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QUALITY CHARACTERISTIC ANALYSIS OF BADUY PALM SUGAR

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ABSTRACT

The palm sugar center of Banten Province, Indonesia, is in Lebak Regency with a production contribution of approximately 70%. Baduy's palm sugar has the potential to be the best palm sugar in Banten. The quality of palm sugar is based on chemical and organoleptic properties such as water insoluble material, water content, ash content, reducing sugar and saccharose sugar as well as sensory tests. The distribution of variance and deviation of its standard was analyzed by statistical means, such as, histogram, control chart and Pareto chart. The results of this study are expected to increase the confidence of the domestic and foreign people to consume it so that it becomes one of the food tourism destinations in Banten. This study aims to determine: the characteristics of product quality, the diversity and the deviation of chemical characteristic compared to Indonesian National Standard (abbreviated SNI) Palm Sugar.

The average value of Baduy's palm sugar chemical characteristic, namely water content, ash content, water insoluble content, reducing sugar content and saccharose sugar content, respectively were 8.3749 %bb, 1.6773%bb, 0.5946%bb, 0,5625 %bb and 85.78%bb. The percentage of discrepancy from the chemical characteristics analysis of Baduy palm sugar with SNI, namely the sugar content as saccharose reached 63%, ash content reached 15% and water content reached 12%. While the results of reducing sugar content and water insoluble content analysis were in accordance with SNI. Based on the Pareto diagram, the results of the chemical characteristic analysis of Baduy palm sugar that most do not comply with SNI were the sugar content as saccharose. The average saccharose sugar content reached 85.78% bb, did not meet the SNI at 77% bb. In the sensory analysis, Baduy palm sugar had characteristics that were close to ideal compared to other commercial palm sugar.

1.Introduction

Sugar commodity in Indonesia is second commodity under rice commodity in terms of demand (Kurniasari et al. 2015). There are various types of sugar in Indonesia based on the ingredients, namely cane sugar, palm sugar and coconut sugar. The need for sugar in Indonesia will continue to increase along with the population and income increase. The International Sugar Organization states that Indonesia's sugar consumption will grow 4% per year to meet the needs of the national population of 240 million people. The limited knowledge and low level of education of sugar craftsmen have caused less attention to process sanitation from tapping to product packaging. This results the unbalance demand for sugar based on the total sugar offered by domestic production

Palm sugar is one of sugar types in Indonesia which is made from palm sap by boiling the

sweet sap which is harvested from the male flower stalks of Arenga pinnata. Palm sugar has a peculiarity compared to other sugar's types, such as it is more soluble, the condition is dry and clean and has a distinctive aroma. Based on the chemical composition, palm sugar contains higher sucrose of 84.81% than coconut sugar 71.89% and palm sugar 76.86%, so palm sugar is able to provide higher energy. Based on the nutritional content, palm sugar contains higher protein and phosphorus and lower fat than coconut sugar and palm sugar. This shows that palm sugar is better for consumption and more beneficial for body health compared to other sugar's types.

Banten is one of the palm sugar production centers in Indonesia which has palm plants with a large area of 3,040 ha. Sugar palm production in Banten experienced an increasing trend from 2016 - 2018 with an average of 2,691 tons/year (BPS, 2019). The palm sugar center in Banten Province is in Lebak Regency. Palm sugar production in Lebak has experienced unstable growth over the past 3 years, namely 3,527 tons (2016), 2,945 tons (2017) and 3,827 tons (2018). This is due to the presence of plants that have decreased productivity, unproductive plants and seasonal changes.

Lebak Regency contributes 70% palm sugar in Banten. Baduy (Lebak Regency's original tribe) has the potential to produce the best palm sugar in Banten. The advantages of Baduy palm sugar come from organic plants that grow in the hills or mountains so that they are not exposed to chemical fertilizers that can harm health. Baduy consists of two groups, namely the inner Baduy and the outer Baduy. This sugar production is only allowed for the outer Baduy people in Lebak, South Banten. In accordance with applicable customary rules, the Inner Baduy people is only allowed to drink the basic ingredients before turning it into sugar, namely palm wine.

Quality grading for sugar craftsmen is generally only based on sensory properties, namely color and texture. According to BSN (2021), the quality of palm sugar is based on chemical and organoleptic properties such as water insoluble material, water content, ash content, reducing sugar and saccharose sugar as well as sensory tests. One of the problems currently faced by Baduy palm sugar craftsmen is the high diversity and deviation of the chemical characteristic of the the palm sugar produced. This causes the low competitiveness of palm sugar products in the market. The distribution of diversity and deviation of Baduy palm sugar can be analyzed by statistical quality control techniques. Statistical quality control techniques that can be used are the histogram method, control chart and Pareto diagram (Haryanti and Mustaufik, 2020).

Although Baduy palm sugar has been widely sold freely, however, no research has been conducted to determine the quality of this product. This characteristic test is needed to determine the suitability of Baduy palm sugar with Indonesian national standards and can provide recommendations in improving the quality of Baduy palm sugar based on SNI of Palm Sugar.

2. Materials and methods

This research was carried out in three stages of primary data, namely: the first stage is analysis of sample quality characteristics including water insoluble material, water content, ash content, reducing sugar, and saccharose sugar as well as sensory testing; the second stage is data analysis of variance and deviation of the chemical characteristic. Secondary data collection was also carried out to support primary data by conducting field observations and interviews with Baduy palm sugar craftsmen.

Sampling was done by purposive random sampling method with a directed system, which was selected about 20% of the 25 palm sugar craftsmen randomly scattered in Kanekes Village. Each sample of palm sugar from 5 different places was taken as much as 1 kg. Sampling was carried out twice at each place in the same time.

2.1. Analysis of Quality Characteristics

2.1.1. Water Content Analysis (BSN[a], 1992)

The sample was weighed 2 g in a closed weighing glass which weight is known. The samples were dried in an oven at 105oC for 3 hours. The sample was cooled and weighed to a constant weight.

2.1.2. Ash Content Analysis (BSN[a], 1992)

The sample was weighed 3 g into a porcelain dish which the weight is known. Samples were ashed in a kiln at a maximum temperature of 550oC until complete ashing. The sample was cooled and weighed to a constant weight.

2.1.3.Analysis of Insoluble Parts in Water (BSN, 2021)

The sample was weighed 20 g, put into a glass, added 200 ml of hot water, stirred until dissolved. In hot conditions, the water-insoluble part was poured into filter paper which had been dried and weighed. The filter paper was dried in an oven at 105^{o}C for 2 hours, the sample was weighed to a constant weight.

2.1.4. Reducing Sugar Analysis

The main principle is that the sugar will reduce ions Cu^{2+} to ions Cu^{+} when heated (Wirajana et al. 2016). A total of 0.5 mL of the enzyme was mixed with 0.05 g of palm sugar sample. 2 mL buffer fosfat pH 6 0,1 M was added to the solution. The solution mixture was incubated at 70°C for 15 minutes. 0.5 mL of 10 mg/mL main glucose solution and 2.0 mL of DNS reagent were added to the solution. Incubate at 90 °C for 15 minutes. The mixed solution was added with 1.0 mL of 40% potassium sodium tartrate and allowed to stand for 20 minutes. The solution mixture was centrifuged at 5000 rpm for 1 minute. The absorbance of the supernatant was measured at a wavelength of 540 nm. The calculation of reducing sugar content formed at an incubation time of 15 minutes was performed using a UV-Vis spectrophotometer.

2.1.5. Analysis of Sugar as Saccharose (BSN[b], 1992)

50 ml of the reducing sugar filter was pipetted into a 100 ml volumetric flask. 25 ml of 25% HCl was added, a thermometer was installed and hydrolysis was carried out on a water bath. When the temperature reaches 68-70 ^{o}C, the temperature is maintained for 10 minutes. 30% NaOH was added until neutral (pink color) with phenolphthalein indicator. 10 ml of the solution was pipetted and put into a 500 ml Erlenmeyer. 15 ml of distilled water, 25 ml of Luff's solution and a few grains of boiling stone are added to the solution. The solution was heated for 10 minutes then removed and cooled in a bath filled with ice. 10 ml of 20% KI solution and 25 ml of 25% H_2SO_4 solution were added to the solution. Titar with 0.1 N tio solution with 0.5% starch solution as an indicator. The blank determination solution was carried out with 25 ml of water and 25 ml of Luff's solution.

Table 1. List of Sensory Attributes

Appearance	Odor	Texture	Taste
light brown color	palm odor	sticky texture	honey taste
dark brown color	acid odor	light texture	palm sap taste
cloudy appearance	sweet odor	thick mouthfeel	
clear appearance	bitter odor	lumpy mouthfeel	
foamy sugar	metalic odor	liquid texture	
clean sugar	honey odor	sandy texture	
	caramel odor		
	palm sap odor		

2.2.6. Sensory Analysis

Sensory analysis was carried out to compare the sample with commercial palm sugar and also get the ideal product and its characteristics. Sensory testing used the Check-All-That-Apply (CATA) method with 50 untrained panelists who are palm sugar consumers (Giacalone, 2013). Twenty-two sensory attributes tested can be seen in Table 1. The data obtained in the sensory were then analyzed using the XL STAT 2020.5.1 software (Addinsoft, New York, USA, 2021). Additionally, Principal Component Analysis (PCA) was conducted to describe the relationship between products and attributes.

2.2.Data Analysis of Diversity and Deviation of Chemical Characteristic

Data analysis used statistical quality control techniques. Analysis of the chemical characteristics (water content, ash content, insoluble parts in water, reducing sugar and sugar as saccharose) of Baduy palm sugar were carried out using histogram and control chart methods. Analysis of characteristic deviation used Pareto diagram.

3. Results and discussions

3.1. Analysis of Quality Characteristics

3.1.1. Water Content Analysis

Based on the analysis result of water content of the Baduy palm sugar samples, the average result was 8.3749 %b/b. This value is still within the specification limit of SNI Palm Sugar, which the maximum set 10% b/b. The data total that meets the specifications which can be seen in Table 2.

Table 2. Result of Water Content of Baduy Palm Sugar

Sample Number	SNI Standard (%b/b)	Result (%b/b) Test 1	Test 2	Average	Standard Deviation	Description
G1	Maximum 10	10,1273	10,1085	10,1179	0,0094	Abnormal
G2		6,8826	6,8962	6,8894	0,0068	Normal
G3		9,8306	9,8586	9,8446	0,0140	Normal
G4		8,2117	8,1596	8,1857	0,0261	Normal
G5		8,6731	8,6055	8,6393	0,0338	Normal

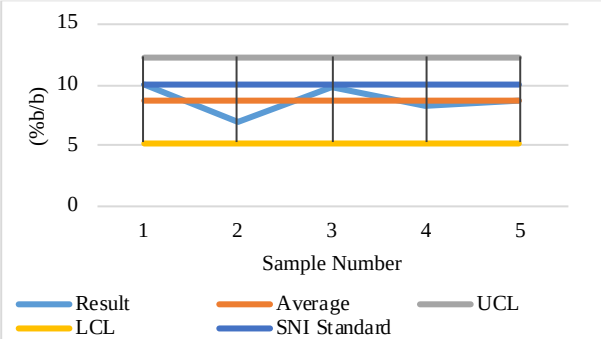

Figure 1. Diversity Water Content

The water content in palm sugar can vary depending on the production process, storage temperature, and conditions when storing the product (Susi, 2013). When compared to sugar from other regions, it tends to be high. The water content of palm sugar in Tasikmalaya is about 5%, while palm sugar in Banyumas is around 6%. Baduy palm sugar is produced at high temperatures, before being packaged, the sugar does not undergo a cooling process for a long time so that steam condensation occurs after the packaging process.

Diversity Data Analysis

Based on the water content analysis, there are two measurement data that are above the SNI Palm Sugar limit, namely G1 and G3 sample. This indicates that it needs the improvement process to improve the quality of Baduy palm sugar, referring to the average water content of 8.3749, because this number still tends to be high compared to palm sugar from other regions.

The standard deviation with the histogram diagram shows a value of 1.3097, where this number indicates the diversity of the data which tends to be high. This can occur due to production method differences or the absence of standards that are used simultaneously the results of the water content obtained tend to vary.

In Figure 1, it can be seen that the scattered data tends to approach the average test results. This means that the distribution of the data tends to be normal. In the control chart, the water content has a Cp value of 1.27 so that the process capability can be good but still needs to be increased.

Improving the quality of this water content can be done by controlling the temperature consistently in the cooking of palm sap. In addition, packaging can also be done after the sugar conditions have dried or cooled. Baduy palm sugar packaging can also be developed using water-resistant materials.

3.1.2. Ash Content

The average ash content of Baduy palm sugar is 1.6773% b/b, still below the specification limit contained in SNI Palm Sugar, which is a maximum of 2% b/b. The percentage of sugar that does not meet the standard is 40% which can be seen in Table 3. The ash content can determine whether the food processing process is good, the higher the ash content, the possibility of process improvement is needed to reduce the amount of inorganic substances in food (Lukito and Guyarto, 2017). The ash content of Baduy palm sugar samples tends to be high when compared to other palm sugar such as Tasikmalaya palm sugar with an ash content of 0.56% and Banyumas palm sugar with an ash content of 0.4% (Susi, 2013)

Table 3. Result of Ash Content of Baduy Palm Sugar

Sample Number	SNI Standard (%b/b)	Result (%b/b) Test 1	Test 2	Average	Standard Deviation	Description
G1	Maximum 2,0	2,0682	2,0625	2,0654	0,0029	Abnormal
G2		1,3196	1,3231	1,3214	0,0017	Normal
G3		1,2394	1,2482	1,2438	0,0044	Normal
G4		1,6333	1,6131	1,6232	0,0101	Normal
G5		2,1375	2,1333	2,1354	0,0021	Abnormal

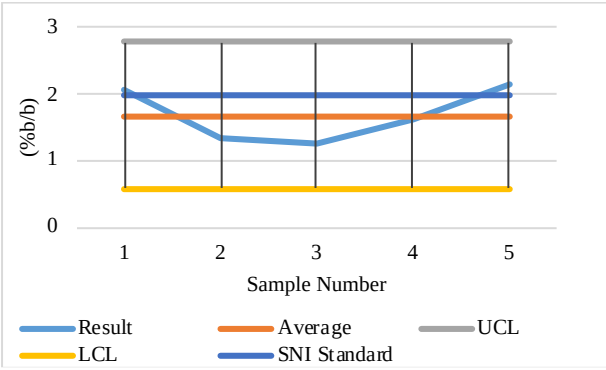

Figure 2. Diversity Ash Content

Diversity Data Analysis

Based on the test results presented in Table 3, there are four test data that pass the SNI specification limit, namely G1 and G5 sample. The standard deviation with the histogram diagram shows a value of 0.4131, where this number indicates the diversity of the data which tends to be low. This high ash content can be caused by production preparation conditions, production conditions, cooking temperatures that are too high (Fadilla, 2021). Temperature control is very necessary to reduce the ash content in Baduy palm sugar. The packaging process is not clean so that there are still organic and non-organic minerals in palm sugar products.

In Figure 2, it can be seen that the scattered data tends to be close to the average. The Cp value of the ash content control chart is 1.24 so this process has high capability, but process control still needs to be done. Ash content is closely related to the mineral content of the product. Poor filtering process can cause high ash content in foodstuffs. The ash content shows how much metal, sand or mineral impurities are in the food. High ash content will be able to affect the taste of a food ingredient.

3.1.3. Water Insoluble Content

The average analysis result is 0.59%, which still below the specification limit for Palm Sugar SNI, where the maximum is 1.0% b/b. The percentage of content that meets the standard is 100% can be seen in Table 4. The palm sugar production process has the possibility of contamination of water insoluble materials into the product. In the extraction process, natural materials can enter the palm sap and pass through the filtering process because the production location is close to the trees. In addition, the processing equipment can be insoluble in water. Although the test results show conformity, the presence of this content can be controlled so that the quality of Baduy palm sugar will increase.

Diversity Data Analysis

All samples are within the limits of the SNI specification with a standard deviation of 0.110 which indicates that the diversity of test results tends to be small. This happens because the materials used have the same characteristics. However, there are still four data that have deviations close to the limit, namely G4 and G5 samples. This parameter can affect other components such as sugar content and product organoleptic characteristics. Improving the quality of Baduy palm sugar can be controlled through a hygienic production process to reduce the potential for contamination of insoluble materials that can enter the product.

In Figure 3, it can be seen that the data is spread close to the average. The Cp value of the water insoluble content is 6 so that the process capability is very good and the quality control is good.

Table 4. Result of Water Insoluble Content of Baduy Palm Sugar

Sample Number	SNI Standard (%b/b)	Result (%b/b)		Average	Standard Deviation	Description
		Test 1	Test 2			
G1	Maximum 1,0	0,5315	0,5309	0,5312	0,0003	Normal
G2		0,4899	0,4894	0,4897	0,0003	Normal
G3		0,5214	0,5238	0,5226	0,0012	Normal
G4		0,7029	0,7068	0,7049	0,0020	Normal
G5		0,7249	0,7244	0,7247	0,0002	Normal

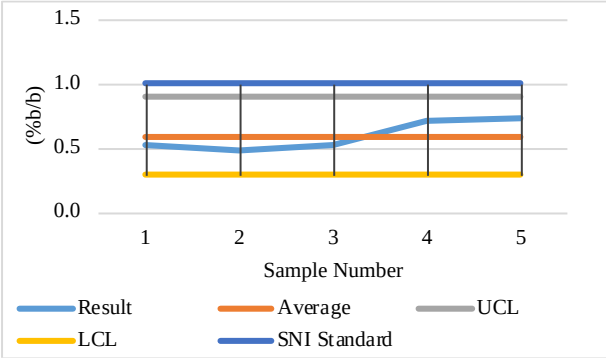

Figure 3. Diversity Water Insoluble Content

3.1.4. Reducing Sugar Content

The content of reducing sugar has a close relationship with the water content. The higher the reducing sugar content, it is easier for food to absorb water from its environment. Table 5 shows that the average reducing sugar is 0.5625%. This figure is still below the SNI limit, which is a maximum of 10% b/b. The percentage of content that meets the standards is 100%. This happens because the average palm sap only contains 0.5-1% reducing sugar.

The tapping process occurs in 3-4 days, it is possible that a fermentation process occurs which causes a decrease in reducing sugar levels. The reducing sugar content in Baduy palm sugar can occur due to changes in the pH of the palm sap or during cooking. A decrease of pH can increase the inversion reaction or change non-invert sugar (saccharose) to invert sugar (reduction). The speed of the inversion reaction is strongly influenced by the cooking temperature, cooking time, and the pH of the solution.

Table 5. Result of Reducing Sugar Content of Baduy Palm Sugar

Sample Number	SNI Standard (%b/b)	Result (%b/b)		Average	Standard Deviation	Description
		Test 1	Test 2			
G1	Maximum 10,0	0,5700	0,5252	0,5476	0,0224	Normal
G2		0,5670	0,5753	0,5712	0,0042	Normal
G3		0,6206	0,6484	0,6345	0,0139	Normal
G4		0,5106	0,5182	0,5144	0,0038	Normal
G5		0,5262	0,5639	0,5451	0,0189	Normal

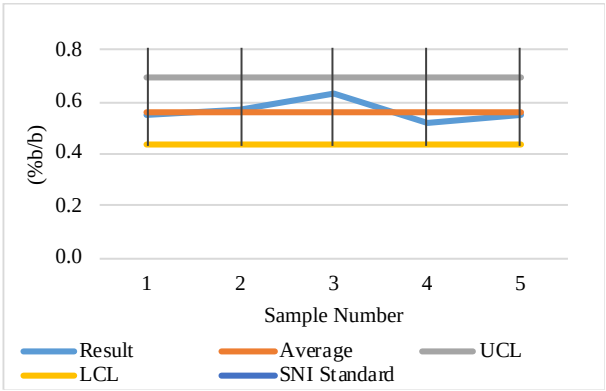

Figure 4. Diversity Reducing Sugar Content

Diversity Data Analysis

All palm sugar samples meet the standards that have been set. Even the test results of reducing sugar are very low compared to the SNI specifications. The reducing sugar parameter does not need special attention in improving the quality of Baduy palm sugar. The standard deviation shows a value of 0.0450 which indicates that the tested data has low diversity. The results of reducing sugar content are strongly influenced by the pH of the sap. The data above has little diversity because the raw material for Baduy palm sugar comes from palm sap which both grow in the Baduy area.

The distribution of data on the control chart in Figure 4 is close to the average value. All samples contain reducing sugars that are not much different and the testing process has been carried out properly. This is in line with the Cp value of 1.5, so that the process capability can be said to be very good and it is in good statistical control quality.

3.1.5. Saccharose Sugar Content

The content of saccharose is closely related to the content of reducing sugars. The lower the saccharose content, the higher the reducing sugar content. Based on Table 6, it can be concluded that all Baduy palm sugar samples do not meet the SNI standard, which the maximum is 77%. The average value of the saccharose sugar analysis was 85.78%. This is in line with the low reducing sugar content, which is below 1%.

Saccharose levels in foodstuffs can affect the texture. The higher the saccharose sugar content, the harder the texture will be. The decrease in the saccharose sugar content can be done by increasing the cooking time (Lay and Heliyanto, 2011). However, this can change the color into darker so that a preservative such as sodium metabisulfite is needed in accordance with SNI limits.

Table 6. Result of Saccharose Sugar Content of Baduy Palm Sugar

Sample Number	SNI Standard (%b/b)	Result (%b/b) Test 1	Test 2	Average	Standard Deviation	Description
G1	Maximum 77	86	86	86,0000	0,0000	Abnormal
G2		85,3	85,3	85,3000	0,0000	Abnormal
G3		84,2	84,2	84,2000	0,0000	Abnormal
G4		86,9	86,9	86,9000	0,0000	Abnormal
G5		86,5	86,5	86,5000	0,0000	Abnormal

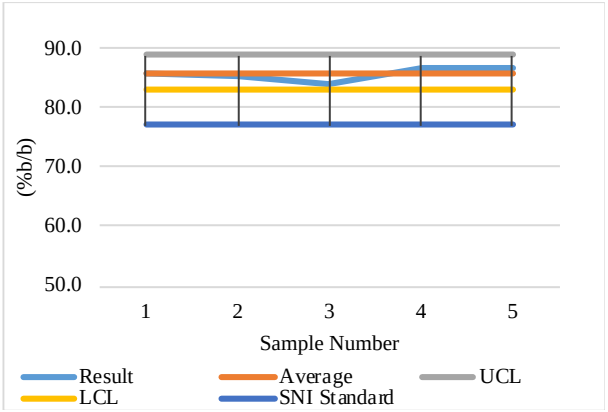

Figure 5. Diversity Saccharose Sugar Content

Diversity Data Analysis

All samples did not meet the specifications or standards set by SNI. The distribution of data does not match the normal distribution and shows varying frequencies. The standard deviation shows a value of 1.0663, this means that the diversity of the data tends to be high. The amount of sugar content as saccharose is influenced by the waiting time for the hardening process, cooking time and reducing sugar content. The amount of sugar content as saccharose is influenced by the waiting time for the hardening process, cooking time and reducing sugar content.

The uniformity of product quality can be controlled by making a Standard Operating Procedure (SOP) for palm sugar production so that the craftsmen have a reference and do not change any time. Saccharose sugar affects the density of sugar. The higher the saccharose sugar content, the denser and tougher the product will be. This causes the standard setting of 77%, so that sugar is easily crushed when it will be processed as an additive.

The Cp value of the control chart in Figure 5 is 5.7, so the process capability is very good. Generally, palm sugar can contain 80-90% total sugar, in other words the total sugar content in Baduy palm sugar can be said to be normal (Christina et al. 2017). However, to increase saccharose sugar, producers must reduce the amount of product impurities.

Table 7. Sensory Analysis Sugar Profile

Sugar Name	Sample Code	Origin of Sugar
Probolinggo palm sugar	256	Probolinggo
Javara palm sugar	741	Bekasi
Cap badak palm sugar	397	Tangerang
Sample G2	163	Outer Baduy
Sample G4	574	Outer Baduy

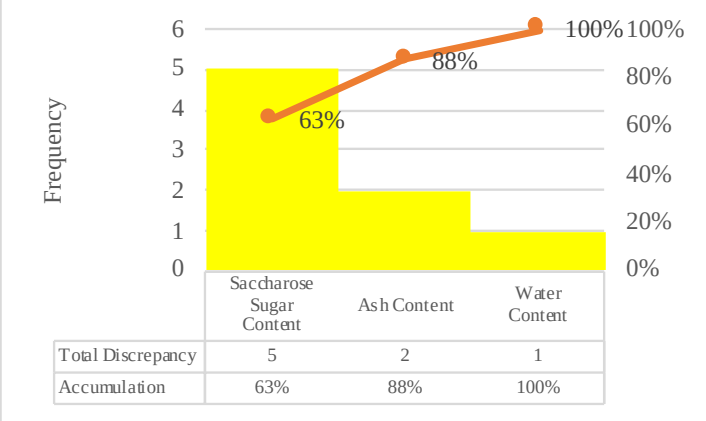

Figure 6. Pareto Diagram Chemical Characteristics of Baduy Palm Sugar

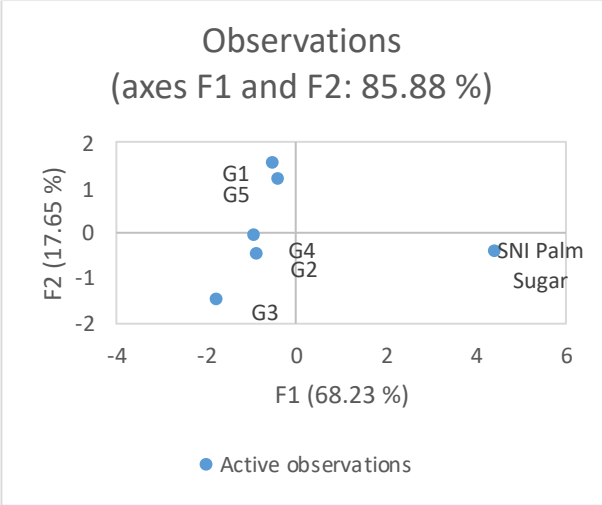

Figure 7. Principle Component Analysis of Samples Based on Chemical Characteristics

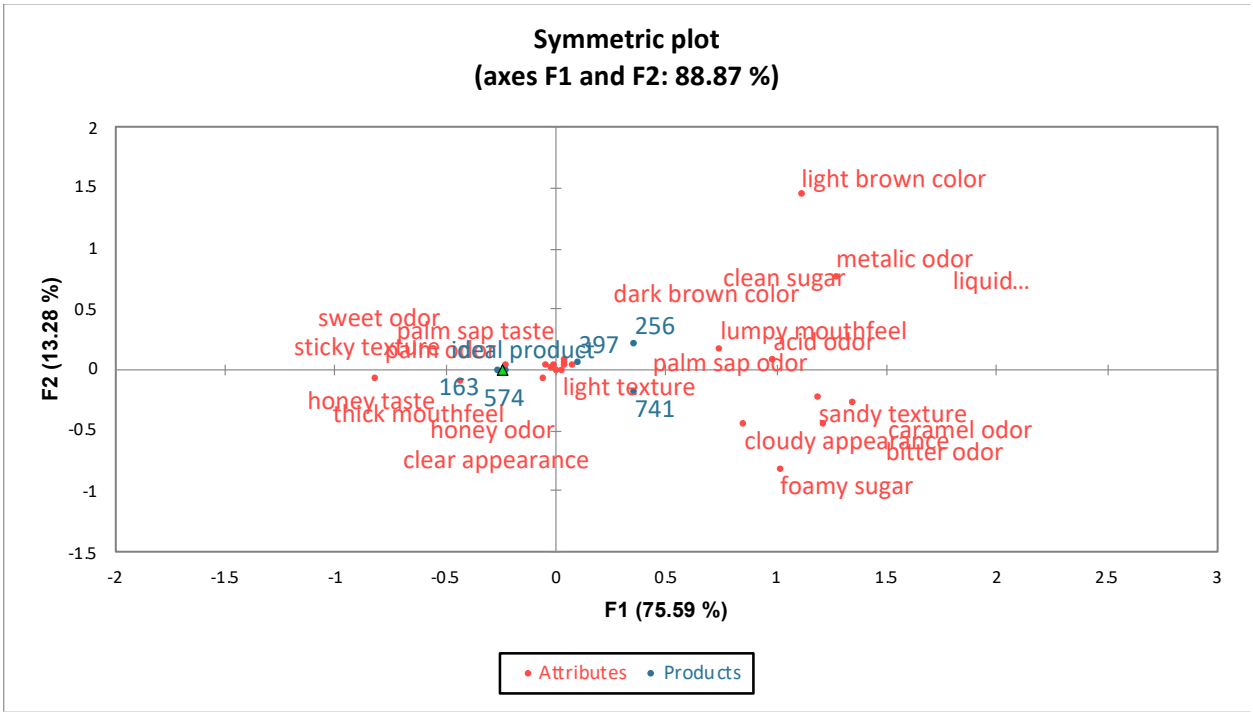

Figure 8. Symetric Plot Sample

3.2. Deviation Data Analysis

The total discrepancy in the Pareto diagram of Figure 6 shows a value of 63%, where the highest to smallest deviations are sugar content as saccharose, ash content and moisture content. Meanwhile, other parameters are free from deviations or meet the specifications set by SNI Palm Sugar. This indicates that the three parameters must be improved immediately in order to improve the quality of Baduy palm sugar.

3.3.Sensory Analysis

PCA is conducted to determine the sample that meet with SNI (BSN, 2021). The Biplot in Figure 7 shows the relationship between samples and chemical characteristics compared to Standard. The selection of sample codes G2

and G4 were caused by these samples had the best results of chemical analysis compared to other samples. The sugar sample used in sensory analysis can be seen in Table 7.

In Figure 8, based on consumer, the ideal product has the attributes of dark brown color, clear appearance, clean sugar, palm odor, sweet odor, sticky texture, honey odor, palm sap odor, honey taste and palm sap taste. It can be seen that palm sugar with sample codes 574 and 163 is in the same quadrant as the ideal product. The two samples are Baduy palm sugar samples which have the attributes of sweet aroma, palm sap taste, palm aroma, honey taste, sticky texture, and the appearance of clear sugar.

Meanwhile, sugar with code 397 which is considered as Badak sugar and code 256 which is considered as Probolinggo sugar is in quadrant two. Both of these sugars have the attributes of clean sugar, light texture, light brown color, palm sap aroma, and metallic aroma. While the code 741 which is Javara sugar is in quadrant 3 has the attributes of foamy sugar, light texture, sandy texture, bitter aroma, and caramel aroma. In this plot, it can be concluded that the panelists considered that Baduy palm sugar was close to the ideal palm sugar characters.

4. Conclusions

The average value of the chemical characteristics of Baduy palm sugar, namely water content, ash content, water insoluble content, reducing sugar content and saccharose sugar content respectively were 8.3749 %bb, 1.6773%bb, 0.5946%bb, 0,5625 %bb and 85.78%bb. The percentage of discrepancy in the analysis of the chemical characteristics of Baduy palm sugar with SNI 3743-2021, namely the sugar content as saccharose reaches 63%, ash content reaches 15% and water content reaches 12%. Baduy palm sugar, namely G2 and G4 are sugars that are most similar to ideal palm sugar compared to other commercial palm sugar. It means Baduy palm sugar has good potential to be traded in a wider market and can compete with other commercial palm sugar**.**

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