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Sensory profiling of Robusta and Liberica coffee leaves functional tea by modifying brewing temperature

K. Fibrianto¹, K A Daryanto¹, N Sholihah¹, L Y Wahibah¹, N Hasyati¹, A N Al-Baarri² and D M Hariyadi³

¹Brawijaya Senso-Gastronomy Center, Faculty of Agricultural Technology, Universitas Brawijaya, Malang, Indonesia
²Faculty of Animal and Agricultural Sciences, Diponegoro University, Semarang, Indonesia
³Faculty of Pharmacy, Airlangga University, Surabaya, Indonesia

E-mail: kiki.fibrianto@ub.ac.id

Abstract. Traditionally, the coffee leaves, particularly the mature, is mostly used as compost or cattle feed. The leaves have also been traditionally processed as herbal tea in which popular in West Sumatera as Kahwa tea. This current study aims to characterise the sensory profile of Robusta and Liberica coffee leaves tea using Rate All That Apply (RATA) method. Not only profiling, but optimising the sensory acceptance of the coffee leaves tea is also required. The sensory optimisation was conducted by applying Just about Right (JAR) method. Both RATA and JAR evaluation were involving 110 consumer respondents. All coffee leaves tea was brewed by decoction technique ranging from 85 - 100°C. There are 7 out of 27 sensory attributes which were significantly affected by brewing temperature. These are sweet flavour, burnt flavour, earthy flavour, woody flavour, sweet and bitter taste, and astringent mouth-feel. Penalty analysis of JAR data shows that sweet taste, bitter taste and astringent mouth-feel of Robusta coffee leaves were optimum at 95°C. Meanwhile Liberica coffee leaves tea was optimum at 85°C for most attributes except woody flavour. To some extent, the changes of sweet, bitter taste and astringent mouth-feel attributes are correlated to caffeine and total phenolic compound.

1. Introduction

It has been common that most of the traditional coffee farmers in Indonesia focus on producing coffee beans which then sell it directly to the market. The coffee is a seasonal plant, which the harvesting time is only 1 or 2 periods over the year for Arabica and Robusta. As most of traditional coffee farmers only rely on coffee beans production for income, product diversification may increase their earnings. Coffee leaf as one part of coffee plants has been traditionally processed as “Kawa Daun”, an authentic drink from Minangkabau, West Sumatera. Coffee leaves have been reported comprising of chlorogenic acid and mangiferin, which pose high antioxidant effects [1]. Therefore, this traditional drink can be further developed as functional tea.

According to previous literature, it has been reported that under an optimum condition for brewing, the coffee leaves tea, particularly from old leaves produces a tea-like taste and colour with a subtle coffee aroma with superiority in total phenolic content [2]. Further aromatic profile as performed by GC-MS was also reported that green aroma compounds such as 2-furanmethanol (CAS), 2-heptanol...
(CAS), 2-heptanol (CAS), safranal, beta-cyclocitril, hexanal (CAS), 4-heptanal(Z)- (CAS), benzeneacetaldehyde, benzaldehyde, nonanal, and alpha-ionone were dominant [3].

While investigation of Robusta and Arabica coffee leaves tea have been reported, to date, there is no publication related to Liberica coffee leaves tea. Since both Robusta and Liberica are both types of coffee plants cultivated in Indonesia, the sensory profiles of both coffee leaves tea is important to characterise. Further investigation is also required to optimise their sensory profiles as well as their functional properties of brewed coffee leaves tea.

2. Materials and Method

2.1. Samples

The coffee leaves, both Robusta and Liberica were taken from Amadanom, Dampit, Malang, and South East Java at an altitude of 300-460 MASL. They were considered as old leaves, in which taken from third to the eight leaves from the bud. The leaves then dried at 90°C for 4 hours and grounded to get coffee leaves powder. The leaves powder were brewed by decoction method (boiling tea into hot water) with a ratio of 1: 100 (1 gram of tea powder in 100 ml of water) at various temperatures of 85°C, 90°C, 95°C and 100°C for 5 minutes. There were 8 samples for both types of coffee leaves tea. Each sample was served in 25 ml paper cups at sensory booth temperature (26±1 °C). Mineral water and plain crackers were provided and instructed to panellists as a palate cleanser between samples.

2.2. Total phenolic analysis

For the total phenolic compound analysis, 0.1 ml of the sample was diluted in 1 ml methanol with a ratio of 1:10. Then 0.2 ml of diluted sample was taken in the test tube, and mixed with 0.8 ml Na₂CO₃ (10%) and 1 ml of Folin-Ciocalteu reagent (7.5%) until it was entirely homogeny mixed. The mixture was covered with aluminium foil for 30 minutes. The absorbance was measured at 765 nm. The standard curve was made in the same way by replacing the sample with gallic acid standard.

2.3. Caffeine analysis

Dried coffee leaf tea (2 grams) was extracted by adding 100 ml of distilled water and simming for 5 minutes before filtering. Exactly 2 g of CaCO₃ (PA Merck) was added to the filtrate and then heated for 5 minutes and cooled at room temperature. A separating funnel was inserted and 15 ml of chloroform (technical grade, Merck) as well as 2 ml of the mixture. After separated, the bottom layer was taken. This step was repeated 3 times. The diluted extract was then injected UV-Vis 270-300 nm spectrophotometer.

2.4. Sensory evaluation

The study involved 110 untrained including male panellists (n=28) and female panellists (n=82) between 18 and 32 years old. The main requirement for panellist recruitment is that panellists get used to drink tea or coffee, as well as not being allergic to tea or coffee. Panellists conducted tests at the Sensory Analysis Laboratory, Faculty of Agricultural Technology, Universitas Brawijaya, Malang.

The study was conducted in two stages. First, RATA (Rate-All-that-Apply) method was applied to profile sensory attributes of the coffee leaves tea [4]. Samples were presented randomly for each panellist, so that none of the panellists experience same sequence and thus avoids bias. The panellists were asked to rate 27 attributes according to the intensity of perceived attributes on 5 point structured scale: (1= very low, 2= low, 3= medium, 4= high and 5= very high). This RATA data was analysed by the General Linear Model (GLM) Analysis of Variance (ANOVA) on MINITAB 17. Furthermore, the Pearson Correlation Coefficient (PCC) correlation test was conducted on total phenolic content and caffeine and related sensory attributes.

At the second step, all significant attributes obtained from first stage were further checked related to their preference and acceptance. Panellists were asked to measure sensory attributes with intensity: (1= very low, 2= low, 3= JAR (appropriate), 4= strong, and 5= very strong) in combination with hedonic scale and consumer acceptance. JAR data will be processed using XLSTAT.
3. Results and Discussion

3.1. Characterisation of the sensory attributes of Robusta coffee leaf tea and Liberica using the RATA method

As shown by Table 1, there are 7 out of 27 sensory attributes which were significantly perceived (p-value <0.05) as affected by different types of coffee leaves. Those included sweet flavour, burnt flavour, earthy flavour, wood flavour, sweet taste, bitter taste, and astringent mouth-feel. Except for sweet taste and sweet flavour, Liberica shows higher intensity among the 7 attributes. Sweet flavours in steeping coffee leaf tea can be influenced by simple sugar content in coffee leaves. It was reported that coffee leaves contain glucose, sucrose, and fructose [5] which affect sweet flavour in steeping leaves tea.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>p-value (Types of Coffee Leaves)</th>
<th>Robusta</th>
<th>Liberica</th>
<th>p-value (Brewing temperature)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweet Flavour</td>
<td>0.000</td>
<td>0.81</td>
<td>0.49</td>
<td>0.871</td>
</tr>
<tr>
<td>Burnt Flavour</td>
<td>0.000</td>
<td>0.48</td>
<td>0.93</td>
<td>0.201</td>
</tr>
<tr>
<td>Earthy Flavour</td>
<td>0.000</td>
<td>1.05</td>
<td>1.48</td>
<td>0.220</td>
</tr>
<tr>
<td>Woody Flavour</td>
<td>0.000</td>
<td>1.15</td>
<td>1.73</td>
<td>0.655</td>
</tr>
<tr>
<td>Sweet Taste</td>
<td>0.000</td>
<td>1.06</td>
<td>0.34</td>
<td>0.865</td>
</tr>
<tr>
<td>Bitter Taste</td>
<td>0.000</td>
<td>1.60</td>
<td>4.05</td>
<td>0.169</td>
</tr>
<tr>
<td>Astringent</td>
<td>0.000</td>
<td>1.29</td>
<td>2.11</td>
<td>0.939</td>
</tr>
</tbody>
</table>

Notes: The data is presented as mean ± standard deviation for 3 replicates. Different letter notation indicates a significant different (p-value<0.05) between type of leaves

As reported, burnt flavour is mainly affected by furan compounds [6]. Those are specifically included 3,5,5-Trimethyl-2 (5H) -furanone compound and 5,6,7,7a-tetrahydroydro-4,4,7a-trimethl-2 (4H) -benzofuraone which gives a strong burning aroma. In this current study, earthy flavour was also detected. The presence of earthy flavour can be attributed by compounds 2-6-Dimethyleyclohexanol and 2-isobutyl-3-methoxypyzaine [7]. Woody flavour was also perceived significantly (p-value<0.05). This woody flavour can be attributed by aromatic compounds such as beta-ionone, pentanal, alphan-ionone, and 2-penten-1ol [8]. In addition, benzaldehyde compounds were reported constituting woody and burnt aroma [9].

In this current study, sweet taste of Robusta leaf tea was more intense than that of Liberica leaf tea. It has been suggested that sweet sensations are produced by various groups of compounds, groups of sugars, amino-peptide-protein, and benzene derivatives and other hydroxy compounds such as alcohol and glycol [10]. Not only sweet taste, bitter taste was also perceived significantly (p-value<0.05) on both Robusta and Liberica coffee leaf tea. The bitter taste can be attributed by several components such as caffeine, L-isoleucine, L-leucine, L, phenylalanine, L-tyrosine, L-valine. Most are amino acid groups except caffeine which is an alkaloid group [10]. Strong astringent mouth-feel was perceived significantly on Liberica coffee leaf tea. The astringent mouth-feel can be attributed by the presence of phenolic compounds such as catechins and tannins which contribute to the fluctuations of astringencies by working with proteins in saliva or proteins at certain taste receptors [11].

3.2. Optimisation of Robusta and Liberica coffee leaves tea attributes using the penalty analysis method

As represented by Figure 1 and Figure 2, the mean drops plotted versus the percentage of panellists who responded to each attribute of the products tested were evaluated. The plot is divided into four subplots using vertical lines that represent 20% of consumers. The top right subspace contains important attributes (more than 20% of consumer ratings) that must be emphasised during product development. As observed for Robusta coffee leaves brewed on 85 °C the largest percentage of consumers (about
61.82% stated that the sweet taste and sweet flavour was “too little”. The sweet taste was considered by most of the panellists as “too little”. Less than 40% rate the wood flavour as “too little” and by less than 20% the sweet flavour, sweet taste, and astringent were “too much” (Robusta coffee leaves on 90 °C). Smaller percentage rated the sweet flavour as “too much”, burn flavour, earthy flavour was considered as “too little” by nearly 50% of the consumers (Robusta coffee leaves on 95 °C). The woody flavour was rated as “too much” by 30% and about 37% felt like the bitter taste “too little”. Minority (more than 20% though) rated bitter taste as “too much” and the sweet taste “too little”. (Robusta coffee leaves on 100 °C).

The largest percentage of consumers (90%) considers the bitter taste “too much” and sweet taste as “too little” (Liberica coffee leaves on 85 °C). The sweet taste was considered by the most of the panellists as “too little”. Less than 55% rate the burn flavour, earthy flavour, and wood flavour as “too little” and by less than 70% the astringent were “too much” (Liberica coffee leaves on 90 °C). Smaller percentage rated the bitter taste as “too little”. Astringent was rated as “too much” by 30% and about 0.91% felt like the bitter taste “too little” (Liberica coffee leaves on 95 °C). Majority of the consumers perceived the sweet taste as “too little”. Larger percentage considered the astringent as “too much” (Liberica coffee leaves on 100 °C).

**Figure 1.** Mean drop plot of all the four evaluated products. Products from top left to bottom right: Robusta coffee leaves tea on (A) 85°C; (B) 90°C; (C) 95°C; (D) 100°C. The too low endpoint of the JAR scales are highlights with red, the too strong endpoint is highlighted with blue. The dashed line represents the 20% of the consumers.
Figure 2. Mean drop plot of all the four evaluated products. Products from top left to bottom right: Liberica coffee leaves on (A) 85°C; (B) 90°C; (C) 95°C; (D) 100°C. The too low endpoint of the JAR scales are highlighted with red, the too strong endpoint is highlighted with blue. The dashed line represents the 20% of the consumers.

It has been reported that the higher the brewing temperature the higher the total phenol extracted [12]. High temperature solvents can increase the efficiency of the extraction process because heat can increase cell wall permeability, increase solubility and diffusion of extracted compounds and reduce solvent viscosity, but temperatures that are too high can reduce polyphenol compounds. It was also suggested that the longer extraction time for green tea, the phenolic content tended to decrease [13]. If the brewing time exceeds 5 minutes, it produced a very dark steeping colour, and led to bitter taste and aroma [14]. The results of total phenolic level and caffeine concentration of Robusta and Liberica are presented in Table 2.

The temperature of brewing which produced the highest functional properties was obtained from the brewing temperature of 100 °C for Robusta coffee leaf tea, where the total phenolic content was 38.73 mg GAE/g and the caffeine content was 0.19%. Meanwhile, under the same brewing condition, Liberica coffee leaf tea consisted of 42 mg GAE/g total phenolic content and 0.26% of caffeine content. The higher the caffeine, the higher the bitter intensity would be. The bitter taste is also to some extent may be contributed by phenolic compounds.
Table 2. Total phenolic content and caffeine of Robusta and Liberica leaves tea

<table>
<thead>
<tr>
<th>Sample</th>
<th>Brewing Temperature</th>
<th>Total phenol (mg GAE/100 mL)</th>
<th>% caffeine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robusta</td>
<td>85 °C</td>
<td>23.9 ± 2.51 c</td>
<td>0.109 ± 0.005 d</td>
</tr>
<tr>
<td>Robusta</td>
<td>90 °C</td>
<td>28.1 ± 4.12 bc</td>
<td>0.140 ± 0.009 c</td>
</tr>
<tr>
<td>Robusta</td>
<td>95 °C</td>
<td>35.3 ± 4.46 b</td>
<td>0.166 ± 0.006 b</td>
</tr>
<tr>
<td>Robusta</td>
<td>100 °C</td>
<td>38.7 ± 0.27 a</td>
<td>0.194 ± 0.011 a</td>
</tr>
<tr>
<td>Liberica</td>
<td>85 °C</td>
<td>14.6 ± 0.31 c</td>
<td>0.167 ± 0.006 d</td>
</tr>
<tr>
<td>Liberica</td>
<td>90 °C</td>
<td>16.9 ± 1.20 bc</td>
<td>0.204 ± 0.008 c</td>
</tr>
<tr>
<td>Liberica</td>
<td>95 °C</td>
<td>22.7 ± 3.05 b</td>
<td>0.240 ± 0.005 b</td>
</tr>
<tr>
<td>Liberica</td>
<td>100 °C</td>
<td>42.0 ± 0.79 a</td>
<td>0.264 ± 0.010 a</td>
</tr>
</tbody>
</table>

Notes: The data is presented as mean ± standard deviation for 3 replicates. Different letter notation indicates a significant different (p-value<0.05) among brewing temperatures for the same leaves tea.

4. Conclusions
Based on the results of the penalty analysis, Robusta coffee leaf tea brewed with decoction technique at 95 °C produced an optimum sensory attributes for sweet taste, bitter taste and astringent-mouth-feel. Meanwhile at 85 °C brewing temperature for Liberica, most of the attributes was optimum except woody flavor. Considering the sensory assessment as well as its functional properties, Robusta coffee leaf tea tend to be more superior to that of Liberica due to its lower caffeine but higher total phenolic compound.

References


