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Macronutrient and Sensory Analysis of Block, Crystal, and Liquid Coconut Sugar

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ABSTRACT

This study aimed to determine the nutritional content of the block, crystal, and liquid coconut sugar, along with the preferred coconut sugar type, through sensory analysis. The design of this research was descriptive analysis. The nutrient content analysis method was carried out proximately, while sensory analysis used a hedonic test and a hedonic quality test. The results showed that crystal coconut sugar had the highest energy, fat, protein, and carbohydrate content of 377 kcal/100g, 0.56%, 1.29%, and 91.7%, respectively. Block coconut sugar presented energy of 363.14 kcal/100g, 0.46% fat, 1.2% protein, and 88.55% carbohydrates. Meanwhile, liquid coconut sugar showed 293.7 kcal/100g of energy, 0.22% fat, 1.24% protein, and 71.69% carbohydrates. The results of the sensory analysis showed no significant differences between each form of coconut sugar in aroma (p=0.66) and texture (p=0.08) elements from the hedonic test. Additionally, there were significant differences in the color and taste attributes (p=0.00). Contrastingly, the hedonic quality test showed significant differences in all attributes of all forms of coconut sugar. Besides, crystal coconut sugar was preferred over the block and liquid coconut sugar. It has a slightly typical brown sugar aroma, insignificant fine to fine texture, dark brown to light brown color, and slightly sweet to sweet taste. Therefore, crystal coconut sugar is the most preferred form with the highest nutritional content.

I. Introduction

The coconut is known as the tree of life because almost all its parts can be utilized, from its roots, stems, fruits, and leaves (Alam, 2020). Coconut parts can be used as food or household products. Coconut sugar is one of the coconut derivative products which has been used for a long time in South and Southeast Asia as a natural sweetener due to its abundant supply (Arcieri, 2014). Indonesia and the Philippines are the world's largest producers of coconut sugar (Broberg, 2014). In Indonesia, coconut sugar is widely used as a food ingredient for traditional foods, such as *ice cendol*, *lupis cake*, *klepon*, *putu cake*, *cenil*, *combro*, and *gemblong*.

Coconut sugar is made from the sap of cut flower buds of the coconut palm in three forms block, crystal, and liquid. The manufacturing process consists of two stages. The first stage is harvesting or tapping the coconut tree blossoms. In this stage, the farmer makes an incision on the flower stalk, allowing the sap to flow out of the incision. The sap is collected and put into a bamboo pole or traditionally called "*bumbung*". The second stage is the evaporation process from the collected sap. The sap is cooked over medium heat to remove the moisture content, resulting in thicker sap, like syrup (liquid coconut sugar). Further heating will form crystals or block coconut sugar. The coconut sugar form highly depends on its moisture content (Broberg, 2014).

Coconut sugar is often used as an alternative sweetener in food or beverages (Asghar et al., 2020) due to changes in a healthier lifestyle and understanding of the detrimental effects of high sugar consumption. However, information regarding the nutritional content of coconut sugar is still minimal. Therefore, we examined the macronutrient of coconut sugar in the block, crystal, and liquid forms.

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Sensory analysis was also conducted to determine the preferred type of coconut sugar (Maryani et al., 2021).

II. Method

In this study, we used local Indonesian coconut sugar products from sap farmers in Central Java, Indonesia. Coconut sap was processed into coconut sugar in three forms of the block, crystal, and liquid coconut sugar. Nutritional content analysis of the coconut sugar was carried out proximately. Analysis of moisture content was conducted using the oven method, ash content using the dry ashing method, fat content using the Weibull hydrolysis method, and protein content using the Kjeldahl method. Energy content was calculated by the sum of fat content multiplied by 9 kcal, while the protein and carbohydrate content were multiplied by 4 kcal. Carbohydrate content was analyzed using the carbohydrate by different method (Association of Official Agricultural Chemists & Horwitz, 1975; Badan Standarisasi Nasional, 1992a).

Sensory analysis was performed using the hedonic and hedonic quality tests, involving 30 semi-trained panelists. The hedonic test included aroma, texture, color, and taste attributes on a scale of 1 to 5 (extremely dislike, dislike, normal, like, extremely like). The hedonic quality test also encompassed the attributes of aroma, texture, color, and taste on a scale of 1 to 5. For the aroma attribute, the scores 1 to 5 represented very not typical of brown sugar, not typical of brown sugar, slightly typical of brown sugar, typical of brown sugar, and very typical of brown sugar, respectively. In the color attribute, score 1 represented blackish brown, 2 showed dark brown, 3 indicated light brown, 4 showed brownish yellow, and 5 represented yellow color. In the taste attribute, the score 1 to 5 showed sweet slightly sour, sweet slightly bitter, slightly sweet, sweet, and very sweet tastes, respectively. Meanwhile, for the texture attribute of the coconut sugar, every coconut sugar form had a different range. For the block coconut sugar, the range 1 to 5 represented very soft, soft, slightly hard, hard, and very hard, respectively. Meanwhile, the 1 to 5 range in crystal coconut sugar showed very coarse, coarse, slightly fine, and very fine texture, respectively.

This research used descriptive analysis. Analysis results of the nutritional content were compared with the quality requirements of palm sugar numbers (Badan Standarisasi Nasional, 1992b, 1995). Sensory test data were analyzed using the Kruskal-Wally's test, followed by the Mann-Whitney test. Hedonic and hedonic quality tests were given values for the attributes of aroma, texture, color, and taste. Each attribute had a minimum value of 5 and a maximum of 20, with the 50:50 ratio of hedonic test scores to hedonic quality.

III. Results and Discussion

A. Nutrient Content of Coconut Sugar

Moisture content analysis is fundamental in determining the quality of food ingredients, preservation, and stability. It is also required to calculate the nutritional value accurately (Nielsen, 1998). The moisture content of coconut sugar represents the percentage of water in the sugar. As presented in Table 1, the results showed that crystal coconut sugar had the lowest moisture content compared to other coconut sugar. This finding is related to the longer cooking process of crystal coconut sugar. The longer heated period produces less moisture content in the coconut sap and forms sugar crystallization. The moisture content of block coconut sugar of 7.56% has met the 10% moisture content required in (Badan Standarisasi Nasional, 1995)palm sugar. Meanwhile, the moisture content of crystal and liquid coconut sugar was slightly higher than the quality requirements for palm sugar SNI 01-3743-1995 and SNI 01-2978-1992 (≤3.0% & 20%). This was presumably due to the storage of coconut sugar before our analysis processes. The long storage time of coconut sugar can affect the texture and increase the moisture content due to its hygroscopic character (Dwiyanti et al., 2014).

The ash content of coconut sugar was slightly higher than the ash content requirements for palm sugar (Badan Standarisasi Nasional, 1995) of 2.0%. Block coconut sugar has an ash content like the one discovered in (Muchaymien et al., 2014) study (2.22%). Meanwhile, the ash content of crystal coconut sugar in this study was 1.5%, slightly higher than that of (Maryani et al., 2021).

In addition, the highest fat content of 0.56% was observed in crystal coconut sugar, while the lowest fat content (0.22%) was found in liquid coconut sugar. A study from Asghar et al. (2020)

showed that fresh coconut sap has 0.01% crude fat. The protein content of the block, crystal, and liquid coconut sugar was similar (1.2%), as presented in Table 1. Fresh coconut sap was known to have a protein content of 0.26% (Asghar et al., 2020). Additionally, the protein content in coconut sugar is relatively small because the main component of sugar is carbohydrates.

Table 1. Nutrient Content of Block, Crystal, and Liquid Coconut Sugar

Parameter	Unit	Block	Crystal	Liquid
Moisture	(%)	7.56	3.78	24.61
Ash	(%)	2.23	2.67	2.24
Fat	(%)	0.46	0.56	0.22
Protein	(%)	1.2	1.29	1.24
Carbohydrate	(%)	88.55	91.7	71.69
Energy	(kcal/100g)	363.14	377	293.7

Carbohydrates dominate the coconut sugar content compared to other nutrients, as the main component of coconut sugar is carbohydrates. Crystal coconut sugar has the highest carbohydrate content of 91.7%, while the lowest was liquid coconut sugar with 71.69% carbohydrate. These results are also in line with the energy content of coconut sugar, where crystal coconut sugar presented the highest energy content of 377 kcal/100g. Energy content in sugar is influenced by the amount of fat, protein, and carbohydrates. One gram of fat can produce 9 kcal, while one gram of carbohydrates and protein only produce 4 kcal (Insel et al., 2022).

B. Sensory Analysis of Coconut Sugar

The sensory analysis consisted of a hedonic test and a hedonic quality test. The hedonic quality test was carried out to determine the panelists' impression of the product characteristics, specifically. Meanwhile, the hedonic test was used to measure the preference level or satisfaction degree of sensory food characteristics (Choi, 2014).

Aroma is an odor that the olfactory system detects when volatile compounds from food are smelled into the respiratory tract (Meilgaard et al., 1999). Table 2 shows that coconut sugar preference's average aroma is between normal and like. The results of the Kruskal Wallis test showed no significant difference in the aroma of each form of coconut sugar (p=0.66). Besides, Table 3 presents that block and crystal coconut sugar has a slightly typical brown sugar to typical brown sugar aroma. Simultaneously, the liquid coconut sugar aroma was not typical of brown sugar to slightly typical of brown sugar. Also, there was a significant difference between each coconut sugar aroma, according to the hedonic quality test result (p=0.000). Mann Whitney's test results indicated that the aroma of block and crystal (p=0.016), crystal and liquid (p=0.000), as well as block and liquid (p=0.040) coconut sugar were significantly different. Meanwhile, those coconut sugar presented a typical aroma of coconut sugar, in accordance with (Badan Standarisasi Nasional, 1995).

Table 2. Average Score of Hedonic Test

Coconut Sugar Form	Attribute			
	Aroma	Texture	Color	Taste
Block	3.60[a]	3.67[a]	3.27[a]	3.53[a]
Crystal	3.47[a]	3.83[a]	3.9[b]	3.33[a]
Liquid	3.17[ab]	3.33[ab]	2.93[a]	2.57[b]

[a.]Note: Significant value, $p < 0.05$. Values followed by the same letter in each column indicate they were not significantly different.

Table 3. Average Score of Hedonic Quality Test

Coconut Sugar Form	Attribute			
	Aroma	Texture	Color	Taste
Block	3.93[a]	4.03[a]	1.37[a]	3.5[a]
Crystal	3.33[b]	3.70[a]	2.87[b]	3.43[a]
Liquid	2.73[c]	3.33[ab]	1.87[c]	2.5[b]

[b.]Note: Significant value, $p < 0.05$. Values followed by the same letter in each column indicate they were not significantly different.

The texture is an attribute related to the function of touch. Three elements that affect texture are mechanical (hardness & elasticity), geometric (sandy & crumbly), and moisture content (oily & moist) (Meilgaard et al., 1999). The average texture attributes of each form of coconut sugar were normal to like, as shown in Table 2. The results of the Kruskal Wallis test showed no significant difference between the texture attributes of each coconut sugar (p=0.080). Table 3 also shows that the average texture of liquid coconut sugar is watery to slightly thick. The texture of block coconut sugar was slightly hard to hard, while the texture of crystal coconut sugar was slightly fine to fine. The results of the Kruskal Wallis test also showed a significant difference between each form of coconut sugar (p=0.009). Additionally, the Mann Whitney's test showed significantly different results between the block and liquid coconut sugar (p=0.000), while block and crystal coconut sugar (p=0.123) and crystal and liquid were not significantly different (p=0.151). Coconut sugar texture was in accordance with SNI 01-3743-1995, which was normal (a bit hard for block coconut sugar and a bit fine for crystal coconut sugar).

The hedonic test results presented in Table 2 showed that the color attribute of liquid coconut sugar was classified as normal to dissatisfying, while block and crystal coconut sugar were classified as normal to likable. Results of the Kruskal Wallis test on the hedonic test's color characteristic revealed a significant difference between each kind of coconut sugar (p=0.000). The data were further analyzed using the Mann-Whitney test, in which the results suggested that block and crystal coconut sugar (p=0.001) and crystal and liquid coconut sugar had a significant difference (p=0.000). Meanwhile, molded, and liquid coconut sugar were not significantly different (p=0.077). The color of liquid and block coconut sugar were classified as blackish brown to dark brown. Meanwhile, the color of crystal coconut sugar was dark brown to light brown. The results of the Kruskal Wallis test, along with the further tests, on the hedonic quality, showed a significant difference between each form of coconut sugar (p=0.000). The coconut sugar color was in accordance with the quality standard of coconut sugar, which was brownish yellow to brown (Badan Standarisasi Nasional, 1995). Assessment of color attributes was strongly influenced by lighting and panelists' point of view (Meilgaard et al., 1999). Each table utilized for the analysis was fitted with a lamp that serves as a light source, preventing evaluation errors.

Table 2 presents that the taste of block and crystal coconut sugar is normal to likable, while the taste of liquid coconut sugar is normal to dissatisfying. Kruskal Wallis test showed a significant difference between the taste of each form of coconut sugar (p=0.001), whereas the results of further tests showed a substantial difference in the block and liquid coconut sugar (p=0.001), as well as crystal and liquid (p=0.004). Meanwhile, the test results of block and crystal coconut sugar were not significantly different (p=0.327). The average score for taste presented in Table 3 indicated that block and crystal coconut sugar was slightly sweet to sweet. Meanwhile, liquid coconut sugar was sweet slightly bitter to slightly sweet. Several panelists stated that the liquid coconut sugar had a slightly sour taste. This is presumably due to the fermentation process during sugar storage. Kruskal Wallis test results showed a significant difference between each form of coconut sugar (p=0.016). Also, significant differences were found in the block and liquid sugar (p=0.013), as well as crystal and liquid sugar (p = 0.014), while block and crystal sugar were not significantly different (p=0.725).

Table 4 shows that crystal coconut sugar has the highest score on both the hedonic and the hedonic quality tests. Furthermore, the assessment of variable attributes was also in accordance with the quality requirements for palm sugar SNI 01-3743-1995. Therefore, crystal coconut sugar is the most preferred coconut sugar form by the panelists.

Table 4. Respondents' Preference for Coconut Sugar

Variable	Coconut Sugar Form		
	Block	Crystal	Liquid
Hedonic Test			
Aroma	3.6	3.47	3.17
Texture	3.67	3.83	3.33
Color	3.27	3.9	2.93
Taste	3.53	3.33	2.57
Total Score 1	14.07	14.53	12
Hedonic Quality Test			
Aroma	3.93	3.33	2.73

Variable	Coconut Sugar Form		
	Block	Crystal	Liquid
Texture	4.03	3.7	3.33
Color	1.37	2.87	1.87
Taste	3.5	3.43	2.5
Total Score 2	12.83	13.33	10.43
Score Proportion 1 (50%)	7.03	7.26	6
Score Proportion 2 (50%)	6.42	6.67	5.22
Total Score 1+2	13.45	13.93	11.22

IV. Conclusion

The form of coconut sugar affects its nutritional content. In this study, crystal coconut sugar presented higher levels of energy, protein, fat, and carbohydrates than the block and liquid coconut sugar. The nutritional content of crystal coconut sugar has also met the palm sugar quality requirements of SNI 01-3743-1995, with 388 kcal/100g energy, 1.29% WW protein, 0.56% wt fat, and 91.7% w carbohydrates. Sensory analysis based on the hedonic and hedonic quality also showed that crystal coconut sugar is the most preferred sugar by the panellists, with an acceptance score of 13.93. Besides, hedonic quality test results also suggested that this form of sugar has met the quality requirements of palm sugar SNI 01-3743-1995.

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