Journal of Applied Science, Engineering, Technology, and Education *ISSN: 2685-0591 (online)*
Vol. 6 No. 2 (2024)
https://doi.org/10.35877/454RI.asci2818

The Influence of Temperature and Drying Time on The Physical and Chemical Characteristics of Cocoa Pod Tea (*Theobroma cacao,* L.)

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Abstract

Cocoa is one of the plantation products that plays an important role in the Indonesian economic sector because it contains many nutrients that provide health effects on the body, one of which is high antioxidant content. Processing of cocoa shell waste in the food industry can be optimized. One process of utilizing cocoa shell waste is processing it into tea. The drying process affects the resulting cocoa husk tea. In addition, drying temperature also affects the antioxidant content of a food product. The drying process for this research used a food dehydrator. It produces a large driving force of drying air so that it can remove the water content in the ingredients. This research aims to determine the temperature and drying time using a food dehydrator, which produces cocoa husk tea and has characteristics according to Indonesian National Standard (SNI). The research methods used experimental and descriptive analysis. The treatment used in this research employed a food dehydrator temperature, by 50°C, 55°C, 60°C, and 65°C with a drying time of 4.5 hours and 6 hours respectively. The results of this research indicated that the temperature and drying time were 50°C and 4.5 hours to produce cocoa husk tea according to SNI with 8,018% water content and 7,98% ash content.

Keywords : chemical characteristics, food dehydrator, cocoa fruit skin

Received: 23 July 2024 Revised: 29 November 2024 Accepted: 20 December 2024

1. Introduction

According to FAO (2020), Indonesia is the 3rd largest cocoa producing country in the world. Kamelia & Fathurohman (2017) also mentioned that over the last 15 years in 2010, cocoa production has increased to reach 70.919 tons. The percentage contribution of cocoa pods is 75%, so that 53,190 tons of cocoa shell waste is produced per year. Unprocessed cocoa pods waste can cause environmental pollution. In fact, the polyphenolic compounds contained in cocoa fruit skin can act as antioxidants (Utami et al., 2017).

According to Panak Balentić et al. (2018), cocoa pod skin is rich in fiber, protein, and bioactive components. The content of phenolic compounds in cocoa pod skin has the potential to be an antioxidant, including *catechin, quercetin, epicatechin, gallic,* and *protocatechuic* acid. These are the composition of phenolic compounds contained in dried cocoa pod skin (Valadez-Carmona et al., 2018), as well as tannin content, which functions as an antioxidant (Vásquez et al., 2019). The high content of polyphenolic compounds, one of which is flavonoids, as an antioxidant, prevents diabetes, prevents cancer and hypertension, relieves stress, prevents inflammation, and for the healthy heart organ in the body (Towaha, 2014., Putri & Winata, 2019., Ravishankar et al., 2013., and Ren et al., 2003).

Therefore, the use of cocoa shell waste can be utilized as a diversified raw material and processed into herbal tea drinks. One of the factors that influences the antioxidant activity of the cocoa husk tea produced is the drying temperature used. This is because antioxidant compounds are sensitive to heat (Husni et al., 2014). The drying process is carried out using a food dehydrator with the speed is 0.8 m/s and the circulation pattern occurring in the chamber area. Moreover, the driving force of the drying air produced is greater so that the water content in the food can be evaporated (Chandra & Witono, 2018).

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The processing cocoa pods husk tea includes the process of preparing materials and tools, sorting, washing the husk, slicing the husk, drying, reducing the size with a grinder, and sieving using a 40-mesh sieve (Kusuma et al., 2019). The aim of this research is to determine the temperature and drying time that produces cocoa husk tea with the characteristics according to SNI through the drying process using a food dehydrator at various different temperatures, by 50 ^{0}C, 55 ^{o}C, 60 ^{o}C, and 65 ^{o}C for 4,5 hours, and 6 hours.

2. Materials and Methods

2.1. Material

This research was conducted in November 2021-February 2022 at the Food Processing Technology Laboratory, Sensory Testing Laboratory, and Food Chemistry Laboratory at the Department of Food Industry Technology, Faculty of Agricultural Industrial Technology, Padjadjaran University. The materials used in this research were aluminum foil, distilled water, cling wrap tea bags, filter paper, and cocoa pod shells obtained from Gunung Kidul plantation, Yogyakarta. Equipment used includes basins, dark bottles, small cups, aluminum cups, platinum or porcelain cups, desiccators, food dehydrators, grinders, crustangs, analytical balances, ovens, 40 mesh sieves, plates, knives, small spoons, slicing, spatulas, and furnace.

2.2. Research Design

In this research, experimental methods were used and then analyzed descriptively. This research consisted of eight treatments in duplicate as follows:

A= Temperature 50ºC for 4.5 hours
B= Temperature 55ºC for 4.5 hours
C= Temperature 60ºC for 4.5 hours
D= Temperature 65ºC for 4.5 hours
E= Temperature 50ºC for 6 hours
F= Temperature 55ºC for 6 hours
G= Temperature 60ºC for 6 hours
H= Temperature 65ºC for 6 hours

2.3. Making Cocoa Husk Tea

The raw material for fresh cocoa pods husks was sorted, then washed, and cut into small pieces with a thickness of ± 1.3 mm, then slices of cocoa husk were obtained. Next, the cocoa pod husk slices were dried using a food dehydrator at temperatures of 50ºC, 55ºC, 60ºC, and 65ºC for 4.5 hours and 6 hours to obtain dried cocoa husk slices. Next, the dried cocoa pod husk slices were crushed with a grinder and sieved 40 mesh to obtain cocoa husk tea powder.

The stages of making cocoa husk tea refer to Kusuma et.al. (2019), Yulianti et al. (2019), and Simanjuntak (2013) which were modified shown on Figure 1.

2.4. Water Content Analysis (AOAC, 2005)

The empty aluminum foil cup was placed in the oven at a temperature of 105ºC and held for an hour, then placed in a desiccator for 15 minutes and then weighed until a constant weight was obtained. A sample of 1 g was placed in a constant empty cup. This treatment was repeated until a constant weight was obtained. After weighing, the cup containing the sample was placed in an oven at 105º C, heated for three hours. Then, the cup was placed in a desiccator for 15 minutes to cool and then weighed until a constant weight was obtained. The cup and sample were put back into the oven to be heated for 30 minutes, kept in a desiccator for 15 minutes and then weighed again. This treatment was repeated until a constant weight was obtained and the percentage of water content was calculated.

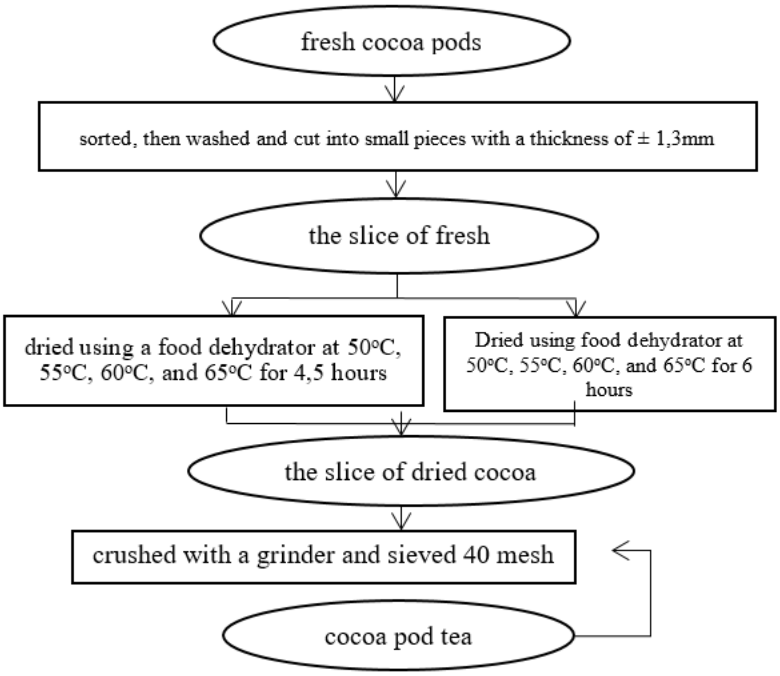

Figure 1. Flow Diagram of the Process for Making Cocoa Peel Tea
(Source: Modification Kusuma et.al., 2019; Yulianti et al., 2019; and Simanjuntak, 2013)

2.5. Ash Content (AOAC, 2005)

A porcelain cup was used and placed in a kiln at 550°C for 60 minutes. After heating, the cup was placed in a desiccator for 15 minutes. Once cooled, it was weighed. The porcelain cup was then heated again in the kiln for 30 minutes, followed by 15 minutes in the desiccator, and weighed after cooling. This process was repeated until a constant weight was achieved. Subsequently, 1 gram of the sample was added to the cup and heated in a furnace at 550°C for 5 hours. Afterward, the cup was cooled at room temperature for 15 minutes and placed in a desiccator. The porcelain cup containing the ash was then weighed. This treatment was repeated until a constant weight was obtained, and the ash content was calculated.

2.6. Triangle Test (Lasimpala et al., 2014)

This triangle test was carried out on the color, aroma, and taste characteristics by two samples of cocoa husk tea with the highest antioxidants after drying for 4.5 hours and 6 hours, as well as green tea as a comparison for commercial tea. Panelists were asked to identify examples that were different or the same between the three samples. Then, the panelists provided scores. If the product is same, then give a rating of '0' and if the product is different, then give a rating of '1'. The results obtained were compared with the two-sample test table with the confidence levels of 5% and 1%, then conclusions drawn.

3. Results and Discussion

3.1. Analysis of Cocoa Fruit Skin Tea Water Content

Water content shows the amount of water contained in a material (Daud et.al., 2019) . This water content test used oven drying. If a food ingredient has a free water content value close to zero, then this could inhibit the growth of microorganisms, inhibit enzyme activity, maintain the quality of the food product, and prevent chemical reactions (Manfaati et al., 2019). The results of testing the water content of cocoa husk tea samples are presented in Table 1 and Figure 2.

Table 1 Water Content Analysis

Sample	Water content (%)
A = Temperature 50ºC for 4.5 hours	8.018% ± 0.000
B = Temperature 55ºC for 4.5 hours	6.850% ± 0.000
C = Temperature 60ºC for 4.5 hours	5.366% ± 0.002
D = Temperature 65ºC for 4.5 hours	5.094% ± 0.001
E = Temperature 50ºC for 6 hours	6.000% ± 0.000
F = Temperature 55ºC for 6 hours	10.861% ± 0.000
G = Temperature 60ºC for 6 hours	9.250% ± 0.000
H = Temperature 65ºC for 6 hours	10.308% ± 0.002

Note: The water content of cocoa husk tea was calculated on a wet basis

The water content of cocoa husk tea changes with increasing temperature and drying time. From Table 1, it is found that the water content of cocoa husk tea samples dried for 4,5 hours at a temperature of 50ºC to 55ºC decreased, from 8018% to 6,850% at a temperature of 60ºC. It decreased to 5,366% and re-decreased at a temperature of 65ºC became 5,094%, while the water content of the cocoa husk tea sample dried for 6 hours at a temperature of 50ºC to 55ºC increased from 6,000% to 10,861%. At a temperature of 60ºC, decreased to 9,250%, and re-increased at a temperature of 65ºC to 10,308%. The quality requirements for packaged dry tea are defined by SNI 3836:2013, which specifies a maximum water content of 8% (Indonesian National Standard, 2013). According to Table 1, the water content of cocoa husk tea samples meets the SNI standard for dry tea. Specifically, the water content for cocoa husk tea dried at 55°C for 4.5 hours was 6.850%, at 60°C for 4.5 hours was 5.366%, at 65°C for 4.5 hours was 5.094%, and at 50°C for 6 hours was 6,000%.

Data from research on the water content of cocoa husk tea after drying for 4.5 hours resulted in a decrease in water content as the temperature increased. This is because the evaporation that occurs would be faster, resulting in more water in the material being evaporated due to the influence of increasing drying temperature, so that the resulting water content will be smaller (Leviana & Paramita, 2017; and Benefit et al., 2019). Meanwhile, the results of water content after drying for 6 hours did not show a decrease in water content as the temperature increased. This is caused by several factors, including that the cocoa pod skin samples that come from farmers are not uniform because they have differences in color, harvest age, and mass of cocoa pods, apart from environmental factors, such as location and harvest season which also influence the water content produced (Lee & Cho, 2012; and Setiawan et al., 2019). The influence of climatic conditions and the cocoa plantation area also influences the quality, chemical composition produced, and metabolism of the cocoa fruit. There are several changes in climate factors including rainfall, humidity, intensity of sunlight, and wind speed caused by differences in temperature, which can affect enzyme activity during metabolic processes (Alam et al., 2010).

The condition of water in food will also affect the quality of the final food product produced. Fresh cocoa husks have water adsorption conditions because they have 27% crude fiber and 8% protein, 16,27% carbohydrates, 20,11% lignin, 31,25% cellulose, and 48,64% hemielulose (Nasir et al. ., 2020). Adsorption water is usually bound to the surface or layer around hydrophilic molecules through hydrogen bonds between molecules, such as carbohydrates, proteins, pectin, and starch. Adsorption water would be more difficult to remove when dried because the adsorption water will form a multilayer layer, but its binding force will become weaker (Kusnandar, 2020).

Initially, fresh cocoa pods contain high water content up to 85% (Nasir et al., 2020). Testing of the water content between fresh cocoa pod skin and dried cocoa pod skin was carried out by Wulan (2001) producing a water content for fresh cocoa pod skin samples of 79,50% and dried cocoa pod skin samples of 17,96%. The use of temperature also needs to be considered in drying. This is due to the uneven drying process due to drying at a too high temperature, but using a too slow temperature is also less effective and can affect the results of the water content (Huriawati et al, 2016). Drying at high temperatures can cause the surface of the material to dry too quickly because the speed of movement of the water in the sample to the surface is not comparable so that the water in the sample cannot evaporate and causes the surface of the material to harden (case hardening) (Ulaan, 2015).

3.2. Analysis of Ash Content of Cocoa Fruit Skin Tea

Ash content is the result of the mineral content that is still present in a food sample after going through the ashing process (Mustafa & Elliyana, 2020). Ash content testing was carried out by placing the sample in the furnace until the sample is completely white and a constant weight was obtained. The results of testing the water content of cocoa husk tea samples are shown in Table 2.

Table 2 Ash Content Analysis

Sample	Ash content (%)
A = Temperature 50ºC for 4.5 hours	7.983 ± 0.079
B = Temperature 55ºC for 4.5 hours	10.548 ± 0.026
C = Temperature 60 º C for 4.5 hours	10.234 ± 0.072
D = Temperature 65 º C for 4.5 hours	9.914 ± 0.018
E = Temperature 50 º C for 6 hours	9.106 ± 0.023
F = Temperature 55 º C for 6 hours	8.251 ± 0.104
G = Temperature 60 º C for 6 hours	9.630 ± 0.037
H = Temperature 65 º C for 6 hours	10.023 ± 0.033

It can be seen that the ash content of cocoa husk tea increases with increasing temperature at a drying time of 4.5 hours but decreases first for a drying time of 6 hours. Table 2 is found that during drying process for 4.5 hours at a temperature of 50ºC to 55ºC, the ash content increased, from 7.983% to 10.548%. Then the ash content decreased slightly to 10.234% at a temperature of 60ºC, and then redecreased at a temperature of 65ºC to 9.914%, while in cocoa husk tea with drying for 6 hours, at a temperature of 50ºC to 55ºC decreased from 9.106% to 8.251% and increased as the temperature increased, at a temperature of 60ºC and 65ºC with ash content of 9.630% and 10.023%. The ash content results obtained depend on the ashing method, drying time, and temperature (Supraptiah et al., 2019).

The type of material can influence the ash content results. The ash content in samples of cocoa husk tea is still relatively high and does not meet SNI because the ash content in fresh cocoa husk is relatively high, reaching 15.4% (Listyati, 2015). According to Usman (2007)**,** cocoa pod skin contains quite high mineral content in ash, one of which is calcium. According to Riansyah et al. (2013), an increase in ash content occurs as the drying temperature increases because more water content is removed from the food. The aim of determining the ash content is to ensure the purity, quality, and authenticity of a material from the sample being tested (Azah et al, 2020).

Based on the Indonesian National Standardization Agency (2013) SNI 3836:2013, the quality requirements for packaged dry tea are a maximum water content (w/w) of 8% and a maximum ash content (w/w) of 8%. Then, based on Tables 1 and 2, the cocoa husk tea treated with A and D meets the appropriate SNI standards.

3.3. Sensory Characteristics of Cocoa Husk Tea

The sensory testing carried out consists of aroma, color, and taste using the triangle test method. This technique was carried out by testing three tea samples consisting of two samples of cocoa husk tea, each of which had characteristics according to SNI, namely treatment A and treatment D and 1 sample of commercial tea, namely green tea which was assessed as having high antioxidants.

ADK

Figure 2. Cocoa Fruit Skin Tea and Green Tea

3.4. Color

Color is one of the most important sensory attributes in a food product. Color has a function, namely as an attraction for consumers, determining the level of freshness of a product, a product identification mark, and a quality attribute, so that it becomes one of the quality aspects that determines whether the quality of a food product will be liked by consumers or not (Tarwendah, 2017). The results of the triangle test on color components to determine whether there are differences between the three samples tested on 20 semi-trained panelists can be seen in Table 3.

Table 3. Color Component Triangle Test Results

Sample Code	Number of Panelists Who Say Different	Color Smallest Amount for Different Levels 5%	1%	Number of Panelists (N)
A	16	11	13	20
D	14	11	13	20
K	17	11	13	20

Note: A = cocoa husk tea at 50ºC for 4.5 hours, D = cocoa husk tea at 65ºC for 4.5 hours, and K = commercial green tea

Based on Table 3, it was found that the number of panelists who stated that there were differences between the three samples were 16 panelists for the cocoa husk tea sample treatment A, 14 panelists for the cocoa husk tea sample treatment D, and 17 panelists for the sample code K. This shows that each sample has a very real different color.

This color difference is based on the difference in processing methods between cocoa husk tea and green tea as commercial tea. The differences in processing consist of the use of different temperatures, drying process times, and raw materials for making tea. The color of the cocoa pod skin tea will appear darker as the drying temperature increases. From research by Sari et al. (2019), The same data was also obtained, namely that by increasing the temperature and drying time, the color of the brewed tea would become increasingly brown or dark.

The color produced by cocoa husk tea is slightly brownish yellow. The color of sample D cocoa husk tea which was dried at a temperature of 65ºC for 4.5 hours gave a slightly brownish yellow color, which was more intense than sample code A of cocoa husk tea, dried at a temperature of 50ºC for 4.5 hours. This color comes from carotenoid pigments contained in cocoa pod skin (Jayanti et al., 2021). This is because carotenoids are relatively stable at heating temperatures (Mudambi & Rajagopal, 1977). However, using temperatures above 100ºC can cause a decrease in color intensity due to damage to ß-carotene and browning reactions (Wulan, 2001), while the color of commercial green tea in sample code K tends to be yellowish or orange and as the brewing process takes longer the color of the tea becomes green, and the result is dark chocolate. According to Sari et al (2019), that the catechins in tannins have color characteristics from colorless to yellowish. The color produced by green tea is due to the chlorophyll compounds contained in green tea leaves. The formation of this orange color occurs because some of the carotenoid pigments are oxidized.

The change in color of green tea to dark brown with increasing time and a longer steeping process is caused by an enzymatic oxidation process, causing the breakdown of green chlorophyll into pheophytin which gives black color (Towaha & Balittri, 2013). Furthermore, another compound is tannin. This is because these compounds have an influence in determining the quality of the aroma in the tea making process. This is due to differences in drying temperatures and the raw materials used. The formation of green tea color comes from the conversion of catechin compounds into theaflavins and thearubigins where the results of the formation of theaflavins and thearubigins come from the occurrence of oximatism, which causes the change of polyphenols into oxidizing compounds (Towaha & Balittri, 2013).

3.5. Aroma

Aroma is one of the organoleptic properties in the form of volatile compounds, that give an impression of the quality of food products through human response. This response entered the nasal cavity and was then received and the olfactory nerve will sense it (Tarwendah, 2017). The results of the triangle test on aroma components to determine whether there are differences between the three samples tested on 20 semi-trained panelists can be seen in Table 4.

Based on Table 4, it is found that the aroma of green tea with 17 panelists is very significantly different from the aroma components of samples A and D of cocoa husk tea with 1 panelist in each sample. This has met the requirements where the number of panelists who stated the difference is in accordance with level of 1%, while sample code A and D cocoa husk tea are not significantly different in terms of aroma components and these two cocoa husk tea samples have the same aroma. The aroma of this green tea is the typical aroma of commercial green tea leaves in common. The aroma of commercial tea produced generally comes from the oxidation process of carotenoid pigments, which will produce unsaturated aldehydes and ketones so that this will form the characteristic aroma of tea in general (Towaha & Balittri, 2013). This is in accordance with Fellow's (1988) statement that the formation of aroma in food products is caused by volatile components that evaporate during the processing process using high temperatures. So, it can be concluded that the aroma in the green tea sample has a higher volatile content evaporated due to the use of a higher temperature compared to the two cocoa husk tea samples.

Table 4 Triangle Test Results for Aroma Components

Sample Code	Aroma			
	Number of Panelists Who Say Different	Smallest Amount for Different Levels		Number of Panelists (N)
		5%	1%	
A	1	11	13	20
D	1	11	13	20
K	17	11	13	20

Note: A = cocoa husk tea at 50 °C for 4.5 hours, D = cocoa husk tea at 65 °C for 4.5 hours, and K = commercial green tea

3.6. Flavor

Taste provides benefits to a product, besides increasing consumer appeal, it also serves as an identifying mark for a product. The results of the triangle test on taste components to determine whether there are differences between the three samples tested on 20 semi-trained panelists can be seen in Table 5.

Table 5. Triangle Test Results for Flavor Components

Sample Code	Flavor			
	Number of Panelists Who Say Different	Smallest Amount for Different Levels		Amount Panelists (N)
		5%	1%	
A	10	11	13	20
D	9	11	13	20
K	19	11	13	20

Note: A = cocoa husk tea at 50°C for 4.5 hours, D = cocoa husk tea at 65°C for 4.5 hours, and K = commercial green tea

Based on Table 5, it is found that the taste of green tea with 19 panelists is very significantly different in terms of taste components than sample A cocoa husk tea with 10 panelists, and sample D cocoa husk tea with 9 panelists. This has met the requirements where the number of panelists is stated that the difference was appropriate at the 1% level, while cocoa husk tea sample codes A and D were not significantly different in terms of taste components. Green tea has the same astringent or chelic taste as commercial tea in general, while sample D cocoa husk tea has a slightly astringent taste compared to sample A cocoa husk tea. The formation of the taste of green tea comes from the conversion of catechin compounds into theaflavin and thearubigin so that formed a distinctive taste of tea in general (Towaha & Balittri, 2013).

Meanwhile, the formation of a good astringent taste in sample F cocoa husk tea and green tea was caused by tannin compounds. According to Sari et al. (2019), that the catechins in tannins, apart from having color characteristics ranging from colorless to yellowish, also provided a bitter and astringent taste to herbal tea brews. However, the characteristics of tannins depend on the phenolic-OH groups in a plant. Thus, tannin compounds have an influence in determining the quality of tea which is related to color, aroma and taste in the tea making process.

4. Conclusion

Cocoa pod husks, a by-product of cocoa bean processing, have gained attention as a potential source of valuable compounds and as a base for herbal teas. This study explores how different drying temperatures and durations affect the final product's characteristics, including color, texture, and chemical composition. The research results indicated that drying cocoa husk tea at 50°C for 4.5 hours produced tea that met the SNI standards, with a water content of 8.018% and an ash content of 7.983%. Subsequent sensory testing of the color, aroma, and taste of the treated cocoa husk tea revealed significant differences compared to green tea, which was used as a commercial sample in a triangle test. The drying process affects the resulting cocoa husk tea. In addition, drying temperature also affects the antioxidant content of a food product. One of the factors that influences the antioxidant activity of the cocoa husk tea produced is the drying temperature used. This is because antioxidant compounds are sensitive to heat. The optimal conditions identified in this research provide a foundation for the production of high-quality cocoa pod tea with desirable sensory attributes and potential health benefits. Future research could explore the effects of pre-treatments or alternative drying methods to further enhance the quality of cocoa pod tea.

Acknowledgments

The author would like to express gratitude to the Dean of the Faculty of Agricultural Industrial Technology at Padjadjaran University, who has provided equipment and laboratory facilities for this research.

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