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EVALUATION OF PHYSICAL AND CHEMICAL CHARACTERISTICS OF COCOA POWDER PRODUCTS IN INDONESIA

[Evaluasi Karakteristik Fisik dan Kimia Produk Bubuk Kakao di Indonesia]

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ABSTRACT

Cocoa (*Theobroma cacao* L.) is a plant that produces the main raw material for the chocolate industry. Cocoa plants are spread throughout tropical countries in the world, such as Indonesia, South America, and Africa. Cocoa beans can be turned into a range of processed chocolate goods, such as chocolate bars and cocoa powder, to raise their economic value. The characteristics of cocoa in each region have different characteristics depending on the factors of the planting process in the region and the processing process. This study will compare the characteristics of cocoa powder from various regions in Indonesia such as Yogyakarta, Jember, Lampung, Aceh, Kendari, and Jayapura. Moisture content of cocoa powder ranges 4.23-11,86, ash content ranges 4,06-10,58, protein content ranges 16,10-24,99, fat content ranges 11,75-40,37, and carbohydrate content by difference ranges 34,83-48,24. The physical analysis in this study includes fineness analysis with a range of 99.27%-99.70 %, color test using the Hunter Method with L value ranging from 29.79 to 42.05, a* value ranging from 17.65 to 24.71, b* value ranging from 18.75 to 26.29, and pH analysis with a range of 5.74-6.93. In conclusion, there are differences in the characteristics of cocoa powder between regions in Indonesia. The differences in environmental factors and processing processes in each area make cocoa powder's nutritional content and physical properties different.

Keywords: Cocoa powder, physical analysis, proximate analysis

ABSTRAK

Kakao (Theobroma cacao L.) adalah tanaman yang menghasilkan bahan baku utama untuk industri cokelat. Tanaman kakao tersebar di negara-negara tropis di seluruh dunia, seperti Indonesia, Amerika Selatan, dan Afrika. Biji kakao dapat diolah menjadi berbagai produk cokelat olahan, seperti cokelat batangan dan cokelat bubuk, untuk meningkatkan nilai ekonominya. Karakteristik kakao di setiap wilayah memiliki perbedaan tergantung pada faktor-faktor proses penanaman di wilayah tersebut dan proses pengolahannya. Penelitian ini akan membandingkan karakteristik bubuk kakao dari berbagai wilayah di Indonesia, seperti Yogyakarta, Jember, Lampung, Aceh, Kendari, dan Jayapura. Kadar air bubuk kakao berkisar 4,23-11,86%, kadar abu berkisar 4,06-10,58%, kadar protein berkisar 16,10-24,99%, kadar lemak berkisar 11,75-40,37%, dan kadar karbohidrat berkisar 34,83-48,24%. Analisis fisik dalam penelitian ini meliputi analisis kehalusan berkisar 99,27%-99,70%, uji warna menggunakan Metode Hunter dengan nilai L berkisar 29,79-42,05, nilai a berkisar 17,65-24,71, nilai b* berkisar 18,75-26,29, dan analisis pH berkisar 5,74-6,93. Kesimpulannya, terdapat perbedaan karakteristik bubuk kakao antara wilayah-wilayah di Indonesia. Perbedaan faktor lingkungan dan proses pengolahan di setiap wilayah menyebabkan kandungan gizi dan sifat fisik bubuk kakao menjadi berbeda.*

Kata Kunci: *Bubuk kakao, analisis fisik, analisis proksimat*

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INTRODUCTION

Cocoa (Theobroma cacao L.) is a plant that produces the main raw material for the chocolate industry. Cocoa plants are spread throughout tropical countries in the world, such as Indonesia, South America, and Africa. Cocoa beans can be turned into a range of processed chocolate goods, such as chocolate bars and cocoa powder, to raise their economic value (Hadinata & Marianti, 2020). Cocoa can be processed into various processed products such as chocolate bars, chocolate flavors, and chocolate drinks (Faiqoh, Muhammad, & Praseptiangga, 2021) (Wijanarti, Sabarisman, Revulaningtyas, & Sari, 2020). The roasting of cocoa beans to generate brown beans with a chocolate aroma can be used to make processed cocoa products (SuJung Hu, Byung-Yong Kim, & Moo-Yeol Baik, 2016). The cocoa beans are ground into a cocoa mass after they have been roasted. When mass cocoa is squeezed, cocoa butter and cocoa powder are produced (Aprotosoaie, Luca, & Miron, 2015) (Montoya & Valencia,, 2021). Chocolate bars and cocoa powder made from processed cocoa beans include a variety of bioactive compounds that have beneficial health effects. Cocoa powder extract contains at least eight major bioactive components (Adefegha, Oboh, & Olabiy, 2018) (Baranowska, et al., 2020) (Pedan, et al., 2018).

Indonesia itself is one of the largest cocoa producers in Southeast Asia. Cocoa plantations in Indonesia are spread throughout the islands, including Java, Sumatra, Kalimantan, Sulawesi, and Papua. The characteristics of cocoa in each region have different characteristics depending on the factors of the planting process in the region and the processing process (Moser, et al., 2010). Planting environmental factors that affect the characteristics of cocoa, such as soil/land, altitude, topography, soil chemical properties (soil acidity/pH, unclean elements, organic matter content), and climate (Rubiyo & Siswanto, 2012).

Raw cocoa generally has a characteristic bitter and astringent taste, but regional differences can make these characteristics different. The difference in these characteristics can be seen in the physical quality of the cocoa beans, such as the size of the cocoa beans, the acidity level, and the color of the beans. Cocoa products produced from different regions will also produce different characteristics of cocoa products, such as color and product acidity (Sukha, Umaharan, & Butler, 2017). Geographical factors, including climatic conditions and soil characteristics of cocoa plantations, significantly influence the quality and properties of cocoa products (Cambrai, et al., 2010). Cocoa bean processing processes such as fermentation, drying, and roasting cocoa will also affect the product produced (D'Souza, Grimbs, Behrends, Bernaert, & Ullrich, 2017). Generally, the processing process can improve the characteristics of natural cocoa (Yunita, et al., 2021). Among the stages in the post-harvest and processing process like fermentation and roasting are the two most crucial phases in the formation of volatile compounds that make up the aroma (Marseglia, Musci, Rinaldi, Palla, & Caligiani, 2020). Therefore, in this study, we will compare the characteristics of cocoa powder from various regions in Indonesia.

MATERIAL AND METHODS

Material

Cocoa powder is taken from cocoa farmers in various regions in Indonesia, such as Yogyakarta, Province Yogyakarta., Jember, Province East Java., Lampung, Province Lampung., Aceh, Province Aceh., Kendari, Province Sulawesi, and Jayapura, Papua. Materials used for chemical analysis such as petroleum ether, boric acid (H_3BO_3), K_2SO_4, $CuSO_4$, H_2SO_4 and aquadest from Sigma-Aldrich (Singapore).

Analysis

This powdered chocolate was subjected to chemical analysis, including water content using the thermogravimetric method (AOAC, 2005), ash content (AOAC, 2005), protein content with micro-Kjeldahl method (AOAC, 2005), fat content with soxhlet extraction (AOAC, 2005) and carbohydrate by difference (AOAC, 2005). The physical analysis carried out is a fineness test with a sieving process (SNI

01-2891-1992), color test using the Hunter method using a chromameter and pH testing with a pHmeter (Valverde, S´anchez-Jimenez, Barat, & Perez-Esteve, 2021) conducted in the laboratory of the Department of Agricultural Product Technology, Faculty of Agriculture, Universitas PGRI Yogyakarta and Chem-Mix Pratama laboratory, Yogyakarta.

RESULT AND DISCUSSION

The physicochemical profile of chocolate products is shown through several parameters, including water content, ash content, fat content, protein content, and carbohydrate content. These various parameters greatly affect the course of chocolate derivative products, for example, cocoa powder products.

Chemical Analysis

Moisture Content

The moisture content of cocoa powder products determines the quality of the powder obtained during the processing of cocoa beans. The cocoa powder products used in this study were obtained from local chocolate producers from various regions in Indonesia, which have been confirmed to use bean-to-bar chocolate processing and processing equipment.

Table 1. Moisture Content Cocoa

Sample Cocoa	Moisture Content (% dry basis)
Yogyakarta	4.2327[a]
Jember	4.3358[a]
Lampung	4.6260[b]
Kendari	11.8624[d]
Jayapura	5.2549[c]
Aceh	4.4111[ab]

Some of the areas sampled in this study are well-known cocoa-producing areas in Indonesia, including the Yogyakarta district located in the Special Region of Yogyakarta, then the city of Banda Aceh, which is included in the province of Aceh, the city of Bandar Lampung in the province of Lampung, the district of Jember in the province of East Java, Kendari city in Southeast Sulawesi, and Jayapura city in Papua province (Febrianto & Zhu, 2022).

Based on the data obtained from the water content analysis, it is known that cocoa powder originating from the Yogyakarta, Aceh, and Jember areas has relatively the same moisture content (dry basis), namely 4.2327%, 4.4111%, and 4.3358%, respectively. While the moisture content of cocoa powder from Aceh (4.4111%) also not significantly different from Lampung (4.6260%). And the moisture content of cocoa powder originating from the Jayapura area is 5.2549%, and the highest water content is indicated by cocoa powder originating from Kendari at 11.8624%.

The water content indicated by the six types of cocoa powder was mostly below 10%, except for chocolate from Jayapura. The high moisture content of cocoa powder products from Jayapura can be caused by an imperfect drying or roasting process. This can affect the quality of cocoa powder with characteristics that are easy to absorb water or hygroscopic (Alasti, Asefi, Maleki, & SeiiedlouHeris, 2020). The climatic and geographical conditions of a region will influence the physicochemical composition of the resulting cocoa powder (Ferreira, et al., 2022).

Ash Content

The ash in cocoa powder can indicate the mineral content in processed cocoa beans. In this study, the lowest ash content was shown by cocoa powder originating from Lampung at 4,0606%. In comparison, the highest ash content was detected in cocoa powder from the Aceh region at 10,5848%. This finding is interesting because the two cocoa-producing areas are located on the island of Sumatera but show significant differences in the parameters of the ash content of cocoa powder processed in their respective regions.

Table2. Ash Content Cocoa

Sample Cocoa	Ash Content (% dry basis)
Yogyakarta	6.6239[d]
Jember	6.4907[d]
Lampung	4.0606[a]
Kendari	5.9893[c]
Jayapura	4.4286[b]
Aceh	10.5848[e]

Then, the ash content of cocoa powder from other regions varied between 4.4-6.6%, including Jayapura at 4.4286%, Kendari at 5.9893%, Jember at 6.4907%, and Yogyakarta at 6.6239%. Ash content in chocolate products can be affected by several things, including the type of base compound added in the alkalization process during cocoa processing (Alasti, Asefi, Maleki, & SeiiedlouHeris, 2020). The climatic and geographical conditions of a region will influence the physicochemical composition of the resulting cocoa powder. The fermentation process of cocoa beans will also affect the final characteristics of the cocoa powder (Ferreira, et al., 2022).

Total Protein Analysis

The protein content of cocoa powder from various regions varies between 16.1089% to 24.9969%. Cocoa powder from Lampung contained the lowest protein, while cocoa powder from Aceh had the highest protein content. This pattern is directly proportional to the ash content previously described and inversely proportional to the fat content in cocoa powder.

Table 3. Total Protein Cocoa

Sample Cocoa	Protein Content (% dry basis)
Yogyakarta	18.0195[c]
Jember	17.3627[b]
Lampung	16.1089[a]
Kendari	18.8804[d]
Jayapura	18.2793[c]
Aceh	24.9969[e]

Although the protein content in processed chocolate products is rarely discussed and its function highlighted, research proved that the protein fraction in cocoa has implications for its properties as bioactive compounds and sensory attributes in chocolate products (Rawel, Huschek, Sagu, & Homann, 2019). The content of essential amino acids in chocolate is also influenced by the processing process, especially at the fermentation stage. The cocoa bean fermentation process changed compounds such as acids, esters, ketones, pyrazines, aldehydes, and terpenoids (Fang, et al., 2020).

Fat Content

In terms of fat content, the data shows that cocoa powder originating from Lampung has the highest fat content of 40.3715%. While the lowest fat content of 11.7590% is indicated by cocoa powder originating from Aceh. This is inversely proportional to the ash content parameter discussed previously, where cocoa powder from Lampung was recorded to have the lowest ash content. In contrast, cocoa powder from Aceh had the highest ash content.

Table 4. Fat Content Cocoa

Chocolate Powder Origin	Oil Content (% dry basis)
Yogyakarta	30.4911[c]
Jember	33.0762[d]
Lampung	40.3715[f]
Kendari	24.0472[b]
Jayapura	34.1091[e]
Aceh	11.7590[a]

This indicates a possible link between ash and fat content in chocolate-processed products. Meanwhile, in other samples of cocoa powder, it was known that the fat content varied in cocoa powder from Jayapura (34.1091%), Jember (33.0762%), Yogyakarta (30.4911%), and Kendari (24.0472%). The fat content in cocoa can be affected by the area or location where the cocoa is cultivated (Samaniego et al., 2021). Meanwhile, the process of alkalization and the base compound used can also affect the level of fat-soluble phenolic compounds (Li, et al., 2014).

Carbohydrate Content

Carbohydrate content in processed cocoa products showed varied results and significant differences. Cocoa powder originating from Aceh has the highest carbohydrate content of 48.2481%. On the other hand, cocoa powder from Lampung has the lowest carbohydrate content of 34,8330%. However, the carbohydrate content in cocoa powder from other regions is also in the range of numbers that are not much different, namely 34.83-40.63 %.

Table 5. Carbohydrate Content Cocoa

Sample Cocoa	Carbohydrate Content (%)
Yogyakarta	40.6327[d]
Jember	38.7346[c]
Lampung	34.8330[a]
Kendari	39.2206[c]
Jayapura	37.9281[b]
Aceh	48.2481[e]

Like the protein content in processed cocoa products, the fermentation process also affects the carbohydrate content. In addition to the fermentation process, the roasting process also increases the carbohydrate content of the cocoa powder (Agus, Mohamad, & Hussain, 2018). Research shows that the carbohydrate compounds in cocoa beans include fructose, glucose, sucrose, raffinose, melibiose, stachyose, mannitol, and myo-inositol (Megías-Pérez , Grimbs, D'Souza, Bernaert, & Kuhnert, 2018).

Physical Analysis

Fineness

The fineness of the particle size is one of the important characteristics of powdered food products that can affect the product's properties.

Tabel 6. Fineness Cocoa

Sample Cocoa	Fineness (%)	SNI (%)
Yogyakarta	99.70 ± 0.031	
Jember	99.61 ± 0.007	
Lampung	99.53 ± 0.015	min 99.5
Kendari	99.33 ± 0.041	
Jayapura	99.60 ± 0.001	
Aceh	99.27 ± 0.005	

The fineness of cocoa powder from the Yogyakarta, Jember, Lampung, and Jayapura areas has a range of values above 99.5%, indicating that the particle size of the cocoa powder produced has passed the sieve and is following the standards of SNI. In contrast, the cocoa powder from the other two regions has not mets. The degree of fineness of cocoa powder products indicates the uniformity and distribution of particle size resulting from the grinding process. The finer the powder produced, the easier it will be to dissolve in water so that when this cocoa powder is brewed, it is not easy to experience clumping. (Aditya, Ali, & Ayu, 2018).

Color Testing

Color is one of the parameters that can indicate the product's quality and affect consumer acceptance of the product. Color is also closely associated with soundness, maturity, and product safety. Food products with a dark color will make consumers perceive that the product seems not fresh or too ripe. Therefore, this color parameter becomes an important factor in determining product quality (Setiadi, et al., 2021) (Zhu, et al., 2009).

The Hunter color system in cocoa powder testing is used to measure color uniformity and determine color changes if there is a browning process in cocoa powder. The principle of measuring the color of the hunter based on the value L*, a* dan b*. The L* value indicates the product's brightness with a range of 0 (black) to 100 (bright). Values a* and b* show chromatic color with a* value indicating reddish to greenish and b* values indicating bluish to yellowish (Li, et al., 2014).

Tabel 7. Color Testing Cocoa

Sampel	Color Description	Warna		
		L	a	B
Yogyakarta	brown	42.05	17.65	22.46
Jember	brown	37.11	21.24	21.39
Lampung	brown	29.79	23.77	19.91
Kendari	brown	41.07	18.87	20.39
Jayapura	brown	32.68	24.71	18.75
Aceh	brown	39.59	18.27	26.29

The comparison of the color values of various types of cocoa powder in multiple areas in Indonesia can be shown in the table. The test results show that the color of cocoa powder from multiple locations in Indonesia has an L value ranging from (29.79-45.76), a+ value (17.65-24.71), and b+ value (18.06-22.46). The dark color of cocoa powder is influenced by the Maillard reaction that occurs during the processing of cocoa beans into cocoa powder. The Maillard reaction occurs due to a combination reaction between anthocyanin pigments and sugars. The anthocyanin pigment in cocoa consists of

several compounds, such as phenolic hydroxyl and D-heterocyclic oxygen atoms. The color of cocoa powder is influenced by the different amounts of anthocyanin in cocoa beans, and each region has a diverse variety of cocoa beans. The darker the color of the cocoa powder, the less the number of anthocyanin pigments (Li, et al., 2014). In the test results, the color of cocoa powder in the Lampung region has the smallest L value, which indicates that the cocoa powder has the darkest color and the least amount of anthocyanins compared to other areas.

The color value of cocoa powder is in the reddish chromatic color range. Anthocyanins can be used as natural dyes because they give a reddish color to food products. The reddish color of anthocyanins appears with the presence of a long conjugated double bond and makes the anthocyanin able to absorb the color in the visible light range. The presence of anthocyanins in cocoa powder gives the product a reddish chromatic color (Sakuta, 2013).

The difference in color values for various cocoa powder products from multiple regions in Indonesia is due to the fermentation and alkalization process carried out on each cocoa bean. The change in pH during the process can affect the color change of anthocyanins in cocoa (Khoo, Azlan, Tang, & Lim, 2017). Cocoa color parameters are generally influenced by several factors, such as the roasting and alkalization process carried out during cocoa powder processing. The stronger the alkalization process, the darker the cocoa powder will be (Quelal-Vásconez, Pérez-Esteve, Arnau-Bonachera, Barat, & Talens, 2018).

pH Value

Making cocoa powder is generally done using a mechanical pressing process to separate the cocoa butter from the chocolate paste. The results of the pressing process will leave dregs in the form of solids which will later be milled to produce cocoa powder. One of the steps carried out in the manufacture of cocoa powder is the process of alkalization or dutching. Alkalization is the process of adding alkali to the cocoa mass. Commonly used alkaline substances such as sodium or potassium bicarbonate. The alkalization process on cocoa powder products is carried out to optimally produce chocolate color and flavor, reducing the bitter taste of cocoa powder and increasing the solubility level of cocoa powder when used as a beverage product. In this alkalization process, it will affect the properties and characteristics of cocoa powder products, such as the appearance and pH of cocoa powder (Alasti, Asefi, Maleki, & SeiiedlouHeris, 2020).

Table 8. pH Analysis Cocoa

Sample	pH
Yogyakarta	6.93 ± 0.071
Jember	6.46 ± 0.071
Lampung	6.31 ± 0.007
Kendari	6.77 ± 0.028
Jayapura	5.74 ± 0.092
Aceh	6.73 ± 0.354

The alkalization process on cocoa powder is classified into three groups: mild alkalization, medium alkalization, and strong alkalization. Mild alkalization will produce a cocoa powder with a pH range of 6.5-7.2, medium alkalization with a pH of 7.21-7.26, and strong alkalization with a pH of >7.61 (Miller, et al., 2008). The results showed that cocoa powder from various regions in Indonesia had a pH value in the range of 6.31-6.93. This data indicates that the process of alkalization of cocoa powder in Indonesia uses the mild alkalization method. Mild alkalization is widely used in manufacturing cocoa powder because it can reduce the risk of decreasing polyphenolic compounds in cocoa powder. The alkalization process can increase the decrease of polyphenol compounds in cocoa. Cocoa powder that has not been subjected to the alkalization process has a higher content than the product that has gone through the alkalization process. The total polyphenols in the cocoa powder will decrease significantly

as the concentration of alkali is added, and the pH of the product increases (Alasti, Asefi, Maleki, & SeiiedlouHeris, 2020). However, this alkalization process is also needed to increase the solubility level of cocoa powder products. Alkalization can increase the hydrolysis catalyzed reaction on cocoa powder particles, producing hydrophilic particles that will easily dissolve in water. These hydrophilic particles are needed for cocoa powder, which is made into beverage products so that there is no clumping when cocoa powder is dissolved in the water (Muhammad, Kongor, & Dewettinck, 2021).

In the pH test, the highest value was found in cocoa powder from Yogyakarta, Sulawesi, and Aceh at 6.93, 6.77, and 6.73. The difference in pH in cocoa powder can cause the product's color to be different. The higher the pH, the more reddish the color of the cocoa powder produced. Anthocyanin pigments can turn into brown polymers when the concentration of alkali added during the alkalization process increases. This increase in pH increases the process of forming chocolate polymers in cocoa powder. This is following the color test that has been carried out previously, which showed cocoa powder from Yogyakarta, Sulawesi, and Aceh had a greater reddish color than from other regions. The pH value of cocoa powder products can be used as a way to determine the quality of cocoa products. Suppose the cocoa powder has a high value. In that case, it indicates that the antioxidant content, such as polyphenols in cocoa, has been significantly reduced, and the product's appearance will also be browner.

CONCLUSION

Based on the research result, it shows that the moisture content of cocoa powder ranges 4.23-11,86, ash content ranges 4,06-10,58, protein content ranges 16,10-24,99, fat content ranges 11,75-40,37, and carbohydrate content by difference ranges 34,83-48,24. The physical analysis in this study includes fineness analysis with a range of 99.27%-99.70 %, color test using the Hunter Method with L value ranging from 29.79 to 42.05, a* value ranging from 17.65 to 24.71, b* value ranging from 18.75 to 26.29, and pH analysis with a range of 5.74-6.93. In conclusion, there are differences in the characteristics of cocoa powder between regions in Indonesia. The differences in environmental factors and processing processes in each area make cocoa powder's nutritional content and physical properties different.

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