



OPTIMIZATION OF BREWING TIME AND TEMPERATURE FOR CAFFEINE AND TANNIN LEVELS IN DAMPIT COFFEE LEAF TEA OF ROBUSTA (*COFFEA CANEPHORA*) AND LIBERICA (*COFFEA LIBERICA*)

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ABSTRACT

Coffee constitutes a plant product high in economic value. Extremely abundant throughout Indonesia, different varieties can be found in each region. Coffee leaves represent a by-product of coffee production which are disposed of without being subjected to further processing. One advantage of coffee leaf waste is that it can be made into coffee leaf tea, to prevent various diseases. The caffeine and tannin content can be optimized by temperature and brewing time. Research on coffee leaf tea remains limited, with little study of Liberica coffee leaf tea. This investigation was to determine the optimal brewing time and temperature of Robusta (*Coffea canephora*) and Liberica (*Coffea liberica*) coffee leaf tea. This research used the Response Surface Methodology (RSM) method with Central Composite Design (CCD). Data analysis using RSM method was conducted incorporating two factors. The first factor was the brewing temperature with a minimum value of 91 °C and a maximum value of 99 °C. The second factor was brewing time with minimum and maximum values of three and seven minutes respectively. Identifying the optimal treatment was based on two factors, caffeine and tannin content. Optimized processes were applied to conduct organoleptic tests on 110 untrained panelists using the Rate-All-That-Apply (RATA) method to highlight the majority attributes experienced by the panelists. The optimal brewing temperature and duration for robusta coffee leaf tea were 93.43 °C and 4.80 minutes which produced caffeine and tannin levels of 74.90 mg.100mL⁻¹ and 293.01 µg.g⁻¹ respectively. In contrast, in the case of Liberica coffee leaf tea, the optimal brewing conditions comprised a temperature of 91.65 °C and duration of 4.84 minutes which produced caffeine and tannin levels of 72.52 mg.100mL⁻¹ and 415.87 µg.g⁻¹. Results of sensory analysis showed that the majority produced five significant characteristics, namely: sweet flavor, fire flavor, sweet taste, bitter taste and astringent mouthfeel.

Keywords: caffeine; tannin; Robusta; Liberica; coffee leaf tea

INTRODUCTION

Coffee represents an extremely abundant plant commodity which can potentially be developed into an increasing source of income for Indonesia. The economic value of coffee is relatively high compared to that of other plantation crops. Moreover, its role as a major source of national income is based on its abundance and range of varieties in each region. According to statistics produced by the **General Directorate of Plantations (2016)**, in 2017 plantations in Indonesia occupied an estimated area of 1,227,787 hectares capable of producing 637,539 tons of coffee. The coffee plantations listed in the statistics include those in the community, state and private sectors. Dampit in East Java, at an altitude of 300 – 460m above sea level, is a renowned coffee producing area (**Malang Electronic Data Manager, 2014**). According to the **Central Statistics Agency of Malang Regency (2018)**, the total coffee production of the Dampit Subdistrict was 2,387 tons from a total cultivated area of 3,373 ha, within

which the seedling area covered 6 ha, the productive plant area 2,965 ha and the mature plant area 372 ha. In Indonesia, several varieties of coffee have been developed, for example, Arabica, Robusta and Liberica. The two former types contain high levels of active compounds such as quilonic acid, pirogalic acid and, particularly, caffeine (**Ciptaningsih, 2012**).

For farmers, the only productive part of coffee plants is their beans which can be processed into drinks or food additives. Being considered waste, coffee plant parts such as the leaves are pruned and discarded. The purpose of pruning is, among other reasons, to improve the quality of coffee, reduce pest attacks and stimulate new growth (**Arief et al., 2011**). Therefore, rather than discarding the coffee leaves, it is necessary to make further use of them in order to maximise coffee farmer income.

Coffee leaves are as delicious as coffee beans and in an example of product diversification, can substitute for tea leaves in the manufacture of tea drinks. Tea itself is a very

common everyday drink that represents the second most consumed beverage after water (Damayanthi et al., 2008). Tea is made from steeping *Camellia sinensis* leaves which have a distinctive flavor and aroma much appreciated by consumers. However, tea can also be made from other plant parts such as rosella flowers, lemongrass stems, soursop leaves, avocado leaves and coffee leaves. This drink is commonly called herbal tea or tisane (Somantri and Tanti, 2011).

At present, coffee leaf tea is relatively unknown, whereas in Sumatra, coffee leaves are used to produce a drink commonly referred to as "Aia Kawa", believed to contain alkaloids, caffeine, saponins, flavonoids and polyphenols that prevent various diseases (Pristiana, Susanti and Nurwantoro, 2017). The caffeine content in coffee leaf drink is lower than that of coffee beans, rendering it an alternative for producers and individuals who want an affordable soft caffeinated drink. Moreover, tea contains tannin compounds and polyphenol, the latter of which functions as an antioxidant. Elements within coffee leaf tea such as caffeine and tannin are beneficial to the body, but must be optimized in order to maximize their positive effects.

Optimizing the beneficial contents of coffee leaf tea drink such as caffeine and tannin can be achieved based on the temperature and duration of brewing. According to Schwalfenberg, Genuis and Rodushkin (2013), both the beneficial and harmful effects of tea depend on the manner in which it is brewed. The longer the tea is soaked, the more caffeine will be extracted, resulting in oxidation. Several previous studies, such as that conducted by Retnaningtyas et al. (2016), have been limited to the use of Arabica and Robusta coffee leaves, while ones relating to Liberica remain rare. Furthermore, caffeine and tannin are yet to be extensively studied. Therefore, it is necessary to conduct research to optimize caffeine and tannin levels within the parameters of brewing temperature and duration. Moreover, such research should be conducted to determine consumer sensory responses to coffee leaf tea characteristics. Sensory responses are required because caffeine and tannin are compounds that contribute to the flavor of the tea. There would be differences between Robusta and Liberica Coffee leaves tea in terms of caffeine and tannin contents due to different brewing temperature and duration. Thus it may change perceived sensory attributes as well.

This research was aimed to provide information and recommendations to agencies with links to agricultural product development, especially coffee farmers, in order to promote greater use of coffee leaves in tea drinks as part of a food diversification program.

Scientific hypothesis

Temperature and brewing time optimization have an influence on caffeine and tannin levels as well as sensory attributes on Robusta and Liberica coffee leaf tea Dampit.

MATERIAL AND METHODOLOGY

Materials

The raw materials used in this study consisted of Robusta and Liberica coffee leaves obtained from the Dampit region of East Java. The testing materials comprised

calcium carbonate, chloroform, distilled water, methanol, folic acid, Na₂CO₃, tannic acid and caffeic acid. The materials employed for organoleptic testing included mineral water and biscuits as palate cleansers. Dampit region is located in East Java, at an altitude of 300 – 460 m above sea level, is a renowned coffee producing area (Malang Electronic Data Manager, 2014). The period of the harvest is every 4 to 6 months in every year.

Method

The raw materials used in this study were fresh Dampit old Robusta and Liberica coffee leaves. Fresh coffee leaves from older mature leaves were washed and then cut into small pieces. After being reduced in size, the coffee leaves were dried in an oven for three hours at a temperature of 90 °C. The dried coffee leaves were subsequently blended to produce coffee leaf powder. The characteristics of the raw materials analysed in this study were used to determine their chemical content consisting of fresh coffee leaves and coffee leaf powder. The chemical parameters adopted for the analysis of raw materials included water content, caffeine content and tannin content.

The methodology applied in undertaking this study was experimental in character, combining Surface Response Method (RSM) and Rate All That Applied (RATA) data. Application of the RSM method involved an optimization process incorporating the Center Composite design available in the Design Expert DX 9 application (Stat-Ease, Inc.) (Maharjan et al., 2014; Montgomery, 2001; Montgomery, 2016). Chemical analysis related to optimization was conducted based on run provided by the software. The optimization process was conducted with three center points or repetitions to obtain 13 runs or experimental treatments, during which the caffeine and tannin levels were analyzed. The research factors applied were those of temperature and duration of the brewing process. The RSM method produced optimization data subsequently subjected to sensory analysis using the RATA method. A CATA evaluation of the product was conducted to determine the sensory attributes present in coffee leaf tea. As shown from the contents of Table 1, panelists were requested to complete the questionnaire by indicating the attributes they experienced when tasting the sample.

For sensory evaluation, the sensory evaluation based on consumer perception was conducted following RATA (Rate All That Apply) method. This experiment was observed according to Completely Randomized Block Design and the data was further analysed on Minitab 17 (Minitab, LLC, Pty Ltd, Australia) with General Linear Model (GLM) followed by Tukey Post-hoc Test.

The questionnaire results relating to the most prominent sensory attributes were further tested using the RATA method. The panelists were asked to complete the questionnaire by assigning ratings to the strength or dominance of the sensory attributes in the sample.

Data Observation and Analysis

The observations in this study were based on analysis of caffeine, tannin, water content, total acid, pH and color. The coffee leaf tea producing optimal levels of caffeine

and tannin was further analyzed by observing sensory properties using the RATA method.

Caffeine Analysis

Caffeine analysis was completed using the spectrophotometric method (Maramis, Citraningtyas and Wehantouw, 2013) which involved adding the sample to hot distilled water, agitating and filtering the resulting liquid prior to adding it to CaCO₃ (calcium carbonate). The coffee solution was placed in a separating funnel and extracted four times, with chloroform being added on each occasion. A bottom layer would be formed that could be removed, with the extract (chloroform phase) subsequently being placed in a rotary evaporator until all the chloroform had evaporated. The solvent-free caffeine extract was deposited in a measuring flask, diluted with distilled water and homogenized. The caffeine level was quantified by means of a UV-VIS spectrophotometer at a wavelength of 275 nm. The results having been obtained, a standard curve representing standard caffeine solution as the equation was $y = ax + b$ and resulted correlation coefficient value in each equation.

Tannin Analysis

Tannin analysis was performed using a spectrophotometric method (de Godoy Pelozo, Carvalho Cardoso and Palazzo de Mello, 2008). The sample was extracted using methanol and the levels measured using a folin ciocalteu reagent that formed a complex with tannin producing a dark green blue color. Color intensity was measured using a spectrophotometer at a wavelength of 755 nm. The tannin concentration was quantified by comparing the sample with a standard tannic acid curve.

Sensory Response Analysis using the RATA Method

Sensory response analysis of coffee leaf tea was performed employing the RATA method. Conducting the test involved 110 untrained panelists, aged 18 – 29, drawn from the surrounding areas of Universitas Brawijaya (Malang). The specified age range was selected because the older the panelists, the less acute their sense of taste (Mojet, Heidema and Christ-Hazelhof, 2003). Sensory testing was performed by completing a questionnaire containing a combination of open and closed questions. The open questions related to the identity of panelists, while the closed questions were designed to elicit their opinions of with regard to the intensity of the perceived attributes of the sample. The resulting data was then recapitulated, processed and analyzed using Minitab to determine the significance of the sensory attributes of the sample. Each rating was scored, followed by the administering of an ANOVA test and a Fischer test.

Statistical analysis

The optimization method used is the Response Surface Method (RSM) method. The RSM methods use a Center Composite Design (CCD) by Design Expert 9 (DX 9) software. Whereas the sensory test uses the Rate-All-That-Apply (RATA) method which is analyzed by the General

Linear Model and Fisher's Post-hoc test using the Minitab 17 software.

RESULTS AND DISCUSSION

Characteristics of Raw Materials

Chemical characteristics of raw materials including the analysis of moisture content, caffeine and tannin content are shown in Table 2.

The contents of Table 2 indicated that the water content contained in fresh Robusta coffee leaves was 75.89%, while that of fresh Liberica coffee leaves was 72.93%. According to Angga et al. (2018), the water content of old tea leaves was approximately 70%. Moreover, research conducted by Kristiningrum, Cahyanti and Wulandari in 2016 into Jember Arabica and Robusta coffee leaves indicated that old coffee leaves had a moisture content of 75.79 – 82.82%. The moisture content of Robusta coffee leaf powder was 6.84%, while that of Liberica was 5.5%. The criterion of good tea quality is a maximum moisture content of 10% (Čížková et al., 2008). The drying process can reduce the moisture content of fresh coffee leaves by approximately 60 – 70% (Deb and Pou, 2016).

The caffeine level in fresh coffee leaves was higher than the level of caffeine in dried coffee leaf powder. The caffeine content of fresh robusta leaves was 0.63%, while that of the powder was 0.23%. The caffeine content of fresh Liberica leaves was 0.43% and the powdered caffeine level was 0.36%. According to the literature, the caffeine content of coffee leaves is relatively low compared to that of coffee beans which is 1.6 – 2.4% (Khotimah, 2014). The amount of caffeine in coffee leaves can vary and is influenced by the cultivation area, growth conditions, environment, season, leaf age and specific production system (Heckman, Weil and Gonzales de Mejia, 2010).

The tannin content of fresh coffee leaves was higher than the that of dried coffee leaf powder. The tannin content of fresh robusta leaves was 19.24%, while that of the leaf powder was 12.27%. The tannin content of fresh liberica leaves was 18.38%, while that of leaf powder was 13.83%. The literature on the subject states that tea leaves contain numerous tannin compounds amounting to 13.76%. These affect both astringence and bitter taste, but both decrease after processing (Karori et al., 2007).

Optimization of Caffeine and Tannin Content of Robusta Coffee Leaf Tea

Optimization of Robusta coffee leaf tea was conducted using the variables of brewing temperature and brewing time. This approach was in accordance with the experimental design of Design Expert 9.0 using Response Surface Methodology (RSM). The observed responses consisted of the caffeine and tannin levels.

The results of the study of the relationship between brewing temperature and duration and the levels of caffeine and tannin are contained in Table 3.

Analysis of the 13 treatment combinations indicated that the response value of caffeine content tended to be low, namely; 67.85 mg.100mL⁻¹, when produced by a brewing process at a temperature of 89.34 °C and of five minutes' duration. The response value of the caffeine level tended to be high at 83.03 mg.100mL⁻¹ which occurred in the

brewing process at a temperature of 99 °C and duration of seven minutes. According to the research conducted by **Putri and Ulfin (2015)**, caffeine content is influenced by the extraction conditions, namely; temperature and extraction duration. The highest caffeine level is found in the temperature of 100 °C. In addition, a longer extraction time can increase the caffeine level in tea. Caffeine is a compound that dissolves readily in hot water. At a temperature of 25 °C its solubility is 2.17 g.100mL⁻¹, while at 80 °C the solubility is 18 g.100mL⁻¹, and at 100 °C, the solubility is 67 g.100mL⁻¹ (**Mumin et al., 2006**).

The tannin level with a high tendency value of 314.857 µg.g⁻¹ resulted from a brewing process at a temperature of 95 °C and of five minutes' duration. Meanwhile, tannin content with a value as low as 225.77 µg.g⁻¹ was obtained at a brewing temperature of 89.33 °C and a brewing time of five minutes. According to **de Hoyos-Martínez et al. (2019)**, all forms of tannin dissolve in water, methanol, ethanol and acetone, demonstrating a high level of solubility that increases when dissolved in hot water. Tannin will break down into pyrogallol, pyrocatechol and phloroglucinol when heated to temperatures of 2,100 F – 2,150 F (98.89 °C – 101.67 °C).

Statistical analysis has demonstrated that increased caffeine content is affected by both the brewing temperature and brewing time. These factors have a significant effect on caffeine content where the higher the linear temperature, the higher the resulting level of caffeine.

Moreover, the higher the water temperature in the brewing process, the greater the ability of water to extract the chemical content of tea and the longer the brewing time. The latter will affect the level of dissolved ingredients, color intensity and aroma. Increasing the brewing time will lengthen the contact time between the hot water and tea, thereby rendering the extraction process more effective (**Saklar et al., 2015**).

Optimization of Brewing Temperature and Time of Robusta Coffee Leaf Tea and Desired Responses

Solution for optimal process based on Design Expert 9.0 application was obtained by determining the desired variable and response criteria and can be seen in Table 4.

In Table 4, the variable criteria for brewing temperature and brewing time chosen were within a specific range. This was because it was expected that the brewing process would be carried out at a temperature and duration between the specified upper and lower limits. In the caffeine content response variable, the selected criteria chosen was that of minimize, because the desired caffeine content was the lowest, thereby rendering it safe for consumption by individuals sensitive to caffeine.

In contrast, the response of the desired tannin content was maximum because to maximize its functional properties such as astringent and antibacterial activity. Based on these criteria, the Design Expert program provides an optimization solution that can be seen in Table 5.

The data in Table 5 indicates that the solution provided by the program had a desirability level of 0.64 or a level of accuracy of the predicted value with an optimization value of 0.64. The desirability value was indicated by the value

of 0 – 1, where the higher the value indicated the more suitable the combination of process parameters obtained to achieve the optimal combination with the desired response variable (**Melati, 2012**). The recommended optimal processing point in terms of brewing temperature was 93.43 °C and of cooking time was 4.80 minutes. The predicted caffeine content following the brewing process was 74.90 mg.100mL⁻¹, while that of tannin was 293.01 µg.g⁻¹.

Optimization of Liberica Coffee Leaf Tea Caffeine and Tanin Content

Optimization of Liberica coffee leaf tea was carried out using variables in the form of brewing temperature and time and in accordance with the experimental design by Design Expert 9.0 using Response Surface Methodology (RSM). The observed responses were caffeine and tannin content. The results of the study of the relationship between brewing temperature and brewing time and caffeine and tannin content can be seen in Table 6.

The optimized caffeine content response represented the amount of caffeine contained in 100 mL of steeped Liberica coffee leaf tea. Based on the analysis of 13 treatment combinations, the response value of caffeine content, which tended to be low at 61.68 mg.100mL⁻¹, was produced by brewing for three minutes at a temperature of 91 °C. The response value of caffeine content which tended to be high at 91.83 mg.100mL⁻¹ resulted from brewing at a temperature of 100.66 °C for five minutes.

The result showed that the highest caffeine content was found following the longest time again range at 100 °C.

The tannin content which had a high tendency value was 464.99 µg.g⁻¹ obtained during a brewing process at temperature of 95 °C and of five minutes' duration. Tannin content tended to have a value as low as 280.57 µg.g⁻¹ obtained at a brewing temperature of 99 °C and a brewing time of three minutes.

Statistical analysis indicated that brewing temperature and time exert a significant influence on caffeine content.

Optimization of Temperature and Time of Liberica Coffee Leaf Tea and Desired Response

The solution for optimal processes based on Design Expert 9.0 application is obtained by determining the desired variable and response criteria as shown in Table 7. In Table 7, the variable criteria for the brewing temperature and brewing time chosen were in a range. This was due to the expectation that the brewing process would be carried out at a temperature and duration between the specified upper and lower limits. In the caffeine content response variable, the criteria chosen was 'minimize', because the desired caffeine content was the lowest. Therefore, it was safe for consumption by those sensitive to caffeine. In contrast, the response to the desired tannin content was 'maximum', due to the optimizing of its functional properties. Based on these criteria, the Design Expert program produced an optimization solution that is contained in Table 8. The solution provided by the program quantified desirability as 0.69. In other words, the level of accuracy of the predicted optimization value was one of 0.69.

Table 1 Sensory Attributes.

Attributes		Description	
Odor	Green	Resembling leaves, vegetables or herbal plants	
	Floral	Reminiscent of jasmine and rose petals	
	Spicy	Possessing the aroma of cloves, pepper or ginger	
	Fruity	Similar to the odor of apples, melons, berries	
	Marine	Resembling seaweed	
	Gouda	Nuts, for example almonds and peanuts	
	Sweet	Sweet like honey, sugar or caramel	
	Fire	Burning like ash or smoke	
	Minerals	Reminiscent of minerals such as metal or chalk	
	Earth	Resembling the odor of soil, moss or compost	
	Wood	Reminiscent of timber such as pine or oak	
	Taste	Sweet	Sweet taste
		Sour	Sour taste
Bitter		Bitter taste	
Flavor	Green	Resembling leaves, vegetables or herbal plants	
	Floral	Similar to the flavor of jasmine and rose flowers	
	Spicy	Spices such as clove, pepper, or ginger	
	Fruity	Fruits like apples, melons, berries	
	Marine	Resembling sea angina or seaweed	
	Gouda	Nuts like almonds, peanuts	
	Sweet	Sweet like honey, sugar, or caramel	
	Fire	Burnt flavors such as ash or smoke	
	Minerals	Resembling minerals like metal or chalk	
	Earth	Resembling soil, moss, or compost	
	Wood	Resembling timber such as pine, oak	
	Mouthfeel	Astringent	Dry and slightly viscous sensation in the mouth
		Oily	Oily sensation in the mouth

Table 2 Raw Material Analysis Data.

Parameters	Robusta		Liberica	
	Leaf*	Powder*	Leaf	Powder
Moisture Content (%)	75.89	6.84	72.93	5.5
Caffeine Content (%)	0.63	0.23	0.43	0.36
Tannin Content (%)	19.24	12.27	18.38	13.83

Table 3 Research Data on Robusta Coffee Leaf Tea.

Std.	"Run"	Factor 1	Factor 2	Response 1	Response 2
		A: Brewing Temperature	B: Brewing Duration	Caffeine Content	Tannin Content
		°C	minute	mg,100mL ⁻¹	µg.g ⁻¹
13	1	95	5	76.55	290.70
8	2	95	7.83	78.68	285.77
1	3	91	3	74.2	231.22
5	4	89.34	5	67.85	225.77
6	5	100.66	5	81.1	254.34
9	6	95	5	76.98	297.71
2	7	99	3	80.2	241.61
3	8	91	7	75.7	265.51
12	9	95	5	76.93	314.86
7	10	95	2.17	70.93	262.13
4	11	99	7	83.03	281.61
10	12	95	5	77.15	305.51
11	13	95	5	77.3	304.21
13	1	95	5	76.55	290.70

Table 4 Criteria for Variables and Desired Responses.

Name	Goal	Limit	Limit	Importance
Brewing Temperature	within range	91	99	3
Brewing Time	within range	3	7	3
Caffeine Content	minimize	67.85	83.03	3
Tannin content	maximize	225.77	314.86	3

Table 5 Robusta Coffee Leaf Tea Optimal Temperature Point and Brewing Time.

No.	Brewing Temperature	Brewing Time	Caffeine Content	Tannin Content	Desirability
1	93.43	4.80	74.90	293.01	0.64 Selected

Table 6 Research Data on Liberica Coffee Leaf Tea.

Std.	"R"	Factor 1	Factor 2	Response 1	Response 2
		A: Brewing Temperature	B: Brewing Duration	Caffeine Content	Tannin Content
		°C	minute	mg.100mL ⁻¹	µg.g ⁻¹
13	1	95	5	80.08	446.29
8	2	95	7.83	83.5	388.36
1	3	91	3	61.68	320.57
5	4	89.34	5	71.98	376.68
6	5	100.66	5	91.83	320.57
9	6	95	5	81.08	399.01
2	7	99	3	86.55	280.57
3	8	91	7	75.18	392.52
12	9	95	5	79.95	398.23
7	10	95	2.17	76.65	290.44
4	11	99	7	80.31	345.25
10	12	95	5	79.45	455.64
11	13	95	5	80.23	464.99
13	1	95	5	80.08	446.29

Table 7 Criteria for Variables and Desired Responses.

Name	Goal	Limit	Limit	Importance
A: Brewing Temperature	is in range	91	99	3
B: Brewing Time	is in range	3	7	3
Caffeine Content	minimize	61.68	91.83	3
Tannin Content	maximize	280.57	464.99	3

Table 8 Liberica Coffee Leaf Tea Optimal Temperature Point and Brewing Time.

No.	Brewing Temperature	Brewing Time	Caffeine Content	Tannin Content	Desirability
1	91.65	4.84	72.52	415.87	0.69 Selected

Desirability value was indicated by a value between 0 and 1, where the higher the value the greater the suitability of the combination of process parameters obtained to achieving the optimal combination with the desired response variable (Melati, 2012). The recommended optimal processing point was 91.65 °C for brewing temperature and 4.84 minutes for cooking time. The prediction result of caffeine content obtained from the brewing process was equal to 72.52 mg.100mL⁻¹ with a tannin content of 415.87 µg.g⁻¹.

Sensory Characterization of Coffee Leaf Tea Panelist Profiles

The panelists involved in testing the sensory characteristics of coffee leaf tea were untrained individuals of average intelligence who had not been formally trained, but were capable of differentiating and communicating the reactions resulting from organoleptic assessment (Ayustaningwarno, 2014). The 110 participating panelists were composed of 24 males and 86 females as shown in Table 9.

The age range of panelists in this study was one of 18 – 29 years. Based on research conducted by Hanspal (2010), tea is most popular among consumers within the 18 to 36 years age range. Significantly, the declining sense of taste of panelists will compromise their ability to differentiate between flavours from the age of 45 (Choi, 2019).

Sensory Attribute Characterization of Robusta and Liberica Coffee Leaf Teas Using the RATA (Rate-All-That-Apply) Method

The measuring of sensory attributes used the RATA sensory evaluation method (Rate-All-That-Apply). This represents a sensory evaluation method utilizing a questionnaire instrument in which there are intensities

for each sensor attribute. The RATA method requires panelists to select the intensity of sensory attributes of the product. Response boxes can be left blank if no attributes are detected in the product (Ares et al., 2014). The intensity used to describe the sensory attributes in the questionnaire ranged from numbers 1 – 5. Attribute number 1 represents ‘Very lacking’, number 2 ‘Lacking’, number 3 ‘Moderate’, number 4 ‘High’ and number 5 ‘Very high’. After completion of the questionnaire, panelist responses to coffee leaf tea were presented in a spider chart contained in Figure 1. The responses represented the average intensity of the sensory attributes from 110 panelists.

Table 9 RATA Sensory Panelist Profile Analysis of Coffee Leaf Tea.

No.	Item	Item Options	Number of People
1.	Sex	a. Male (M)	24
		b. Female (F)	86
2.	Age	a. 18 – 21 (Late teen)	53
		b. 22 – 29 (Early adulthood)	57

Table 10 Sensory Attributes of Coffee Leaf Tea Resulting from Different Leaf Types.

Attributes	<i>p</i> -value (Coffee Leaf Type)
Sweet Flavor	0.005
Fire Flavor	0.001
Sweet taste	0.000
Bitter Taste	0.000

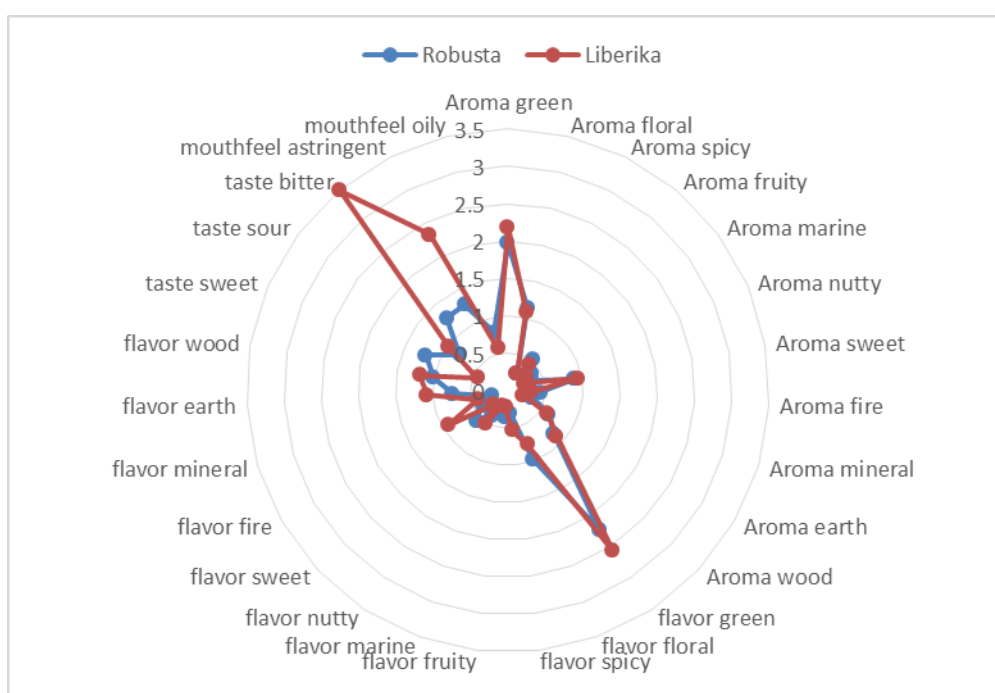


Figure 1 Average Response of the Intensity of Robusta and Liberica Coffee Leaf Tea Sensory Attributes.

Panelist Responses to Coffee Leaf Tea Sensory Attributes to Leaf Types

This study used samples of Robusta and Liberica coffee leaves brewed in accordance with the optimal brewing process solution obtained from the Design Expert application. Robusta coffee leaves were brewed at 93.43 °C for 4.80 minutes. In contrast, the Liberica coffee leaves were brewed at a temperature of 91.65 °C for 4.84 minutes. After sensory evaluation, the data was processed using ANOVA test on Minitab 17 software. The results of the *p*-value analysis of sensory attributes that differed significantly according to the specific variety of coffee leaves can be seen in Table 10.

Data analysis of *p*-value variance for the sensory attributes of the different types of Robusta and Liberica coffee leaves confirmed the existence of five significantly different sensory attributes (*p*-value <0.05), namely: sweet flavor, fire flavor, sweet taste, bitter taste and astringent. The results were significantly different indicating that the panelists experienced a difference in the intensity of the sensory attributes of coffee leaf tea present in the different types of coffee leaves. The analysis results were subsequently subjected to Fisher tests of significantly different sensory attributes.

Sweet Flavor

Sweet flavor is a flavor often associated with the impression of sweetness in items such as fruits and flowers. Sweet Flavor is also considered to be contained in sugar, honey, or caramel (Lee and Chambers, 2007). The ANOVA test result indicated that the variance in sweetness in the different types of coffee leaves differed significantly. It can be concluded that the sweet flavor attribute will become stronger when approaching number 5 and weaker when approaching number 0. The different notation in each sample shows them to be significantly different. Sweet flavor in steeped tea leaves can be contributed to by simple sugars contained in coffee leaves such as glucose, sucrose, fructose, and various volatile compounds such as linalool, dihydroactinidiolide, coumarin, and phytol (Lee, Chambers and Chambers, 2013). Compounds that also contribute to sweet flavor, include: nerol, phenylacetaldehyde, 5-octanolide, menalool oxide and geraniol (Yashin et al., 2015). Liberica coffee leaves had a sweeter flavor because it contained more glucose, sucrose, fructose, and various volatile compounds than Robusta leaves.

Fire Flavor

Fire flavor is associated with the aroma of soil, ash, roasted pepper, coffee and smoke, in addition to heat in the throat (Kim, Lee and Kim, 2016). ANOVA analysis of fire flavor response in the various types of coffee leaves indicated significant differences. It can be concluded that the fire flavor attribute strengthens when approaching number 5 and weakens when approaching 0. The different notation in each sample shows it to be significantly different. Fire flavor in steeped tea leaves can be contributed to by 1-ethyl-1H-pyrrole-2-carboxaldehyde, 3-ethyl-4-methyl-1H-pyrrole-2,5-dione, 3-ethyl-3-methyl-2,5-pyrrolidinedione, coumarone, and coumarine (Yashin et al., 2015).

In addition, research undertaken by Angga et al. (2018) found five aromatic compounds burning in coffee leaves, namely: 2-furanmethanol, safranal, benzeneethanol (CAS), guaiacol and 3,5-cocoa pyrazine.

Liberica coffee leaves had a more fire flavor because it contained more safranal, guaiacol, coumarone and coumarine than Robusta leaves.

Sweet taste

Sweet taste is caused by aliphatic organic compounds containing hydroxy groups (OH), several amino acids, aldehydes and glycerol which are commonly found in food containing simple carbohydrates (Diez-Simon, Mumm and Hall, 2019).

The results of ANOVA analysis of sweet taste response to the differences in the types of coffee leaves varied significantly. It can be concluded that the sweet taste attribute will become stronger when approaching number 5 and weaker when approaching number 0. The contrasting notation in each sample shows it to be significantly different. Sweet taste is often associated with aldehydes and ketones which contain carbonyl groups (Chang, Waters and Liman, 2010). According to research conducted by Angga et al. (2018), coffee leaves contain 15 aldehyde group compounds, six alcohol group compounds and four ketone group compounds. Furthermore, sweet taste is also considered a pleasant sensation produced by the presence of sugar and several other substances. Liberica coffee leaves had a sweeter taste because it contained more aldehyde and ketone than Robusta leaves.

Bitter Taste

Bitter taste is caused by the presence of phenol compounds, flavonoids, isoflavones, terpenes and glucosinolates which exude a bitter, sharp or astringent odor (Drewnowski and Gomez-Cameron, 2000). The results of ANOVA analysis of bitter taste response to the differences in the types of coffee leaves varied significantly. It can be concluded that the bitter taste attribute will strengthen when approaching number 5 and weaken when approaching number 0. The contrasting notation in each sample showed that it was significantly different. Liberica coffee leaves had a much more bitter taste in the ratings because it contained more flavonoid and tannin than Robusta leaves.

Compounds that contribute to bitter taste in tea are phenolic compounds such as flavonoids (quercetin), flavans (catechins, epicatechin and epicatechin gallate, epigallocatechingallate). High levels of flavonoid and tannin in tea contribute to an increase in the bitter taste of tea (Mahmood, Akhtar and Khan, 2010).

Astringent Mouthfeel

Mouthfeel is a physical sensation in the oral cavity caused by food or drink but which differs from taste (Mouritsen and Styrbæk, 2017). Astringency constitutes dryness in the mouth and a slight sensation of stickiness caused by the presence of astringent substances in plants (in the form of leaves, flowers and fruit) that are not yet ripe (Laaksonen, 2011). Rossetti et al. (2009) state that astringent substances are able to constrict body tissue where the lubricant is produced and disappears due to the

deposition of proteins contained in the saliva that lines and lubricates the oral cavity. The result of ANOVA analysis of astringent response to variations in the types of coffee leaves was significantly different. It can be concluded that the astringent attribute will get stronger when approaching number 5 and weaker when approaching number 0. Varying notation in each sample shows that the sample is significantly different. Liberica coffee leaves had a much more astringent mouthfeel because it contained more caffeine, tannin and catechin than Robusta leaves. Astringence is important in determining the sensory quality of drinks such as tea, coffee, juice or wine. The compounds that play the most dominant role in influencing astringence are tannin and catechin. Moreover, astringence is also caused by caffeine and flavonol glycosides (Zhang et al., 2018). In addition to five significantly different attributes, 22 sensory attributes exist that are not significantly different from the various types of coffee leaves.

CONCLUSION

The temperature and length of time required to optimize caffeine and tannin levels in Robusta coffee leaf tea are 93.43 °C and 4.80 minutes respectively. The caffeine level of Robusta coffee leaf tea with optimal steeping amounted to 74.90 mg.100mL⁻¹ and Robusta coffee leaf tea tannin level with optimal steeping amounted to 293.01 µg.g⁻¹. On the other hand, the brewing temperature and time required to optimize the levels of caffeine and tannin in Liberica coffee leaf tea are 91.65 °C and 4.84 minutes respectively. The caffeine level in Liberica coffee leaf tea with optimal steeping is 72.52 mg.100mL⁻¹, while the level of Liberica coffee leaf tea tannin with optimal steeping is 415.87 µg.g⁻¹. Sensory responses of consumers towards Robusta and Liberica coffee leaf tea that have been optimized for caffeine and tannin levels indicate five significant attributes, which are sweet flavor, fire flavor, sweet taste, bitter taste and astringent mouthfeel.

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