugar content was observed in sample X3, indicating a 45% cassava sugar variation and 55% purple sweet potato, at 39.2%. Conversely, the lowest total sugar content was found in sample X0, representing a jam with a 0% cassava sugar variation and 100% purple sweet potato. The variation in betacarotene content can be attributed to the differing amounts of purple sweet potato used in jam production. The elevated betacarotene level in sample X0 suggests that an increased quantity of purple sweet potato in the jam corresponds to higher betacarotene content. In the data analysis of average betacarotene content, the significance result is 0.000 (<0.05), signifying a significant difference in the average betacarotene content of purple sweet potato jam variations with cassava sugar.

Table 2 demonstrates that as the proportion of purple sweet potato decreases in the jam, the betacarotene content also decreases. These findings align with a study on cookies incorporating purple sweet potato flour and white sweet potato. The study indicated that the 100:0 ratio of purple sweet potato to white sweet potato resulted in the highest betacarotene content compared to other variations. This indicates that a higher proportion of purple sweet potato flour contributes to increased antioxidant activity of betacarotene[15].

Purple sweet potato serves as a rich source of complex carbohydrates and serves as a notable reservoir of betacarotene. The betacarotene content in purple sweet potatoes, the primary ingredient in purple sweet potato jam, measures at 4237 µg/100 g. This indicates that purple sweet potatoes are particularly rich in betacarotene, functioning as potent precursors of vitamin A and serving as highly effective antioxidants[16]. Antioxidants play a crucial role in reducing blood glucose levels and shielding cells from the detrimental impacts of free radicals, thereby mitigating the risk of complications associated with diabetes mellitus.

Total Sugar Content of Purple Sweet Potato Variety Jam with Cassava Sugar

Total sugar content was measured using the Luff Schoorl method. In this method, glucose is determined based on its reduction properties to copper (II) ions in the Luff-Schoorl reagent and expressed as reducing sugar. The total sugar content of the four samples of purple sweet potato jam variation with cassava sugar is shown in Table 3.

Table 3. Total Sugar Content of Purple Sweet Potato Variety Jam with Cassava Sugar

Parameter	Total Sugar Content of Jam (%)			
	X0	X1	X2	X3
Total Sugar	2.22 ± 0.45[a]	13.7 ± 0.41[b]	27.5 ± 0.32[c]	39.2 ± 0.11[d]

X0 = 0% cassava sugar and 100% purple sweet potato; X1 = 15% cassava sugar and 85% purple sweet potato; X2 = 30% cassava sugar and 70% purple sweet potato; X3 = 45% cassava sugar and 55% purple sweet potato; a,b = similar letter notation means not significantly different.

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In the data analysis of average total sugar content, the obtained significance result is 0.000 (<0.05), indicating a significant difference in the average betacarotene content of purple sweet potato jam variations with cassava sugar. As illustrated in Figure 2, a discernible trend emerges where the concentration of cassava sugar in the jam correlates positively with the total sugar content in the variations of purple sweet potato jam with cassava sugar. This observation aligns with research on the impact of varying sugar concentrations on the chemical characteristics and total sugar content of namnam fruit sheet jam. Notably, the study reveals that the highest total sugar content is found in samples with the highest sugar concentration (50%), surpassing those with concentrations of 35%; 40%; and 45%[17].

The increase in total sugar can be attributed to a reduction in water content and ingredients, leading to a decrease in the overall mass of the ingredients. This notion is supported by research investigating the influence of different sugar concentrations on the chemical characteristics and total sugar of namnam fruit sheet jam. The study consistently reports that the highest total sugar content is present in samples with the highest added sugar concentration of 50%, in contrast to jam samples with sugar concentrations of 35%; 40%; and 45%[17].

Organoleptic Test of Purple Sweet Potato Variety Jam with Cassava Sugar

The organoleptic test in this study used the hedonic test, wherein the product was evaluated by 25 moderately trained panelists. The characteristics of the panelists, as derived from the hedonic test form in this study, are presented in Table 4.

Table 4. Results of Panelist Characteristics Based on Hedonic Test Forms

Panelist Characteristics	Total
Age	
20	7
21	14
22	3
23	1
Gender	
Female	25
Male	0
Jam Allergy	
Yes	0
No	25
Favorability of Jam/Purple Sweet Potato	
Really like	0
Neutral	25
Strongly dislike	0

Panelists gave an assessment of their liking for the product based on a hedonic scale. The hedonic scale in this study uses 5 scales. The organoleptic results of the panelists with the hedonic test are shown in Table 5.

Table 5. Organoleptic Result of Panelist with Hedonic Test

Parameter	Mean Value of Hedonic Test Sample			
	X0	X1	X2	X3
Color	3.52 ± 1.159^{a}	2.48 ± 1.358^{b}	2.36 ± 0.860^{b}	2.36 ± 1.114^{b}
Smell	3.28 ± 0.891^{a}	3.44 ± 1.158^{ab}	2.92 ± 0.909^{a}	2.60 ± 0.913^{ac}
Taste	4.20 ± 0.866^{a}	3.80 ± 0.957^{a}	2.80 ± 0.764^{b}	1.92 ± 0.997^{b}
Texture	3.8 ± 1.291^{a}	2.64 ± 1.114^{b}	2.32 ± 1.030^{bc}	2.04 ± 1.020^{c}
Overall	3.80 ± 0.816^{a}	3.36 ± 0.860^{a}	2.56 ± 0.821^{b}	1.84 ± 0.850^{b}

X0 = 0% cassava sugar and 100% purple sweet potato; X1 = 15% cassava sugar and 85% purple sweet potato; X2 = 30% cassava sugar and 70% purple sweet potato; X3 = 45% cassava sugar and 55% purple sweet potato; 1 = very much like, 2 = very much like, 3 = like, 4 = somewhat like, 5 = dislike; a,b = similar letter notation means not significantly different.

Color

Color, as an organoleptic indicator, is assessed through the sense of sight. Primarily, the color factor becomes visually apparent before other considerations, and its value is instrumental in organoleptic evaluations, as it visually signifies the level of product acceptance[18].

The assessment of color in the organoleptic test revealed that the preference for the color of purple sweet potato jam variations with cassava sugar did not exhibit a significant difference (p>0.05) between X1 and X2, X1 and X3, and X2 and X3. However, significant differences (p<0.05) were observed between X0 and X1, X0 and X2, and X0 and X3. Notably, the samples with the smallest average scale and highest preference among panelists were X2 (cassava sugar and purple sweet potato ratio 30%:70%) and X3 (cassava sugar and purple sweet potato ratio 45%:55%), both averaging 2.36. This preference is attributed to the deeper purple color of X2 and X3 in contrast to X0, which exhibits a lighter purple hue.

The purple color in sweet potatoes is due to the presence of anthocyanins, providing natural pigments. Additionally, the inclusion of sugar in the jam contributes

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to its color through non-enzymatic browning or the Maillard reaction[19]. The more pronounced the jam's color, the more favored it is by the panelists. This observation aligns with research on dragon fruit peel jam products with added sugar, where panelists generally preferred jams with higher sugar content and concentrated color, characterized by a brownish-red tint[20].

Smell

Smell is a crucial parameter in organoleptic testing, as it can significantly influence consumer perception. A favorable aroma can positively alter the consumer's perception of the product, thereby enhancing its overall appeal[21].

The olfactory aspect of the organoleptic test revealed that the preference for the smell of purple sweet potato jam variations with cassava sugar did not exhibit a significant difference (P>0.05) between X0 and X1, X0 and X2, X0 and X3, X1 and X2, and X2 and X3. However, a significant difference (P<0.05) was observed between X1 and X3. The sample with the smallest average scale and was highly favored by panelists was X3, with a variation of cassava sugar and purple sweet potato at 45%:55%, averaging 2.6. This preference is attributed to the very strong aroma of X3. The distinct smell of purple sweet potato jam can be attributed to volatile compounds released during the processing of purple sweet potato and cassava sugar[22].

Cassava sugar plays a role in enhancing the aroma of purple sweet potato jam, contributing to a well-balanced flavor profile. Other studies suggest that the aroma of jam with higher sugar content is closely linked to the caramelization reaction. This process generates maltol and isomaltol compounds, imparting a robust and sweet aroma to purple sweet potato jam[17]. This finding aligns with research on tongka langit banana peel jam, where increased sugar concentration in the jam correlates with heightened banana aroma[23]. The concentration of cassava sugar directly influences the jam's aroma strength, making it more appealing to the panelists.

Taste

Taste is a parameter evaluated through the sense of taste and plays a pivotal role in consumer product selection. Despite the nutritional benefits, if the taste is unfavorable and not accepted by consumers, the goal of addressing nutritional concerns may not be achieved effectively[19].

The taste component in the organoleptic test revealed that the preference for the taste of purple sweet potato jam variations with cassava sugar did not exhibit a significant difference (P>0.05) between X0 and X1, and X2 and X3. However, significant differences (P<0.05) were observed between X0 and X2, X0 and X3, X1 and X2, and X1 and X3 in terms of taste preference for purple sweet potato jam variations with cassava sugar. The sample with the smallest average scale and was highly favored by panelists was sample X3, with a variation of cassava sugar and purple sweet potato at 45%:55%, averaging 1.92. This preference could be attributed to the higher cassava sugar content, resulting in a stronger sweetness in the jam.

Purple sweet potato and cassava are recognized as food ingredients containing starch or complex carbohydrates that contribute to sweetness. Cassava starch can be processed into liquid sugar, and the greater the amount of cassava sugar added to the jam, the sweeter its taste. The heightened sweetness of the jam correlates with increased favorability among panelists. This finding is consistent with research on the organoleptic test of namnam jam, where the sample with the highest sugar concentration (50%) obtained the highest organoleptic test average, indicating panelists' preference for the sweet taste of the jam[17].

Texture

Texture represents a material's characteristics, encompassing physical properties like number, size, and elemental composition. Additionally, texture describes the form of a material, perceivable through the senses of taste and touch. The state of food texture signifies the vital physical properties of food ingredients assessed in organoleptic tests[19].

The texture element in the test indicates that the preference for the texture of purple sweet potato jam variations with cassava sugar does not exhibit a significant difference (P>0.05) between X1 and X2, and X2 and X3. Nevertheless, significant differences (P<0.05) were noted between X0 and X1, X0 and X2, X0 and X3, and X1 and X3 in terms of texture preference for purple sweet potato jam variations with cassava sugar. The sample with the smallest average scale and highly favored by panelists is sample X3, with a variation of cassava sugar and purple sweet potato at 45%: 55%, averaging 2.04. Panelists favored the thick, gel-textured jam with high spreadability, making it easy to consume and spread on bread.

The addition of sugar and pectin is crucial in achieving a desirable texture in jam. Increased sugar content results in a thicker jam during the cooking process due to sugar binding water, thereby reducing water content[17]. Higher sugar concentration correlates with increased panelist preference for jam texture. This aligns with research on purple eggplant jam with varying sugar concentrations, where panelists favored the texture of jam with the highest sugar concentration[24].

Overall

The overall aspect is a panelist assessment that encompasses all sensory properties. Sensory properties are crucial quality parameters as they determine consumer acceptance of a product. The overall sensory analysis considers all aspects, including color, aroma, taste, and texture, providing a comprehensive evaluation of product acceptance[25].

The overall aspect in the organoleptic test revealed that the overall level of liking for the purple sweet potato variety jam with cassava sugar did not exhibit a significant difference (P>0.05) between X0 and X1, as well as X2 and X3. However, a significant difference (P<0.05) was observed between X0 and X2, X0 and X3, X1 and X2, and X1 and X3 regarding the overall level of liking for the purple sweet potato variety jam with cassava

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sugar. The sample with the smallest average scale and highly favored by panelists is sample X3, with a variation of cassava sugar and purple sweet potato at 45%: 55%, having an average of 1.84 compared to other samples. This is because sample X3 purple sweet potato jam contains a high concentration of sugar and is most preferred by panelists in all aspects, consisting of color, aroma, taste, and texture.

Sugar added to jam can influence the color, aroma, taste, and texture of the jam. Increased sugar content intensifies the color, enhances the aroma and taste, and improves the texture of the jam, making it overall more preferred by panelists. This aligns with other research on namnam jam, where the level of acceptance and overall liking by panelists for the color, aroma, taste, and texture of the highest namnam fruit sheet jam is associated with a sugar concentration of 50%[17]. Higher sugar concentration correlates with increased panelists' liking for the color, aroma, taste, and texture of the jam[17]. Based on this, it can be concluded that the best formulation based on organoleptic tests is sample X3, which has a variation of 55% cassava sugar and 45% purple sweet potato.

The Best Formulation Based on Nutritional Adequacy Figures

The results of the calculation of betacarotene and daily sugar adequacy in purple sweet potato variation jam with cassava sugar as a snack food are presented in Table 6 and Table 7. The calculation results are provided for sample X3, selected as the most preferred formulation by the panelists. Based on the calculation results, variations in jam portions are observed for the early adult category.

Table 6. Calculation Results of Sufficiency of Betacarotene Fulfillment of Purple Sweet Potato Variety Jam with Cassava Sugar in sample X3

Category (Early adults 18-40 years old)	Fulfillment of betacarotene RDA of sample X3 every intermittent meal (1 tbsp)			
	Total sugar content	Total sugar sufficiency	Percentage of sufficiency	Jam weight
Male (18 years old)	338.6 µg	420 µg	80.6%	15 g
Male (19-40 years old)	316 µg	390 µg	81%	14 g
Female (18-40 years old)	293.4 µg	360 µg	81.5%	13 g

Table 7. Calculation Results of Sufficiency of Daily Sugar Fulfillment of Purple Sweet Potato Variety Jam with Cassava Sugar in sample X3

Category (Early adults 18-40 years old)	Fulfillment of total sugar consumption of sample X3 every intermittent meal (1 tbsp.)			
	Total sugar content	Total sugar sufficiency	Percentage of sufficiency	Jam weight
Male (18 years old)	5.88 g	6.625 g	88%	15 g
Male (19-29 years old)	5.48 g	6.625 g	82%	14 g
Male (30-40 years old)	5.48 g	6.375 g	85%	14 g
Female (18 years old)	5.09 g	5.250 g	96%	13 g
Female (19-29 years old)	5.09 g	5.625 g	90%	13 g
Female (30-40 years old)	5.09 g	5.375 g	94%	13 g

Sample X3 (45% cassava sugar and 55% purple sweet potato), which was favored by the panelists, achieved the Recommended Daily Allowance (RDA) adequacy of beta-carotene for each meal in early adults aged 18-40 years, for both men and women, exceeding 80%. Men aged 18 years met 80.6%, men aged 19-40 years met 81%, and women aged 18-40 years met 87%. In terms of total sugar consumption per meal, early adult males aged 18-40 years have met >80%, while early adult females aged 18-40 years have met ≥90%. These calculations indicate that the difference in jam consumption is influenced by variations in the need for beta-carotene in each age group and differences in energy adequacy, resulting in variations in sugar consumption adequacy across age groups.

CONCLUSIONS

There were significant differences in betacarotene content, total sugar, and organoleptic test among the jam variations of purple sweet potato and cassava sugar. The betacarotene content for each variation of cassava sugar and purple sweet potato ratio (0%:100%; 15%:85%; 30%:70%; 45%:55%) were 4230.3 µg/100 g; 3464 µg/100 g; 2955.6 µg/100 g; and 2257.3 µg/100 g, respectively. The total sugar content of jam from each variation of cassava and purple sweet potato sugar ratio, respectively (0%:100%; 15%:85%; 30%:70%; 45%:55%), were 2.2%; 13.7%; 27.5%; 39.2%.

The best formulation among the four jam samples, based on betacarotene nutritional adequacy, daily sugar consumption adequacy, and organoleptic test, is the X3 jam sample, where X3 represents a sample with a variation of 45% cassava sugar and 55% purple sweet potato. This jam was highly favored by panelists. The betacarotene content of jam sample X3 was 2257.3 µg/100 g, while the total sugar content was 39.2%. The recommended portion of purple sweet potato jam as a snack for early adults ranges from 13-15 g per meal.

This study provides valuable insights for readers and individuals with prediabetes, suggesting the consumption of snacks, especially purple sweet potato jam, in the appropriate portion and with consideration of sugar content and the benefits of beta-carotene as an antioxidant. Further research should explore the effects of consuming purple sweet potato jam products on individuals with prediabetes. A limitation of this study

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includes the organoleptic testing, which involved panelists consuming jam and white bread together, potentially influencing perspectives compared to consuming jam alone without bread.

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Author Contributions

SH: conceptualization, data curation, formal analysis, funding acquisition, methodology, software, supervision, validation, writing-review & editing; KH: conceptualization, data curation, formal analysis, investigation, resources, methodology, visualization & writing-original draft.

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