Characteristic Evaluation of Parijoto Fruit Jam Using Low Calorie Natural Sweeteners Based on Coconut Sugar and Cassava Sugar

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ABSTRACT

Parijoto (Medinilla speciosa) is a local Indonesian fruit that remains underutilized due to its sour, astringent taste and its highly perishable nature, making it difficult to distribute and commercialize fresh. One potential way to increase its utilization is to process the fruit into jam. This study aims to evaluate the physicochemical and sensory characteristics of parijoto jam formulated with two natural sweeteners: cassava sugar and coconut sugar. The analyses conducted included determination of water content, ash, protein, fat, carbohydrate, energy value, dietary fiber, total sugar, viscosity, and pH. A sensory evaluation was also conducted using a five-point hedonic scale with 35 untrained panelists to assess appearance, aroma, taste, texture, and overall acceptability. The results demonstrated noticeable differences between the two formulations. Jam made with cassava sugar exhibited higher carbohydrate levels (23.70%), energy content (115.96 kcal/100 g), total sugar (21.76%), and viscosity (26.746 mPas), indicating a sweeter taste and thicker consistency. Meanwhile, jam formulated with coconut sugar contained higher dietary fiber (0.93%), which may offer added nutritional benefits. Despite these differences, neither formulation fully complied with the Indonesian National Standard (SNI 3746:2008), mainly due to excessive water content (72–75%) and insufficient soluble solids. Sensory evaluation revealed that both formulations had comparable consumer acceptability. These findings suggest that both sweeteners are viable for parijoto jam development, provided that further optimization is carried out to improve consistency and meet regulatory standards.

1. Introduction

Parijoto (*Medinilla speciosa*) is a plant native to Kudus Regency, Central Java, often found on Mount Muria. Parijoto is a tropical plant now widely cultivated by the local community. Parijoto fruit has a sour, astringent taste, is small, round, and purplish-red. Parijoto fruit has several potential uses in preventing diseases such as diarrhea, mouth ulcers, and inflammation [1], [2]. Several pharmacological activities, such as antioxidant, antibacterial, anti-inflammatory, and antidiabetic effects, have been identified in parijoto fruit. These activities are influenced by phytochemical

compounds found in parijoto fruit, such as flavonoids, phenolics, tannins, saponins, alkaloids, glycosides, and cardenolin [1], [3], [4]. However, the parijoto fruit has an astringent and sour taste [5] and quickly deteriorates post-harvest [6]. This condition makes the parijoto fruit less popular for direct consumption and difficult to distribute fresh. These limitations are the main factors in the low economic added value and competitiveness of parijoto fruit in the market. Therefore, processing innovations are needed to extend shelf life and enhance flavor; one way to do this is to turn it into processed products such as jam.

In general, people don't like parijoto fruit when consumed directly. This is because parijoto has a sour, astringent taste and is easily spoiled. Parijoto's perishable nature also makes it challenging to ship it outside the city. To increase public consumption of parijoto fruit, it is necessary to develop it into a processed product with a high taste, namely parijoto fruit jam. The advantages of the parijoto fruit when processed into jam include long storage and high public acceptance. Quality parijoto fruit jam products must be free from contamination from water sources, processing facilities, equipment, and processing [10].

Jam is a processed food product in the form of a paste with a soft and elastic texture made from pureed fruit. Jam is generally made from ripe fruits such as pineapple, strawberry, banana, and orange. The concentration of sugar and pectin in the fruit pulp can influence the texture of jam. Not all fruits can be commercially processed into jam because not all have flavors popular with the public. Nowadays, to increase the appeal of products, especially jam, many creative methods are used, resulting in a variety of jam flavors found on the market [7], [8], [10], [9]. Jam is made from 45 parts fruit juice, 55 parts sugar by weight, and pectin as a thickening agent. The mixture of fruit, sweetener, and pectin is cooked until it thickens, and the soluble solids content is at least 65%. To improve product quality and stability, additives such as coloring, flavoring, pectin, and acid are used to balance the physical, chemical, or sensory deficiencies of the fruit used [11]. The shelf life of jam is greatly influenced by several factors, especially the role of sugar as the main preservative. High sugar content, ranging from 65% to 75% soluble solids, can inhibit the growth of microorganisms.

The sweetener often used in jam is sucrose, or granulated sugar. Sucrose's high-calorie content, around 400 calories per 100 grams, can increase the risk of various health problems, such as obesity, type 2 diabetes mellitus, and other metabolic diseases. The use of natural sweeteners in product processing plays a crucial role in supporting public health. Therefore, Parijoto jam is made with low-calorie natural sweeteners, such as coconut and cassava sugars. Coconut sugar and cassava sugar are natural sweeteners that can be used as an alternative to granulated sugar. Coconut sugar has a lower glycemic index than granulated sugar and contains a lot of minerals. Coconut sugar (*coconut sugar*) is widely promoted as a natural sweetener with a better nutritional profile than granulated sugar due to its content of several minerals and phenolic compounds. Several chemical studies and literature reviews report that coconut sugar has antioxidant components and can exhibit a lower glycemic index value than some processed sugars, thus potentially reducing blood sugar spikes when used as a substitute in food formulations [12]. Previous research shows that coconut sugar provides a more stable glycemic response than other sugars, and in addition, coconut sap also contains phenolic compounds with high antioxidant activity, which have the potential to maintain the stability of processed food products [13].

Cassava sugar has emerged as an attractive alternative to traditional sweeteners. Several studies and industry reports indicate that cassava sugar can be processed into a high-performance sweetener, with potential for process modification to produce a lower-calorie product or reduce free sugars [14]. Utilizing cassava as a raw material for sugar also aligns with local commodity value-added strategies and food security, particularly in areas with abundant cassava production. However, the processing technology and organoleptic properties of cassava sugar (flavor and color) require further study when applied to products such as jam [15]. Previous research reported that the cassava starch hydrolysis process can produce high-quality glucose with good thermal stability, opening up opportunities for its use in the modern food industry [14].

Although jam-making is common, no research has specifically examined the suitability of parijoto fruit for jam production or the effects of using alternative natural sweeteners, such as cassava syrup and coconut sugar, on its characteristics. This research gap provides an essential basis for developing the potential of the parijoto fruit as a functional food product typical of the Kudus region. This study aimed to develop and characterize Parijoto jam using coconut sugar and cassava sugar. We

hypothesized that the type of sweetener would significantly influence the physicochemical properties, nutritional profile, and sensory acceptability of the jam.

2. Research Methodology

2.1. Materials

The ingredients used in making parijoto fruit jam (CV Alammu, Colo Village, Kudus, Central Java), coconut sugar, cassava sugar, water, HMP food grade jam pectin (IR & Co, Tegalsari, Surabaya, East Java). Evaluation of physical quality (viscosity, color, and texture), macronutrient test (carbohydrate, protein, fat), and chemical test (water content, total sugar content, fiber, and energy content) were tested in the Chem-Mix Pratama laboratory, Bantul, Yogyakarta. The hedonic test method is used to analyze the level of preference for a product or sample [16]. The criteria for panelists were chefs, pastry experts, and nutrition lecturers who had undergone organoleptic test training. The instrument used was a hedonic test form including sensory parameters of color, taste, texture, aroma, with five categories of preference levels with a score of 5-1, namely very like, like, somewhat like, dislike, and immensely dislike [17].

2.2. Procedures

1) Initial formulation of Parijoto jam

This research is the initial stage of formulation, with a completely randomized design (CRD) and two treatments: F1 parijoto fruit jam made with coconut sugar and F2 parijoto fruit jam made with cassava sugar, as shown in Table 1. Each formulation was tested multiple times to ensure consistent results, and the data obtained were tabulated as mean ± standard deviation. The reliability of the observations is strengthened by the involvement of 35 semi-trained panelists (a chef, a pastry expert, and a nutrition lecturer at Universitas Muhammadiyah Kudus) in sensory testing.

Table 1. Initial Formulation of Parijoto Jam

Composition	F1 (coconut sugar)	F2 (cassava sugar)	Conversion
Parjoto Fruit	872 gram	872 gram	Weighed directly
Water	1000 mL	1000 mL	Density ± 1 g/mL
Pectin	12 gram	12 gram	Pectin powder
Coconut sugar	160 gram	-	Granular solids
Cassava sugar	-	180 gram	Thick liquid
Lemon	5 gram	5 gram	fluid

The difference in the amount of sweetener is determined to equalize the theoretical sweetness level according to the standard solution solids of 650^0 Brix [18] According to the Indonesian National Standard (SNI 3746:2008). Smooth Parijoto fruit is then filtered. The filtered fruit is left for 5-10 minutes to extract the pink parijoto juice. The extracted juice is then cooked with coconut sugar (F1), cassava sugar (F2), and pectin. The mixture is stirred until thickened over low heat. Lemon juice is added to the thickened jam to create a fresh flavor. The packaging process involves waiting for the cooked jam to cool and then transferring it to glass bottles.

2) Preliminary research on low-sugar jam

Evaluation of the characteristics of parijoto fruit jam included organoleptic tests conducted by 35 semi-trained panelists. Hedonic testing was conducted using a Likert scale (1 = dislike very much, 2 = dislike, 3 = somewhat like, 4 = like, 5 = like very much). Organoleptic requirements include not smoking and/or consuming food and/or drinks that have a sharp taste/aroma, not using cosmetics and perfumes with a strong aroma before conducting the hedonic test, have washed hands/used hand sanitizer before conducting the hedonic test, be calm and not cause a commotion when conducting the hedonic test, do not have allergies or a history of illness or are currently taking medications that can affect the hedonic test process, neutralize your sense of taste with a neutralizer (mineral water) provided each time you taste a new sample. Panelists are given a questionnaire to assess color, aroma, flavor, and texture. Jam samples were prepared and served in transparent containers with random codes. The serving order was randomized using a Latin square design to reduce order effects. Samples were given a 1-minute break with a mouthwash of mineral water. Panelists were instructed to rate each parameter based on their personal perceptions and to record their ratings on the provided form.

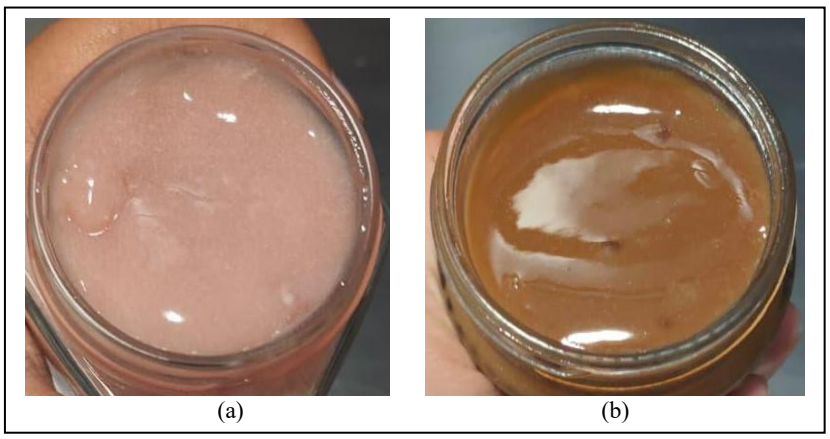
Sensory test results are tabulated as mean ± standard deviation (mean ± SD). Before conducting a difference test, the data were tested for normality using the Shapiro–Wilk test and for homogeneity of variance using Levene's test. If the data are typically distributed and homogeneous, an independent-samples t-test is used to compare two formulas. If the parametric assumptions are not met, the analysis continues using nonparametric methods. All statistical tests were performed at a significance level of $\alpha = 0.05$; differences are considered significant if $p < 0.05$. Evaluation of physical quality (viscosity, color, and texture), macronutrient testing (carbohydrates, protein, fat), and chemical testing (pH, water content, total sugar content, fiber, and energy content) were conducted at the Chem-Mix Pratama laboratory, Bantul, Yogyakarta.

3. Results and Discussion

The assessment results showed that the color of Parijoto jam was attractive to some panelists. The color indicator received 51% of panelists who said they liked it, 3% who really enjoyed it, and 17% who did not. Previous research indicates that adding sugar to jam affects the aroma. At the same time, parijoto fruit has a less pungent smell, so that the results of the formulation of parijoto fruit jam with coconut sugar are more dominant in aroma [19]. The taste indicator of parijoto jam with coconut sugar was well received by the majority of panelists because the characteristic taste of parijoto acid was still evident, without astringency, and the addition of coconut sugar added a natural taste and balance to parijoto jam. Assessment of texture indicators is related to perceptions of quality and satisfaction upon consumption. According to previous research, jam indicators are essential factors in sensory tests because they provide information about the consistency, elasticity, and spreadability of jam, which can determine the level of preference of the jam [14]. The organoleptic test is shown in Table 2. The product of parijoto jam shown in Fig. 1.

Table 2. Organoleptic Test Results

Parameter	Formulation		P-value
	Cassava sugar	*Coconut sugar*	
Color	3.48±0,92	3.2±0.93	0.242
Aroma	3.4± 0.81	3.23±0.77	0.350
Flavor	3.6± 0.85	3.4± 0.9	0.457
Texture	3.63± 0.77	3.57±0.61	0.618



(a) (b)

Fig. 1. (a) Formulation of parijoto jam with cassava sugar, (b) Parijoto jam with coconut sugar

The organoleptic test in Table 2 showed no significant differences in color, aroma, taste, or texture between cassava sugar and coconut sugar, as the p-values were > 0.05. The absence of substantial differences between formulations may be due to the halo effect, which causes panelists' assessments to focus more on the distinctive taste and aroma of Parijoto fruit than on the different types of sweeteners. The use of different sweeteners with intense fruit flavor and attractive color derived from Parijoto anthocyanin made the panelists' perceptions of the two formulations almost identical. The average panelist score in the assessment was around 3.2-3.6 and was in the somewhat liked category. The nutritional content of parijoto fruit jam is shown in Table 3.

Table 3. The Nutritional Content of Parijoto Fruit Jam

Parameter	Parijoto fruit jam with cassava sugar	Parijoto fruit jam with coconut sugar
Water content (%)	72.82815	75.31301
Ash content (%)	0.0496	0.03245
How much protein (%)	0.71875	0.76945
Fat content (%)	2.39375	2.13
Carbohydrate content (%)	23.69715	21.24025
Energy (kcal/100g)	115.9668	104.3373
Total dietary fiber (%)	0.53145	0.93205

Proximate analysis is a food and nutrition science used to determine the elemental chemical composition of food [11]. From Table 3, the results of the water content test show that the formulation of Parijoto far exceeds the National Standard (SNI) 3746-2008 for the production of fruit jam, which states that the maximum water content is 35% and the minimum carbohydrate content is 55% [20]. The water content in jam influences the formation of a gel that affects sensory properties and indicators that determine shelf life [1]. The higher the water content, the shorter the food's shelf life, because it makes it easier for microbes to grow. The raw materials and the amount of sugar added influence the water content in jam. The more sugar added, the lower the water content. The high water content can be caused by the water content of parijoto fruit, which is 13.7%, so that when making parijoto fruit pulp, 99.9% water is added. This high water content is thought to be due to the high proportion of added water (1000 mL) and to the naturally high water content of parijoto fruit. This condition indicates that the cooking and evaporation processes were not optimal. Previous research indicates that high water content can affect the stability, shelf life, and consistency of jam products. Therefore, it's necessary to modify the cooking process or add more thickener to lower the water content to meet standards [21].

The ash content in jam with cassava sugar is 0.0496%, and with coconut sugar, 0.03245%. Ash content describes the amount of minerals in the product, and these results show that the mineral content in Parijoto jam is relatively low [20]. Furthermore, the protein content in jam with cassava sugar is 0.72%, whereas it is higher with coconut sugar at 0.77%. Although the amount is small, the presence of protein still plays a role in taste and contributes a little to nutrition, but in general, jam is not a source of protein [22]. This difference was not statistically significant ($p>0.05$). The protein content comes from the parijoto fruit, while the fat is likely related to the lipophilic phenolic fraction. This is consistent with the findings of [23] which states that bioactive compounds in fruit can bind to lipids, thereby increasing the measured fat content.

The fat content of Parijoto jam is relatively low, 2.39% in cassava sugar jam and 2.13% in coconut sugar jam. This low-fat content is consistent with the characteristics of processed fruit products, so that Parijoto jam can be categorized as a low-fat food. Fat itself acts as a flavor carrier and affects the product's texture [22]. Meanwhile, the carbohydrate content in parijoto jam with cassava sugar is 23.70%, whereas it is 21.24% with coconut sugar. This value is far below the SNI standard, which requires a minimum carbohydrate content 55%. The low carbohydrate content is closely related to the high water content, which dilutes the carbohydrate concentration [24]. This also affects the low-energy value: jam with cassava sugar yields only 115.97 kcal/100 g, and jam with coconut sugar yields only 104.34 kcal/100 g.

Jam with cassava sugar had a higher energy content (115.97 kcal/100 g) than coconut sugar (21.24%; 104.34 kcal/100 g) because cassava sugar is richer in simple glucose, providing greater energy value. Previous research stated that the simple carbohydrate glucose hydrolyzes more quickly than sucrose, increasing energy availability. Nutritionally, this is important to consider, as jam made with cassava sugar tends to have a higher glycemic index [25].

The dietary fiber content of parijoto jam with coconut sugar is 0.93%, compared to 0.53% in jam with cassava sugar. Dietary fiber plays a vital role in digestive health, helps lower cholesterol levels, and prevents degenerative diseases [19]. Total sugar levels show a significant difference of 21.76% in jam with cassava sugar and only 10.82% in jam with coconut sugar. The higher sugar content makes jam with cassava sugar sweeter and thicker, because sugar functions to reduce water content through its hygroscopic properties, thus slowing microbial growth [22]. The characteristics of coconut sugar,

which is known to contain more insoluble dietary fiber. According to previous research, the fiber in coconut sugar helps reduce glycemic response and enhance its health benefits. Therefore, coconut sugar-based Parijoto jam has the potential to be healthier for consumers who require a high-fiber diet [26].

Table 4. Physicochemical Properties Parijoto Jam

Parameter	Parijoto fruit jam with cassava sugar	Parijoto fruit jam with coconut sugar
Viscosity (MPas)	26746 MPas	25923
pH	3.815	3.855

The viscosity of jam with cassava sugar is higher than that of coconut sugar jam because the increase in viscosity is influenced by the interaction of reducing sugars with pectin, which forms a denser gel network. This is supported by previous research showing that sugar content plays an essential role in regulating pectin cross-linking, thereby determining jam viscosity. High viscosity indicates good consistency in jam products [27]. Cassava sugar jam has a thicker texture, in accordance with the nature of sugar, which forms a gel structure. Consumers generally prefer a thicker texture in jam products because it spreads more easily and resembles commercial jam [18]. Glucose molecules have hydroxyl groups (-OH) that can form hydrogen bonds with water molecules and with hydroxyl or carboxyl groups in pectin and other polysaccharides. Glucose is a monosaccharide with a smaller molecular size, interacting more easily and more actively than sucrose. Cassava sugar is a disaccharide composed of glucose and fructose. According to previous research, sugar can significantly affect the dynamics of hydrated water by forming hydrogen bonds that are more stable than bonds with water molecules, so that the glucose contained in cassava sugar will bind as free water and limit the mobility of the water itself, which results in a denser jam structure [28]. According to previous research, the starch system shows that peak viscosity follows the order glucose > sucrose [32].

Table 5. Total Sugar Content Test and The Effect of Sugar Type on The Characteristic Parijoto Jam

Parameter	Parijoto fruit jam with cassava sugar	Parijoto fruit jam with coconut sugar
Total sugar (%)	21.7558	10.8193
Sweetness	Sweeter	Less sweet
Form and solubility	Liquid dissolves easily	Solid, brown granules
Impact on color	Brighter	Brownish appearance

Parijoto fruit jam with cassava sugar tastes sweeter. It is preferred by panelists over jam with coconut sugar because the cassava sugar used in the study is in liquid form and 2.5 times as sweet as cane sugar. Liquid cassava sugar has a sweeter taste and dissolves easily, making it more economical to use and a potential preservative for parijoto fruit jam [22]. Cassava sugar is the result of the hydrolysis of starch, which is rich in free glucose, a monosaccharide with a high soluble sugar content and a pronounced sweetness. Glucose is more easily detected in the phenol–sulfuric acid test because it reacts rapidly with the sulfuric acid reagent to form furfural, which produces a more intense color. Therefore, on the same weight basis, cassava syrup produces a higher total sugar content than coconut sugar, which contains many non-sugar components (minerals, organic acids, and melanoidin compounds from the Maillard reaction) [29]. The high sugar content in jam made with cassava sugar increases sweetness but also affects viscosity and Brix. Sugar strengthens the pectin gel network, making the product thicker [30].

Parijoto fruit jam with coconut sugar had a sugar content of 10.8913%, as coconut sugar contains more vitamins and minerals. Coconut sugar has a glycemic index of 35%, which is lower than granulated sugar [20]. Coconut sugar generally contains 70–79% sucrose, 3–9% glucose, 3–9% fructose, and other non-carbohydrate compounds such as protein and phenolics. Meanwhile, cassava syrup contains >90% reducing sugars (glucose and maltose) [31]. The use of sugar types also affects the color of the jam. The use of coconut sugar provides a natural brown color because the process of making coconut sugar goes through a heating process and contains reducing sugars, amino acids, or

proteins that support the formation of melanoidin brown color through the Maillard reaction [32]. The use of cassava sugar, which is lighter in color, allows the anthocyanin pigment from parijoto fruit to become more dominant, especially in low pH conditions (3.8), which can increase the stability of anthocyanins and prevent color changes to undesirable forms [33]. The distinctive taste of sugar makes it appear darker than cassava sugar, which has a pink color from the parijoto fruit [34]. Research on jam made with coconut sugar showed relatively high anthocyanin loss compared to several other sweeteners. In terms of aroma, coconut sugar imparts a distinctive caramel note, while cassava sugar produces a more neutral aroma [35].

4. Conclusion

This research has successfully developed an acceptable Parijoto fruit spread product using natural sweeteners. However, the current formulation does not meet the SNI 3746:2008 standard due to its high water content and low soluble solids, mainly because of the initial formulation and cooking process. Cassava sugar produces a spread with higher viscosity and sweetness, while coconut sugar provides a distinctive aroma and color. Future research needs to optimize the recipe to achieve a minimum of 65° Brix by reducing the initial water content and extending the cooking time. Furthermore, the stability, shelf life, and glycemic index of the optimized product need to be evaluated.

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