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Antioxidant Content of Tisane of Cocoa Bean Shells as Affected by Roasting Temperatures

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Abstract

Cocoa bean shells are a by-product of chocolate processing that can be used as tisane because of it bioactive compounds that act as antioxidants, such as polyphenols. Roasting holds a vital role in the formation of aroma and taste. Roasting is usually conducted at 100–150°C. The phenolic content is essential in forming the product's sensory properties, especially the astringency; the phenolic content also interacts with proteins through the Maillard reaction in the roasting process. Roasting is carried out on cocoa beans whose nib and shells have not been separated. This study aimed to determine the effect of roasting temperature on the antioxidant activity of tisane drinks from cocoa bean shells. The roasting temperatures used in this study were 100ºC for 20 minutes, 120ºC for 20 minutes, and 140ºC for 18 minutes. Folin-Ciocalteu method was used to determine the total phenolic content and the 2,2 diphenil-1-picrylhidrazyl (DPPH) method to determine the antioxidant activity. Cocoa shell roasted at 100ºC for 20 minutes had the highest total phenolic, antioxidant content, and free radical scavenging (inhibition) activity of 21.55 mg gallic acid equivalent (GAE) g^{-1}, 12.80 mg ascorbic acid (AA) g^{-1}, and 85.18% respectively. Total phenolic content strongly correlated with antioxidant levels, free radical scavenging activity (inhibition), and the color score of L*, b*, and inversely proportional to the color score of a*. The shells roasted at 140ºC for 18 minutes had the highest IC_{50} value of 22.76 mg mL^{-1}. In addition, the roasting temperature can affect the sensory attributes of bitter, astringent, sweet, chocolate, nutty, and roasty characteristics of the tisane drink of cocoa shells.

Keywords: antioxidant, cocoa bean shell tisane, roasting temperature, black tea

INTRODUCTION

In the food industry, cocoa beans are used to make chocolate; however, only the nibs are used in the food industry, while the shells are thrown away. Vásquez *et al.* (2019) report that cocoa bean shells contain around 1.32–5.78% of polyphenol bioactive components, which have the potential as a source of antioxidants. These shells are generally used as non-food products, including animal feed, weed control in some plants, in the production of bioethanol, as a dye, and as an adsorbent (Balentic *et al.*, 2018). There is not much use of cocoa bean shells for food products, yet these shells have the potential to be produced into a functional drink (Lopes *et al.*, 2021). However, the use of cocoa bean shell for drink must consider the content of toxic elements in the shell, such as pesticide residues and heavy metals, because those element much accumulated in the shell.

Tea is widely consumed worldwide; it has become an alternative drink to water. Tea comes in various types, including green tea, black tea, and oolong tea. The most consumed tea in the world is black tea, reaching 78% (Zhang *et al.*, 2019). Black tea is not only served as tea, but it also comes with many other additional ingredients, such as jasmine flowers and synthetic flavors, to enrich the taste. However, some ingredients other than tea leaves (*Camelhia sinensis*) can be used as beverages, known as tisane such as rosella flowers, lilies, roses, and others. For example, lilies contains of 82.36 µg Trolox equiv g^{-1} (Chen *et al.*, 2015), whereas roses contain 10.78 µM Trolox equiv 200 mL^{-1} (Kart & Çaðýndý, 2017). In addition to those ingredients, there has been a growing interest in using cocoa bean shells as tisane because these shells have a distinctive taste. Using cocoa bean shells as tisane also represents an added value because the shells are by-products from the chocolate industry. In addition, the phenolic compounds in the shells are a crucial factor for the sensory properties of the products made due to the interaction of polysaccharides, proteins, and products, known as the Maillard reaction, during roasting (Oracz & Nebesny, 2016).

Roasting involves complex chemical transformations and modifications due to heat, the process greatly impacts the taste. Generally, the roasting of cocoa beans lasts for 10 to 35 minutes, with temperatures varying from 100 to 150° C. The high temperature during roasting causes the cocoa beans to dehydrate so that the concentration of the compounds decreases, such as polyphenols, which are responsible for antioxidant activity (Urbañska & Kowalska, 2019). Other compounds are also formed during roasting that contributes to flavor. This study was expected to provide information on the effect of roasting temperature on antioxidant activity, total phenolic content, steeped color, and sensory attributes of cocoa shells used as tisane. It also aimed to analyze the use of cocoa bean shells as food products as a form of food diversification.

MATERIALS AND METHOD

Ingredients

The ingredients of tisane drink consisted of cocoa beans and black tea. The cocoa beans were obtained from the Kaliwining Experimental Station of Indonesian Coffee and Cocoa Research Institute, Jember, East Java. Trinitario cocoa beans were roasted with three temperature variations, namely 100ºC for 20 minutes, 120ºC for 20 minutes, and 140ºC for 18 minutes. After roasting, the beans were cooled and separated from the shells. As comparison we used three different variations of black tea: black tea, jasmine black tea (black tea + jasmine flower), and synthetic flavored black tea (black tea + synthetic flavor).

Roasting

Trinitario cocoa beans of 0.5 kg were roasted using a roasting machine (ICCRITECH, Indonesian Coffee and Cocoa Research Institute, Jember) at 100ºC for 20 minutes, 120ºC for 20 minutes, and 140ºC for 18 minutes.

Deshelling

Roasted cocoa beans were peeled using a desheller mechine (ICCRITECH, Indonesian Coffee and Cocoa Research Institute, Jember).

Extraction

The extraction of cocoa bean shells and black tea followed the previously reported method (Zhao *et al.*, 2019) with slight modification. First, cocoa bean shells were crushed and weighed as much as 1 g, then dissolved in 10 mL of distilled water which was heated in a Thermomix at 80ºC for 5 minutes. After that, the extract was filtered using Whatman filter paper. Then, the filtered extract was centrifuged at 3000 rpm for 10 minutes.

Total Phenolic Content Assay

Total phenolic content (TPC) assay was conducted using the Folin-Ciocalteau method (Siow *et al.*, 2022) with slight modifications. First, a total of 20 μL of the cocoa bean shell and black tea tisane was reacted with 100 μL of 10% Folin-Ciocalteau reagent (Merck KgaA, Darmstadt, Germany) then allowed to stand for 2 minutes before being added with 80 μL of 7.5% (w v^{-1}) Na_2CO_3 solution (Merck KgaA, Darmstadt, Germany). It was then incubated for 30 minutes at room temperature in the dark, and the absorbance was measured at a wavelength of 765 nm. Next, total phenolic content was measured using gallic acid (Sigma-Aldrich, Illinois, USA) as an external standard and expressed in gallic acid equivalent (GAE).

Antioxidant Test

Antioxidants can counteract or neutralize the formation of free radicals. The test on antioxidant activity (radical scavenging activity) was conducted using the DPPH (2,2-diphenyl-1-picrylhidrazyl) method in ascorbic acid (AA). The DPPH method followed the one presented by Siow *et al.* (2022) with a modification. First, a tisane of 50 μL of cocoa bean shell and black tea was reacted with 100 μL of 0.2 mM DPPH (TCI America) solution. After that, the solution was incubated for 30 minutes at room temperature in the dark, and the absorbance was measured at a wavelength of 517 nm.

Color Analysis

The test examined the color formed by the tisane of cocoa bean shells and black tea using a color reader.

Sensory Test

The sensory test involved 20 untrained panelists; screening was conducted to select panelists who could recognize the sensory attributes to be tested through a basic test with 2 intensity scales, low and high. The basic tests presented were (1) the acid test using 0.25 and 0.5% (w v^{-1}) citric acid solutions; (2) the bitterness test using 0.25 and 0.5% (w v^{-1}) caffeine solutions; (3) the astringency test using raw bananas with green and yellowish green skin; (4) the sweetness test using 1 and 2% (w v^{-1}) palm sugar solution; (5) the chocolate test using 1 and 2% (w v^{-1}) cocoa powder solution; (6) the nutty test using 1 and 2% (w v^{-1}) mung beans; and (7) the roasty test using toast for 3 and 5 minutes. The 25 mL base solution was then prepared in a small plastic cup. For each change of the basic test, panelists were required to drink mineral water to neutralize the sense of taste.

A total of 15 panelists were qualified to evaluate the tisane drinks related to acidity, bitterness, astringency, sweetness, chocolate, nutty, and roasty attributes. First, a tisane of 2 g of cocoa shells and black tea was prepared before the sensory test. Then, the tisane drink was put into a glass bottle before being added with 150 mL of boiling water; it was allowed to stand for 5 minutes. After that, the tea was filtered, and 25 mL of the tea was put into a small plastic cup. Each sample contained no added ingredients, such as sugar and milk. For every change in the sample, panelists were required to drink mineral water to neutralize the sense of taste.

Data Analysis

The experimental study applied a completely randomized design (CRD) based on roasting temperature with 3 replications. ANOVA was performed with a 95% confidence level, and a further test was done by least significant different (LSD) using the Minitab 19 software

RESULTS AND DISCUSSION

Total Phenolic Content

The tisane of cocoa shells and black tea contains phenolic compounds that act as antioxidant; the total phenolic content is presented in Table 1. The analysis shows that the samples of cocoa shells and black tea tisane had varied total phenolic content (significantly different, $p < 0.05$). Black jasmine tea has a higher total phenolic content than cocoa shell tisane and other black teas, with a total phenolic content of 41.84 ± 0.48 mg GAE g^{-1}. According to Li *et al.* (2020), jasmine flowers contain 20–31% phenolic content. Cocoa shell tisane with the lowest roasting temperature of 100ºC for 20 minutes has a higher average total phenolic content of 21.55 ± 0.37 mg GAE g^{-1} than cocoa shell tisane with higher roasting temperatures. Cocoa bean shell tisane with the highest roasting temperature has the lowest total phenolic content of 13.31 ± 0.35 mg GAE g^{-1}. In this study, cocoa shell tisane with the lowest roasting temperature has a higher total phenolic content than other roasting temperatures. The finding confirms several previous studies reporting high temperatures degrade or modify phenolic content (Alamilla *et al.*, 2017). The loss of phenolic compounds is associated with thermal decomposition and heat-induced oxidation. Irondi *et al.* (2019) report that phenolic acids that belong to phenolic compounds evaporate easily during heating.

The main phenolic compound in cocoa bean shells is epicatechin (Poveda *et al.*, 2020). According to Kothe *et al.* (2013), the content of epicatechin, which belongs to the flavan-3-ol subgroup, decreases due to the roasting treatment. Therefore, cocoa bean shells that have undergone roasting have lower epicatechin levels than those that have not been roasted (Siow *et al.*, 2022).

Antioxidants

The phenolic compounds in the tisane of cocoa shells and black tea have potential antioxidants; the antioxidant content based on roasting temperature and black is presented in Table 1. The results show that the antioxidant levels and the percentage of inhibition (radical scavenging) in the sample of cocoa bean shell roasted at 100ºC for 20 minutes

Table 1. Total phenolic content and antioxidants in the tisane of cocoa bean shells and black tea

Sample		Total phenolic content (mg GAE g^{-1})	Antioxidants activity (mg AA g^{-1})	Radical scavenging (%)	IC_{50} (mg mL^{-1})
Cocoa bean shells	100ºC, 20 minutes	21.55 ± 0.37^{d}	12.80 ± 0.17^{cd}	85.19 ± 1.28^{cd}	16.71
	120ºC, 20 minutes	18.60 ± 1.09^{e}	12.65 ± 0.09^{d}	84.08 ± 0.67^{d}	21.39
	140ºC, 18 minutes	13.31 ± 0.35^{f}	12.33 ± 0.14^{e}	81.64 ± 1.08^{e}	22.76
Black tea	A	32.43 ± 0.70^{b}	13.39 ± 0.03^{a}	89.71 ± 0.20^{b}	NA
	B	44.84 ± 0.48^{a}	13.63 ± 0.12^{b}	91.53 ± 0.93^{a}	NA
	C	22.88 ± 0.35^{c}	12.95 ± 0.06^{c}	86.34 ± 0.48^{c}	NA

Different notations after numbers show significant differences ($p < 0,05$)
Notes: A: black tea; B: black tea + jasmine; C: black tea + synthetic flavor; NA: not analyzed

were significantly different ($p < 0.05$) from that at a higher roasting temperature. Cocoa shell tisane roasted at 100ºC for 20 minutes has the highest antioxidant content of 12.80 ± 0.17 mg AA g^{-1} than that roasted at a higher temperature (140ºC for 18 minutes) with the lowest antioxidant content of 12.33 ± 0.14 mg AA g^{-1}. In addition, the percentage of free radical scavenging (inhibition) in tisane of cocoa bean shell roasted at 100ºC for 20 minutes was higher (85.19 ± 1.28%) than that roasted at a higher temperature. Conversely, tisane of cocoa bean shell roasted at 140ºC for 18 minutes has the smallest percentage of free radical scavenging at 81.64 ± 1.08%.

Fakhlaei *et al.* (2020) mention that the roasting temperature can reduce antioxidant activity the higher the temperature used in roasting, especially above 140ºC, the lower the antioxidant activity. The percentage of free radical scavenging activity (inhibition) obtained from the graph plotted against the extract concentration of tisane of the cocoa shell was used to calculate the IC_{50} value. This value was one of the parameters used to determine the ability of antioxidants in the sample. The IC_{50} value can be interpreted as the antioxidant concentration needed to reduce the DPPH concentration by 50% (Cruz *et al.*, 2020). Table 1 shows that the tisane of cocoa shells with a roasting temperature of 100ºC for 20 minutes has the lowest IC_{50} value at 16.71 mg mL^{-1}. According to Olugbami *et al.* (2014), the lower the IC_{50} value, the stronger the ability of a sample to act as a free radical scavenger. The IC_{50} value is inversely proportional to the free radical scavenging activity (inhibition); in other words, less amount of the tisane sample of cocoa shells with a low IC_{50} value is needed to counteract free radicals. Free radical scavenging activity in the tisane sample of cocoa bean shells happens due to the presence of antioxidant molecules.

Black jasmine tea was significantly different ($p < 0.05$) from black tea, synthetic flavored black tea, and cocoa shell tisane because the value was followed by different notation. Black jasmine tea, followed by black tea, has the highest antioxidant levels at 13.63 ± 0.12 mg AA g^{1} and 13.39 ± 0.03 mg AA g^{1}. According to Peluso & Serafini (2017), black tea contains polyphenols, flavanols, catechins, and theaflavins, which are responsible for antioxidant activity; black jasmine tea contains additional ingredients of jasmine flowers, thus it has a higher antioxidant activity. Kumaresan *et al.* (2019) report that the jasmine plant has an antioxidant activity, the flowers have higher antioxidant activity than other parts of the plant, such as leaves. Synthetic-flavored black tea has lower antioxidant levels than black tea and jasmine black tea because synthetic-flavored black tea contains additional ingredients in the form of synthetic flavors.

Color

Color is one of the visual parameters that can provide information about the product (Hartuti *et al.*, 2019). In addition, a product's color is correlated with product profile attributes such as sensory and nutritional content (Pathare *et al.*, 2012). One model often used in color measurement is L*a*b* which is one of the international standards for color measurement based on the *Commission International I'Eclairge* (CIE) (Sudarma, 2016). The color of the tisane of cocoa shells and black tea was measured using a color reader, and the color score is presented in Table 2.

Table 2 shows that the highest L* score of 44.23 ± 0.71 was obtained by tisane of the cocoa shell tisane roasted at the lowest temperature of 100ºC for 20 minutes. Cocoa shell tisane with a roasting temperature of 100ºC for 20 minutes has a significantly different L* score ($p < 0.05$) with other tisanes and three variations of black tea. The color measurement

Table 2. L* a* b* score of the tisane of cocoa bean shells and black tea

Sample		Color			Visualization
		L*	a*	b*	
Cocoa bean shells	100^{o}C, 20 minutes	44.23 ± 0.71[a]	7.77 ± 0.42[e]	21.57 ± 0.38[a]	
	120^{o}C, 20 minutes	39.17 ± 0.31[b]	9.57 ± 0.40[d]	15.60 ± 0.46[b]	
	140^{o}C, 18 minutes	37.30 ± 0.46[c]	10.30 ± 0.30[d]	13.63 ± 0.49[c]	
Black tea	A	23.23 ± 0.47[f]	21.60 ± 1.11[a]	4.70 ± 0.36[f]	
	B	29.97 ± 0.42[d]	15.53 ± 0.49[b]	10.73 ± 0.84[d]	
	C	28.30 ± 1.28[e]	16.77 ± 0.81[c]	8.50 ± 1.08[e]	

Different notations after numbers show significant differences ($p < 0.05$)
Notes: A = black tea; B = black tea + jasmine; C = black tea + synthetic flavor

of a* score in black tea samples was significantly different ($p < 0.05$) from the tisane of cocoa bean shells, jasmine black tea, and synthetic-flavored black tea. The cocoa bean shell tisane roasted at 100^{o}C for 20 minutes has the highest b* color score of 21.57 ± 0.38. The cocoa tisane of shell roasted at 100^{o}C for 20 minutes shows a significant difference ($p < 0.05$) from those roasted at a higher roasting temperature and the three variations of black tea.

The L* score indicates the brightness of a product. The L* score decreases significantly with increasing roasting temperature of 100–140^{o}C due to the Maillard reaction and caramelization, which is a non-enzymatic browning process. Roasting leads to the formation or discoloration of brown (Stanley *et al.*, 2018). The higher the roasting temperature, the darker the color produced from the tisane of cocoa shells, indicated by a lower L* value (Oracz & Nebesny, 2019). In addition, the low L* score is due to the formation of melanoidin compounds resulting from the Maillard reaction during the roasting process. A higher roasting temperature will accumulate more melanoidin compounds (Sacchetti *et al.*, 2016). A positive a* score indicates the redness of the cocoa bean shell tisane. The a* value increases with increasing roasting temperature due to the formation of brown pigment through non-enzymatic browning reactions (Maillard reaction) and phospholipid degradation. A positive b* value indicates a yellow color in the product—the yellow color happens because the tisane contains flavanols, a compound of a yellow pigment (Wan *et al.*, 2019). According to Kothe *et al.* (2013), roasting temperatures above 140^{o}C can reduce the flavanol content by 50%.

According to Yadav *et al.* (2020), black tea contains several tannin components in the natural polyphenol group. Tannins are water-soluble polyphenols (Khasnabis *et al.*, 2015). The L* and a* scores indicate the dark color of the steeping caused by the compounds they contain. Tannins can give a dark color, especially brown (Hong, 2018). In addition to tannins, pheophytin in tea also contributes to black or dark color (Chaturvedula & Prakash, 2011); synthetic-flavored black tea and jasmine black tea have a brighter dark color than black tea. Jasmine flowers in black jasmine tea contain some flavonoid components (Kumaresan *et al.*, 2019). In addition, black tea contains some theaflavin components that contribute to the red-orange color (Chaturvedula & Prakash, 2011).

Sensory Attributes

The sensory attributes of the tisane of cocoa shell and black tea, including acidity, bitterness, astringency, sweet, chocolate, nutty, and roasty, were evaluated by 15 panelists. The panelists evaluated the sensory attributes and assessed the sensory intensity of the tisane of cocoa shell and black tea. The sensory attribute scores came from the Kruskal Wallis non-parametric analysis presented in Table 3.

Table 3. Sensory attributes of the cocoa bean shell tisane and black tea

Sensory attributes		Cocoa shell tisane			Black tea		
		100°C. 20 minutes	120°C. 20 minutes	140°C. 18 minutes	A	B	C
		Mean rank					
Taste	Sour	57.4	51.5	38.1	43.4	36.7	46.0
	Bitter	17.4	37.8	54.7	58.5	62.3	42.3
	Astringent	18.7	34.9	49.6	62.6	59.4	47.8
	Sweet	67.3	55.5	40.8	38.0	35.3	36.1
Flavor	Chocolate	60.3	74.2	68.0	23.5	23.5	23.5
	Nutty	52.1	66.9	73.1	27.0	27.0	27.0
	Roasty	37.1	55.8	78.1	34.2	33.5	34.2

Notes: A = black tea; B = black tea + jasmine; C = black tea + synthetic flavor.

Table 3 shows that the sensory attributes of acid were not significantly different ($p > 0.05$) in the tisane of cocoa bean shell and black tea. However, the sensory attributes of bitter, astringent, sweet, chocolate, nutty, and roasty were significantly different ($p < 0.05$). Black jasmine tea has the highest bitter sensory attribute, with a mean rank of 62.3. Black tea has the highest astringent sensory attribute, which is 62.6. The tisane of cocoa shell roasted at 100°C for 20 minutes has the highest sweet sensory attribute of 67.3. The cocoa bean shell tisane roasted at 120°C for 20 minutes has the highest sensory attribute of chocolate at 74.2. The cocoa bean shell tisane roasted at 140°C for 18 minutes has the highest sensory attributes of nutty and roasty of 73.1 and 78.1. Black tea has higher bitter and astringent sensory attributes than the cocoa bean shell tisane, while for other sensory attributes, the tisane of cocoa bean shells scores higher than black tea.

Choi *et al.* (2020) report that the content of flavan-3-ol polymer compounds is the main contributor to astringency. Astringency is a dry, wrinkled, and rough sensation in the oral cavity (Fernandes *et al.*, 2017). Epicatechins, catechins, and procyanidins are phenolic compounds belonging to the flavan-3-ol subclass that are responsible for bitter taste and astringency (McClure & Grün, 2020).

During roasting, a non-enzymatic browning reaction (Maillard reaction) occurs, which leads to the formation of alcohol compounds, pyrazines, aldehydes, ketones, pyrroles, furans, esters which are responsible for the sensory properties that make up chocolate taste. In addition, roasting leads to the formation of cocoa aroma and flavor; and affects the ability of phenolic compounds to interact with proteins. Methylpyrazine formed in the roasting process also contributes to the aroma of nutty, chocolate, cocoa, and roasty, while ketones and esters contribute to the aroma of fruit and flowers (Lemarcq *et al.*, 2020).

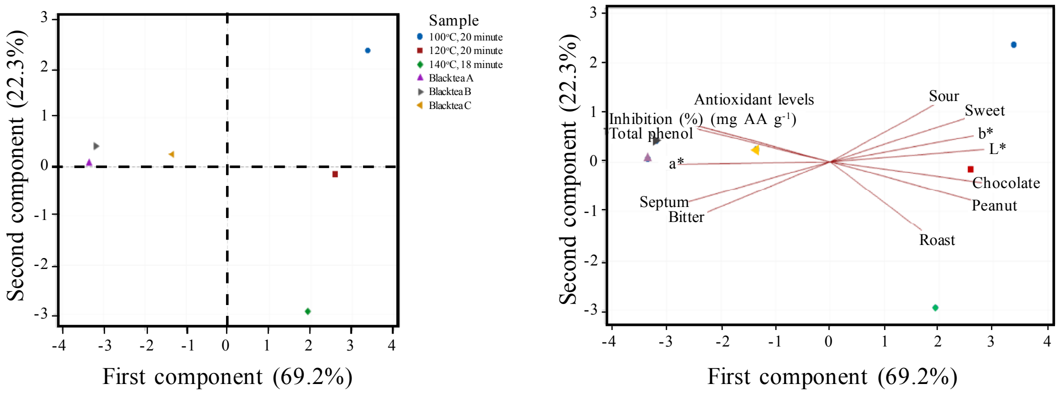
Roasting can also reduce volatile acids, especially acetic acid, which is responsible for acidity (Hinneh *et al.*, 2019); the sour taste is not only caused by acetic acid taste, but also citric, malic, and oxalic acids (Stark *et al.*, 2006). In addition, the sweet taste formed is caused by glucose, galactose, fructose, and amino acids (L-alanine, L-serine, L-proline, and L-threonine) (Stark *et al.*, 2006). The sweet taste from the tisane of cocoa bean shells comes from the fermentation process of cocoa beans (Siow *et al.*, 2022). In this study, the high roasting temperatures led to the loss of sweetness in the tisane of cocoa bean shells.

Phenolic compounds in black tea can cause a bitter and astringent taste. Catechin compounds are the largest contributor of about 70-80% of the total phenol in tea; in other words, catechins are a contributor to the bitter and astringent taste of tea. In addition, flavonoid compounds and caffeine in tea also influence on bitterness and astringency (Zou *et al.*, 2018). Scharbert & Hofmann (2005) confirm that alkaloids (caffeine) and amino acids L-valine, L-leucine, L-isoleucine, L-phenylalanine, and L-tyrosine are components that cause a bitter taste in tea, while theaflavins and catechins cause an astringent taste. Thearubigin in tea also contributes to the astringent sensation in tea (Chaturvedula & Prakash, 2011). Tea also has a sweet taste caused by glucose and amino acids (L-serine, L-alanine, and L-proline).

Correlation between Cocoa Bean Shell Tisane and Black Tea

PCA (principal component analysis) is used for multivariate analysis; it can help visualize information in correlated quantitative data sets. PCA results on total phenol, anti-oxidant levels, free radical scavenging activity (inhibition), L*a*b* color, and sensory attributes of tisane of cocoa bean shells and black tea are presented in Figure 1.

The analysis shows that the eigenvalue of about 90% was obtained using 2 PCs (principle component). PC 1 and PC 2 were able to explain 91.5% of the variation in the data therefore they could represent the existing variables. Total phenol, antioxidant content, antioxidant activity, a* color scores, astringent and bitter sensory attributes greatly affect the first principal component (PC 1), while acid (sour) and sweet sensory attributes, and L* and b* color scores greatly affect the second principal component (PC 2). The first component contributed 69.2% of the total variance, while the second component contributed 22.3% of the total variance. Figure 2 depicts that the PCA biplot of total phenol, antioxidant levels, and inhibition have a positive correlation, while total phenol, antioxidant levels, and inhibition negatively correlate with sensory attributes of chocolate, nutty, and roasty.



a b

Figure 1. Correlation of the attributes of cocoa bean shell tisane and black tea (a) PCA score plot, and (b) PCA biplot

CONCLUSIONS

Black tea had a higher antioxidant content than tisane of cocoa bean shells. Roasting temperature significantly affected the total phenol, antioxidants, color, and sensory attributes of cocoa shell tisane. The higher the temperature in the roasting process, the lower the total phenol and antioxidant content obtained—with a temperature difference of 20°C, a decrease from 2.95 to 5.29 mg GAE g^{-1} was obtained. The high total phenolic content in the cocoa bean shell tisane was significantly correlated with high levels of antioxidants and free radical scavenging activity. In addition, the higher roasting temperature caused the decreased L* and b* color scores of the cocoa bean shell tisane, while the scores of 7.77–10.30, and b* scores of 13.63–21.57. For black tea, the L* scores were around 23.23–29.97, a* scores were around 15.53–21.60, and b* scores were around 4.70–10.73. Sensory attributes of tisane cocoa bean shell changed significantly with increased roasting temperature, including bitterness, astringency, sweetness, chocolate, nutty, and roasty, but not acidity. Cocoa bean shells can potentially be used as an alternative because they contain antioxidant activity and sensory attributes. However, it is necessary to review its safety as a food product, especially related to heavy metal content.

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