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Brewing optimization for functional properties and visual appearance of Dampit Robusta coffee leaves tea

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KEYWORDS

Brewing technique

Optimization

Robusta coffee leaf

ABSTRACT

Coffee leaf tea is made by drying coffee leaves in an oven at 70°C for 4 hours. The quality of coffee leaves tea does not only depend on the process of making tea but also the way the tea is brewed. There were 2 types of brewing techniques investigated in this study, namely infusion and decoction. Response Surface Methodology (RSM) was conducted to optimize the brewing time and temperature for obtaining highly functional coffee leaves tea with optimum total phenolic content (TPC) and antioxidant activity. The Rate-All-That-Apply (RATA) sensory technique was then applied to determine the sensory characteristics of coffee leaf tea. It was observed that optimum tea quality brewed by hot infusion technique was obtained at 80.03°C for 10.4 minutes while that of decoction technique was obtained at 95.38°C for 5.7 minutes. The coffee leaves tea brewed by decoction technique have higher total phenolic content, tannin and antioxidant activity than that of infusion technique (p-value<0.05). Even though the functional properties of coffee leaves tea such as total phenolic content and antioxidant activity, tended to be lower than that of commercial black tea, the coffee leaves tea is still more superior than that of tea leaves that prepared as the process of coffee leaves tea. The coffee leaves tea that brewed by both decoction and infusion techniques were well accepted by consumer panel.

Introduction

Coffee plants are pruned regularly every year. Pruning aims to optimize coffee beans production (Crane et al., 2006). However, abundant coffee leaves waste coming from this maintenance process is normally being processed as compost. This coffee leaves can also be processed in to a herbal drink to increase its economic value as it has potential functional properties.

The herbal drink or tea made from coffee leaves have been known in several places such as Sumatra, Ethiophia and South Sudan (Fibrianto et al., 2019). Coffee leaf herbal tea in which popular as ‘Kawa Daun’ or ‘Kopi Kawa’ is one of the typical Indonesian drinks, precisely originating from Sumatra. The drink was originally made as affordable coffee substitute (Ratanarmo et al., 2017). Therefore, a roasting process is also involved to prepare traditional ‘Kawa Daun’; a lighter version of coffee drink that was more similar to tea. Dampit robusta coffee leaf tea is made by drying coffee leaves in an oven at 70 °C for 4 hours.

The technique of brewing herbal teas (tisane) varies widely around the world, based on traditions and health goals. In general, there are 3 tea brewing techniques, namely infusion, decoction, and maceration. Infusion is a brewing technique in which herbal substances are poured with boiling water and left for 5-15 minutes. This technique is suitable for substances such as leaves, flowers, and other tender parts of plants. Decoction is a technique of brewing a drink by pouring cold water over the substance, then boiling it for 15-30 minutes. Maceration is a technique in which a substance is immersed in water at room temperature for 30 minutes. Decoction and maceration techniques are suitable for brewing roots, rhizomes, and bark (Kaur et al., 2018).

As tea, the quality of coffee leaves tea is highly effected by the brewing techniques. Brewing techniques with optimum temperature and time are very important to determine the quality of dissolved ingredients, taste, aroma and colour intensity. During tea brewing, alkaloids, catechins and

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tannins which affect bitter, astringent, and unpleasant sensations are extracted (Matthews, 2010).

To date, the research on coffee leaves tea has been more focused on characterization of bioactive compounds, such as phenolic compound and alkaloids (Trevisan et al., 2016; Campa et al., 2012). Meanwhile the sensory quality of this drink is less discussed. This current study aimed for characterizing the chemical and sensory profiles of coffee leaf tea prepared by 2 different brewing techniques; hot infusion and decoction. To optimize the functional and sensory properties of the drinks, Central Composite Design (Response Surface Methodology) was applied on several parameters such as total phenolic content, antioxidant activity (IC50) and redness (a*). The optimum brewed coffee leaves tea were then profiled sensorially by Rate-All-that-Apply (RATA) method followed by hedonic and acceptability test.

Research Methods

Tools

The tools and equipment used in this experiment were included electric oven (Memmert), desiccator (Duran), UV-VIS spectrophotometer (Genesys 10s), colour reader (Konika Minolta), thermometer (Corona), analytical scales (Metler Toledo), gas stove (Rinnai), Blender (Miyako), filter cloth, paper cup, glassware and others.

Chemical and reagents

Chemicals and reagents used for the analysis were included: DPPH (Sigma-Aldrich) 0.1 mM, Folin Ciocalteu (Merck), gallic acid (Merck), tanic acid (Merck), Na2CO3 (Merck), CaCO3 (Merck), chloroform (Bratachem), methanol (Merck), and distilled water.

Samples

The Robusta coffee leaves were obtained from Sridonoretno, Dampit, South of Malang with the coordinates of -8.325922.122.770414, at an altitude of 500-600 masl (metres above sea level). The coffee leaves are defined as old leaves as they were taken from the 5th to the 8th levels under the leaf bud. For the sensory test 6 of brewed tea samples including coffee leaf tea (CL), Camellia sinensis tea treated as coffee leaf tea processing (CS) and commercial black tea (CB) in which both infusion and decoction brewing techniques were applied to each samples. The fresh tea leaves (Camellia sinensis) and the commercial one were obtained from Wonosari tea plantation.

Sample preparation

Instead of young leaves, both CL and CS were collected from the old leaves (the 5th to 8th leaves from the tip). These CL and CS were washed, cut, rolled and stored 24 hours to enhance oxidation process. Afterward, the leaves were then dried in an electric oven at 70^{o}C for 4 hours (Liang et al., 2018). The dried leaves were then grinded to make it into powder.

The coffee leaves tea powder were ready to be brewed under 2 types of brewing techniques; hot infusion and decoction. Each brewing technique required 1 g of coffee leaves powder and 100 mL of water. The temperature and time of brewing for each technique was set up by the software (Design Expert). The condition of infusion technique was set between 75-85^{o}C for duration of 5-15 minutes, while that of decoction was set between 90-100^{o}C for duration of 5-10 minutes

Chemical analysis

Analysis of Tannin Content

The analysis of tannin content was conducted for the brewed tea. Exactly 0.1 mLof the tea was diluted in 1 mL of methanol. The mix was then taken for 0.2 mL and added with Na2CO3 7.5%, 1 mL Folin Ciocalteu reagent and vortexed. After incubated for 30 minutes in a dark place at room temperature, the sample was observed on spectrophotometer with a maximum wavelength of 760 nm (Silva-Ramirez et al., 2020).

Caffeine Level Analysis

The 2 grams of dried coffee tea leaves were added into 100 mL of distilled water and heated for 5 minutes. The filtrate was mixed with 2 g of CaCO3. After adding 15 mL of chloroform, the bottom layer was taken then subsequently evaporated. After series of dilution, the sample was then measured by UV-vis spectrophotometer on 270-300 nm (Tfouni et al., 2018).

Total Phenolic Content Analysis

The sample was added in to methanol by a ratio of 1:10. The mix was then taken for 0.2 mL and added by Na2CO3 (10%) and 1 mL of Follin-Ciocalteu reagent (7.5%). Afterwards, the mix was incubated for 30 minutes. The absorbance was measured by spectrophotometer at 765 nm (Abdeltaif et al., 2018).

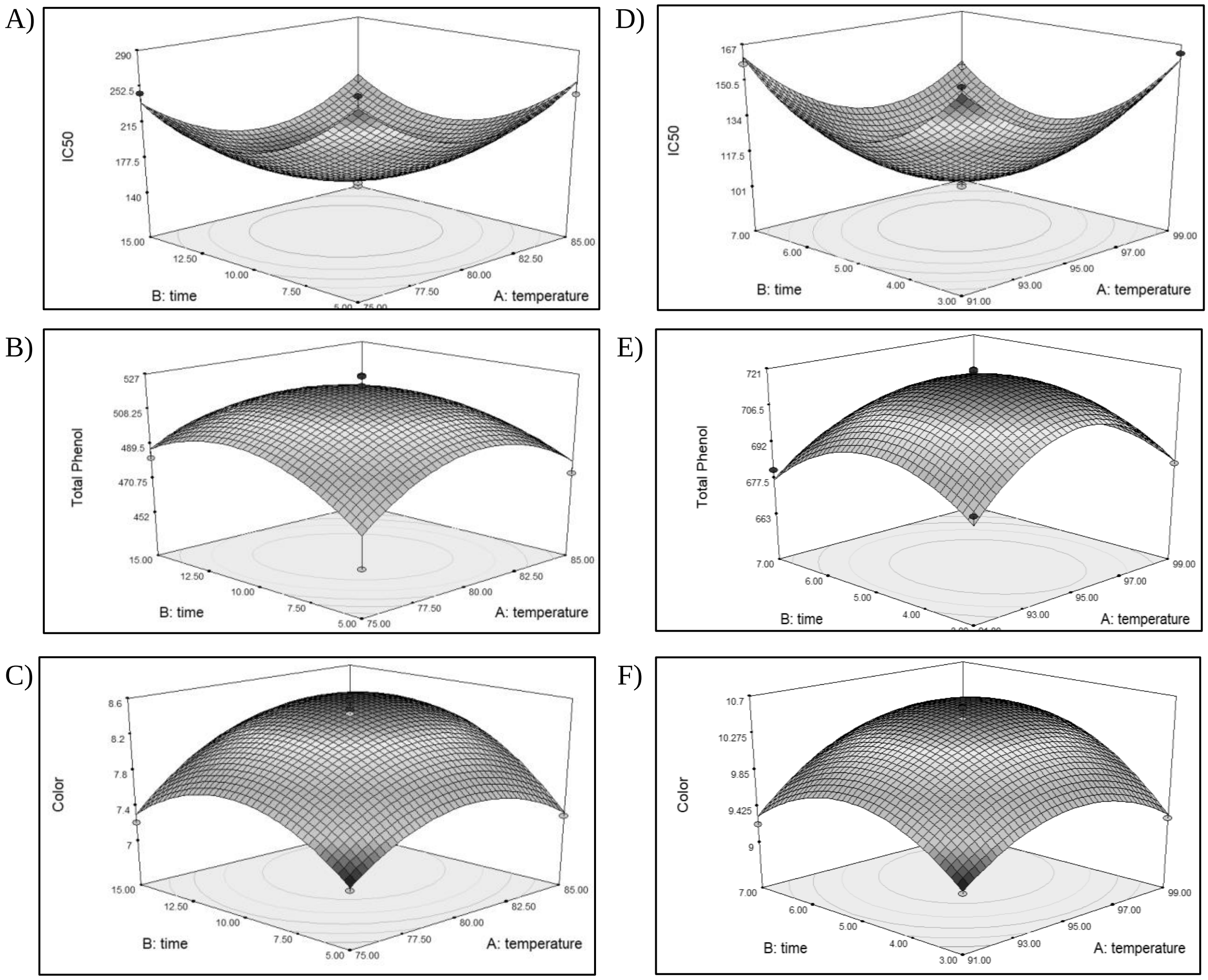

Figure 1. The influence of brewing time and temperature on IC50, total phenolic content and redness (colour a*) for infusion (A-C) and decoction (D-E) techniques

Antioxidant Activity Analysis

The analysis was started by diluting 0.01 mL of sample into 10 mL of methanol. Series of further dilution was then conducted. The DPPH was added and incubated for 30 minutes in a dark place. The absorbance measurements were taken by spectrophotometer at a wavelength of 517 nm. Inhibition Activity (IC50) is defined as concentration that gives a 50% reduction in free radical concentration.

Colour Analysis

The redness (a*) of the brewed coffee leaves tea was measured by colour reader (Konika Minolta). In this study only redness was observed as the redness is one of the important attributes for tea quality.

Sensory Analysis

This study involved 120 untrained panelists, consisted of 63 male and 57 female. The recruited panellists were 18-27 years old. Rate All That Apply method was applied to capture the sensory profile of the products (Ares et al., 2014). The 9scale-rating questionnaires were used to measure the perceived intensity of 27 sensory attributes, including aroma, flavour, taste and mouth-feel. On the next day, the 5-scale-hedonic test was also conducted to measure respondent's preferences on colour/ visual appearance, aroma, taste, and mouth-feel. At the same session, acceptability test was also conducted at the end of the sessions. This acceptability test conducted was using yes or no questions to measure overall acceptance.

Experimental Design and Data analysis

While the main optimization experiments were designed and analysed by Design Expert 7.0, the rest of the data was analysed by General Linear Model in Minitab 17 (α=0.05) and followed by Tukey post-hoc test Response Surface Methodology (RSM) was used for optimization by applying Central Composite Design (CCD).

Table 1. The influence of brewing techniques on functional properties of coffee leaves tea, commercial black tea and treated tea leaves

Sample	Brewing Technique	Tannin (%)	Total Phenolic Content (mgGAE/g)	IC50 (ppm)	Caffeine (%)
Commercial Black Tea	Infusion	23.53 ± 0.31[c]	606 ± 1.7[c]	113 ± 0.6[c]	2.64 ± 0.00[b]
	Decoction	26.46 ± 0.05[a]	728 ± 1.2[a]	107 ± 1.5[e]	2.86 ± 0.00[a]
Coffee Leaves Tea	Infusion	23.08± 0.09[d]	600 ± 1.2[d]	119 ± 1.3[c]	0.09 ± 0.00[e]
	Decoction	26.03 ± 0.05[b]	736 ± 2.2[b]	110 ± 2.0[d]	0.13 ± 0.00[d]
Treated Tea Leaves	Infusion	21.83 ± 0.05[f]	484 ± 2.7[f]	213 ± 0.6[a]	2.35 ± 0.00[c]
	Decoction	22.83± 0.31[e]	535 ± 4.7[e]	203 ± 1.2[b]	2.81 ± 0.58[a]

*. Data is represented as mean±standard deviation obtained by 3 replicates

*. Different superscript within the same column indicates significant different at 95% confidence level by Tukey posthoc-test

Both brewing factors such as brewing temperature and time were set up as suggested by the CCD. Meanwhile, 3 different parameters, such as total phenolic content, antioxidant activity and the redness were observed

Results and Discussion

The Optimization of Brewing Techniques on Coffee Leaves Tea

The three-dimensional surface response visually illustrates the interaction between 2 factors (x) temperature and (y) time, which affects the relationship between the response value and the respective experimental level. Figures 1 A and D show the minimum IC50 response or produce a concave curve. This indicates that the response of the desired IC50 antioxidant activity is minimum. Figures 1 B and E show a total phenolic response, while 1 C and F show the maximum colour response as it can be seen as a convex curve. As suggested by Ngamsuk et al. (2019) the convex curve indicates optimum condition is achieved and therefore the response of TPC and the desired colour were already maximum.

The optimal condition for infusion brewing technique was observed at a temperature of 80.0^{o}C for 10.4 minutes in which corresponded to 154.0 ppm of IC50; total phenol 519.3 mgGAE/g of total phenolic content; 8.5 of redness (a*). The desirability of the model was 0.93. Meanwhile, the optimum condition for decoction brewing technique was observed s at a temperature of 95.4 ^{o}C for 5.7 minutes, in which corresponded to 104.0 ppm of IC50; 717.9 mgGAE/g of total phenolic content; 10.5 of redness (a *). The model desirability for this technique was 0.96.

Temperature was not significantly affect the response of antioxidant activity on infusion techniques. Within temperature range observed in the experiment (75-85ºC), the antioxidant substances in the coffee leaves tea was not sufficiently extracted due to lack of direct contact between solute and solvent as the coffee leaves tea was packed in tea-bags.. Similar result was also reported by Kilic et al. (2007) on rosemary tea brewed within temperatures of 60^{o}C and 80^{o}C in which observed that antioxidant activity had not significantly change (p> 0.05).

The time factor has a significant effect on the response of antioxidant activity (p-value<0.05). The longer brewing time tended to increase antioxidant activity. Antioxidant activity can be linked to the duration of infusion, which can also be attributed by polyphenols and caffeine. The longer brewing tends to increase the possibility of extracting more antioxidant substances in which finally increase the antioxidant activity as well. The brewing duration is one of the important factors in making steeping tea (Lin et al., 2003). According to Turkmen et al. (2007) the longer the brewing time, the tea extracts more antioxidants.

Unlike the infused tea which was not affected by brewing temperature but time, the decocted tea tended to be affected by both factors. The time and temperature of brewing have a significant effect on the response of antioxidant activity (p-value<0.05). The fact that the brewing temperature was significantly affected the decocted coffee leaves tea but it was not affected the infused one might be attributed by the fact that the exposure of coffee leaves tea during decoction brewing is more intensive due to direct contact with water and thus it mediates the heat to be efficiently transferred to tea powder.

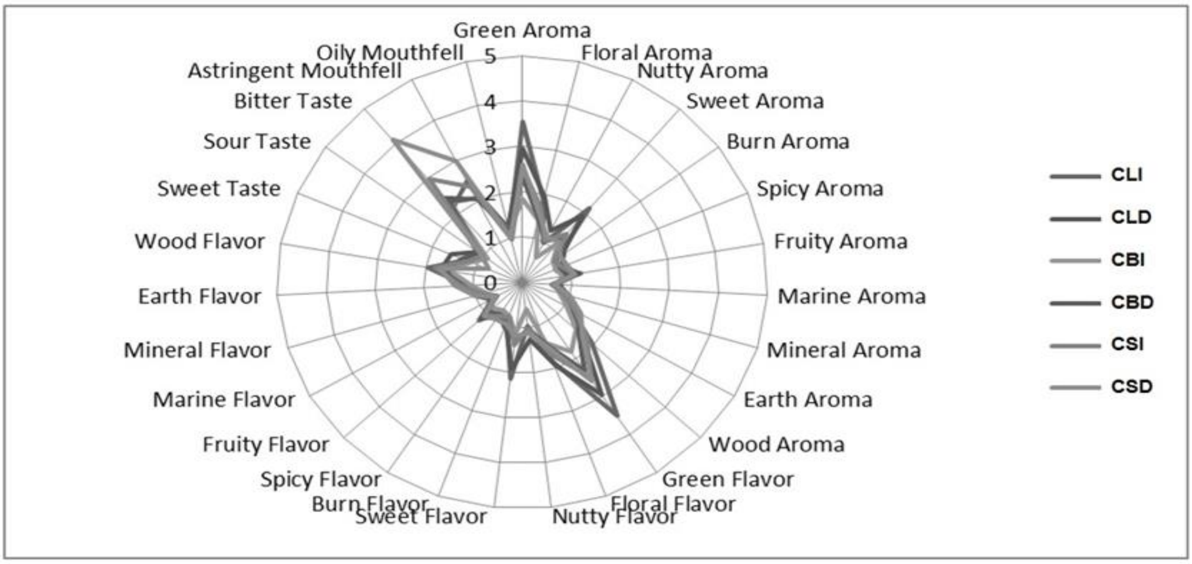

Figure 2. Sensory profiles comparison of coffee leaf tea (CL), commercial black tea (CB) and Camilia sinensis tea (CS) prepared by infusion (I) and decoction (D) brewing techniques.

It was also suggested that increasing time and temperature of brewing, will increase the yield of antioxidant component extracts (Turkmen et al., 2007). According to Armoskaite et al. (2011) the results of green tea extract showed a correlation between antioxidant activity and total polyphenols with the time of brewing.

The duration of brewing was also observed to significantly affect the total phenolic response for decocted coffee leaves tea (p-value<0.05). It was suggested that the optimum brewing time for tea is about 5 to 6 minutes as. during 5 minutes of brewing, almost 80% of phenolic content, flavonoids and antioxidant can be extracted (Gramza et al., 2006). The longer brewing time may even decrease the polyphenols as oxidation and epimerization may be involved (Ashihara et al., 2008).

The time and temperature of brewing significantly affected the redness of both decocted and infused tea (p-value<0.05). High temperature may increase efficiency of solvent-solute interaction and thus increase the solubility of tea component. Therefore the extraction may be more efficient (Lin et al., 2003; Chen et al., 2018).

Comparison among Tea Beverages

Coffee leaf tea generally has higher tannin levels than Camellia sinensis tea (α <0.05), but lower than commercial black tea. This indicates that coffee leaves tea has potential to have higher antioxidant activity than that of Camellia sinensis tea. It was also observed that decoction brewing techniques were able to extract tannins more than that of infusion (p-value<0.05).

Decocted coffee leaf tea has a significantly higher total phenolic content than those of commercial black tea and treated tea leaves. It was reported that coffee leaves contain phenols in the form of phenolic acids (civic, chlorogenic, p-coumaric, ferulic, and sinapic acids), and catechins (catechin and epicatechin) (Gokulakrishnan et al., 2005). In accordance to Kumar (2008), it was suggested that the temperature of 95^{o}C is the optimum temperature for extracting antioxidant and phenolic compounds.

In this experiment it was observed that decocted coffee leaves tea has the highest antioxidant activity among all the tested samples (p-value<0.05) as it has the lowest IC50. According to Campa et al. (2012) coffee leaf herbal tea generally has higher antioxidant activity than Camilia sinensis tea. Consistent with the finding, it was found that there was significant different IC50 between infused and decocted tea, in which decocted tea tended to have stronger antioxidant activity. It has been suggested that coffee leaf herbal tea has components of chlorogenic acid and mangiferin compounds, these two compounds have high antioxidant effects, have anti-inflammatory, anti-diabetic, anti-hyperlipidemic,anti-microbial and antioxidant effects (Montgomery, 2009).

Among the tested tea, it was observed that coffee leaves tea has the lowest caffeine level (p-value<0.05), in which the infused tea has lower caffeine levels than that of the decocted tea. Coffee and tea have caffeine which is known as trimethyxanthin (Kilic et al., 2017). The higher the temperature and time used to brew tea, the more caffeine is extracted (Suyare et al., 2013).

Sensory Characterization of Brewed Coffee Leaves Tea

Aroma

Out of 11 characterized aroma, there were 2 dominant aroma attributes that significantly detected by the panellists (p-values<0.05). As shown Figure 2, sweet and peanut aroma were sensed intensively for coffee leaves tea (p-value<0.05). It was suggested that the coffee leaves tea has more complex both peanut and sweet aroma as those are contributed by more aromatic compounds. While aromatic compounds in tea leaves have 4 nutty aroma compound such as benzenealdehyde, pentanal, 3-methyl butanal and 2-methyl butanal, coffee leaves have 8 nutty aroma compound such as 2,4-heptadienal, butanal-2-methyl (CAS), furfural, pentanal, benzenaldehyde, benzeneethanol (CAS), 2-heptanone (CAS) and 3,5-cocoa pyrazine (Turkmen et al., 2007).

Flavor

Not only sweet aroma, the sweet flavour was also found to be dominant for coffee leaves tea (p-value<0.05). According to Armoskaite et al.(2011) found in coffee leaves, compounds that provide sweet flavors such as maltol, 2,6-Dimethylpyrazine, 2-furfural, 2,3-pentanedione, 2,3-hexandione, dihydro-2-methyl-3-furanone, octanoic acid, and 1- (2-furanyl) ethanone. Furthermore, it has been reported that volatile components identified in coffee contributed in sweet flavour may be attributed by 2,3-butanedione; 2,3-pentanedione; pyridine; 2-ethyl-3-methyl-pyrazine; 2-furfurultiol; and furaneol (Yuwono, et al , 2019).

Taste

Sweet and bitter taste in coffee leaves tea were also found to be significantly recognized by panellists (p-value<0.05). Sweetness is caused by adenylyl cyclase and phospholipase C which are activated by sweet molecules that bind to G-protein coupled receptors (GPCRs), while sweetness indicates sugar content (Sahin et al., 2013). In addition, sweetness is usually considered a pleasant sensation produced by the presence of sugar and several other substances. Sweet taste is often associated with aldehydes and ketones, which contain carbonyl groups (Chyu et al., 2004). The sweet sensation can be produced by various groups of compounds in groups of sugars, amino acids-peptides-proteins, cyclic amines and benzene derivatives. In addition sweetness can also be produced from sugars and other hydroxy compounds, such as alcohol and glycol (Yuwono et al., 2019).

High levels of flavonoids and tannins in tea contribute to increased bitter taste in tea (Balci et al., 2016). In addition phenolic compounds such as flavonols (quercetin) and flavans (catechins, epicatechin, epicatechin gallate, epicatechin, epigallocatecingallate) are responsible for bitterness and astringents in tea drinks (Braud et al., 2015).

Hedonic and Acceptability Test

Among the tested samples, infused CL was more preferable for panelists (p-value<0.05) in terms of aroma, taste, mouth-feel, and overall preferences. It is important to note that respondents did not show any preferences on colour and visual appearance as all the served teas has the colour of common commercial Camilia sinensis tea they normally consumed. The fact that infused CL was more preferable may be attributed that the infused C L tended to have more fragrant, distinctive and pleasant aroma in which milder than that of decocted one (p-value<0.05). While most of the samples were still accepted by panellists, the decocted commercial black tea was rejected as it has strong bitter taste and tight-mouth feel (astringent). It is also important to note that the commercial black tea used in this experiment was the premium tea for export grade. The fact panellist rejected the decocted CB may be attributed due to they normally consumed lower grade of black tea, which has weaker sensory intensities.

Conclusion

It has been observed that the optimum brewing conditions were obtained at 80ºC, 10.4 minutes for infused coffee leaves tea and at 95.4ºC, 5.7 minutes for decocted coffee leaves tea. Under these conditions, , coffee leaves tea has the lowest caffeine level (p-value<0.05) even though the commercial black tea tended to more superior in terms of total phenolic content, tannin content and IC50 (p-value<0.05). Decoction brewing technique, using high temperatures with a short time was more effective for extracting chemical compounds in coffee leaf tea, compared to infusion brewing techniques (p-value<0.05). Both brewing techniques applied on coffee leaves tea were acceptable to consumers, although the decocted coffee leaves tea has better functional properties. In general, coffee leaves tea poses highly potential due to its lowest caffeine and sensory richness to be further developed and promote its consumption and usage.

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