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Influence of water hardness on functional and sensory quality of cold infused robusta coffee leaf tea

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KEYWORDS

Cold infused

Robusta coffee leaf tea

Water hardness

ABSTRACT

Cold infused technique is one of the brewing methods that potentially able to preserve coffee leaf tea functional properties. It is mainly attributed to the absence of heat treatment during its processes. However, without involving heat, the sensory quality of cold brewing tea is generally weak. To overcome this issue, it was hypothesized that water quality used for the brewing is important to govern optimum functional properties of Robusta coffee leaf tea and at the same time to maintain its sensory quality. In this current study, Response Surface Methodology (RSM) was applied by implementing Box-Behnken Design (BBD) to optimize both total phenolic content (TPC) and antioxidant activity by modifying length and temperature of cold brewing as well as its water and coffee leaf powder ratio. There were 3 different commercial drinking water used for brewing to represent 3 different hardness level of water. All optimum brewed coffee leaf tea was then sensorially evaluated by Rate All That Apply (RATA) method. It was found that level of water hardness is positively correlated to TPC but negatively correlated to brewing temperature as well as water and coffee leaf powder ratio. It was also found that the higher level of water hardness, both fruity and marine aroma tended to be more intense (p-value<0.05). Meanwhile the lower level of water hardness tended to enhance sweet aroma and astringent mouth-feel (p-value<0.05) of cold infused coffee leaf tea.

Introduction

The quality of tea is determined by functional properties such as antioxidant activity and multisensory perception such as taste, aroma, and flavour. Both are influenced by the brewing process, tea varieties, storage conditions, and also the quality of water (Jaimes et al., 2015). Commonly, people used to drink tea prepared by hot-brewing technique. This may relate to the fact that the ability of extracting functional and flavour components are more efficient at about boiling temperature. However, it has been reported that after reaching particular points of temperature and time, the quality of coffee leaf tea tends to decrease significantly (Fibrianto et al., 2020), considering that the Robusta coffee leaf contain several antioxiant and antimicrobioal activity, such as alkaloids, phenolic compounds, carbohydrates, proteins, and saponins, with phenolic content of 27.04 µg/g and flavonoids of 10.90 µg/g (Nayeem et al., 2011). Thus, to preserve these functional properties, application of cold brewing that posses the ability to retain all antioxidant agents as it is not heated can be used as alternative to optimize extraction of functional components as well as to balance sensorial properties (Kirk, 2019).

It was reported that different quality of water, particularly its hardness significantly altered sensory attributes of coffee (Fibrianto et al., 2018). However, its effect on quality of coffee leaf tea has not been reported elsewhere. This current work was dedicated to investigate the influence of water quality, particularly the hardness to obtain the optimum both functional and sensorial quality of cold infused coffee leaf tea.

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Research Methods

Materials

The coffee leaf tea was prepared as suggested by Yuwono, et al., (2019) and Fibrianto, et al., (2021). The Robusta coffee leaf was freshly collected from Ampelgading region, Malang, East Java. For brewing, 3 brands of commercial mineral water were used (MW1, MW2, MW3). These 3 brands were selected as they have different claims of mineral content on their packaging.

Method

To optimize the functional quality of cold infused coffee leaf tea, Box-Behken Design (BBD) for Response Surface Methodology (RSM) was carried out followed by Rate-All-That-Apply (RATA) method to characterize the sensory properties in detail (Ares, et al., 2014). The BBD was set by DX 10.0 Design Expert application. Meanwhile, the sensory data was analysed by General Linear Model (GLM) followed by Fisher post-hoc test in Minitab 18.

Brewing temperature range was set between 10ºC to 25ºC, while the duration of brewing was set between 4 to 7 hours. The amount of coffee leaf tea powder was also set between 1 to 3 gram for brewing. Once the optimum conditions achieved in terms of phenolic content (Jayasri and Matthew, 2009) and antioxidant activity (Sahu et al., 2013), the coffee leaf tea brewed by 3 different commercial mineral water were then served to 60 untrained panellist from college students. Each panellist received 3 samples containing 20ml each. Palate cleanser and 5 minutes break was provided between samples.

Results and Discussion

Functional properties optimization of coffee leaf tea as affected by different water hardness

As shown in Table 1 and Table 2, the less mineral content of water tended to require higher optimum temperature of brewing, longer brewing time as well as larger amount of coffee leaf tea. It was suggested that the level of water hardness effect on the efficiency of extraction. On the other hand, for example Mg2+ can increase extraction level of malic acid, citric acid, and quinic, meanwhile chlorine strongly inherit unpleasent flavour (Wellinger et al., 2016). The higher level of water hardness, tend to increase the efficiency of the extraction (Yuwono et al., 2019). It was suggested that too short brewing time lead to less efficient extraction so that the optimum condition would not be achieved (Nindyasari, 2012). Increasing the brewing time tends to enhance the opportunity of perfect extraction (Yuwono et al., 2019). However, at certain point it will start to decrease as the bioactive compounds decomposed (Ahda, 2013; Hariyadi et al., 2020) as shown in Figure 1.

Table 1. Optimum functional conditions of coffee leaf tea brewing from different quality of water

Brewing water	Brewing temperature (^{o}C)	Brewing time (hours)	Powder weight (gram)	Total phenolic content (mg GAE/g)	Antioxidant activity (ppm)
MW1	18.8	6.0	2.4	214.3±6.2 ^{b}	37.8±0.9 ^{b}
MW2	19.0	7.0	2.8	180.8±5.1 ^{c}	46.0±1.9 ^{a}
MW3	18.6	6.1	2.3	235.8±12.8 ^{a}	40.7±1.8 ^{b}

Different notations show significantly different responses based on Fisher Post-hoc test at 95% confidence level

Table 2. Mineral composition of coffee leaf tea brewing water

Brewing water	Ca (mg/L)	Mg (mg/L)	$CaCO_3$ (mg/L)
MW1	0.52	1.02	5.50
MW2	<0.02	-	-
MW3	7.69	1.08	23.66

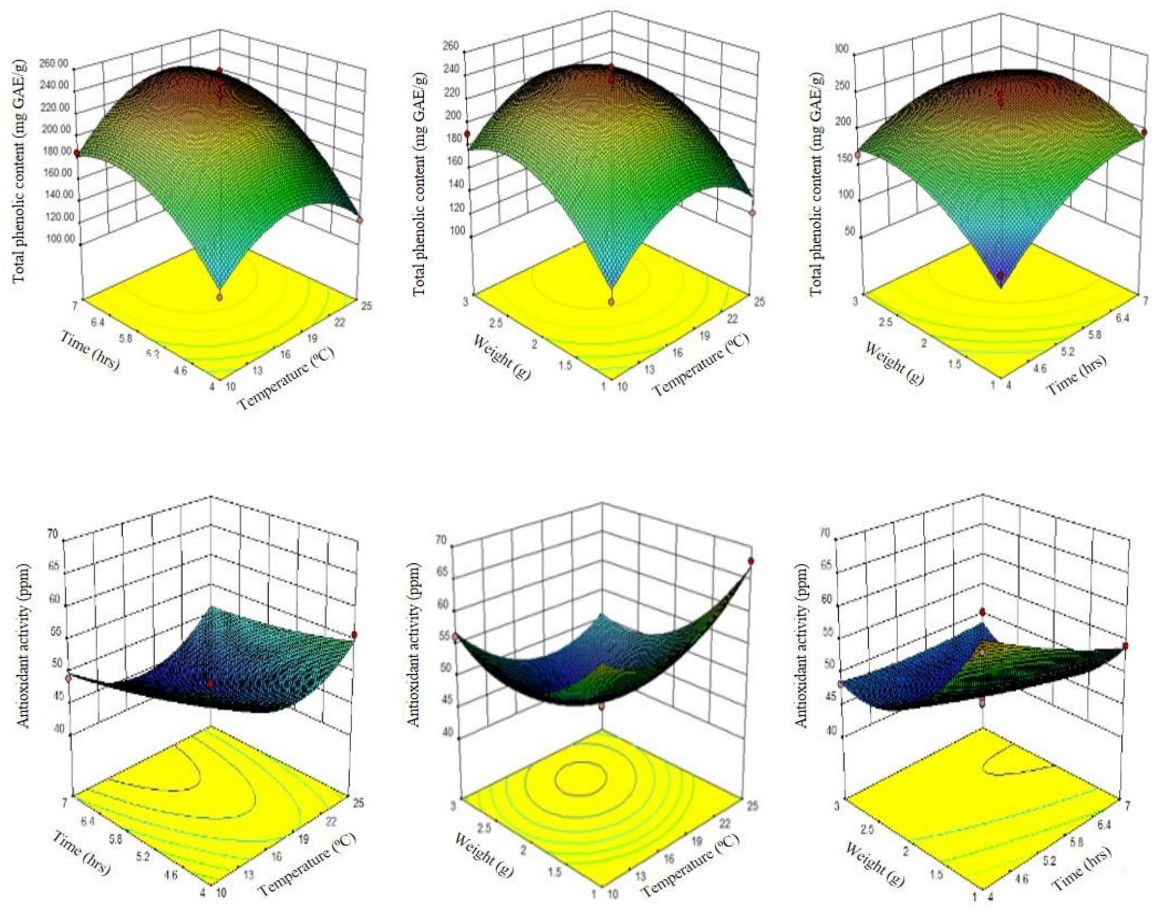

Figure 1. RSM 3 dimensional graph for total phenolic content (top) and antioxidant activity (bottom) as affected by brewing time, temperature and weight of coffee leaf tea involving high mineral water (MW3)

The brewing temperature was also well correlated to the total phenolic content, in which higher brewing temperature tended to yield lower total phenolic content (Fibrianto et al, 2021). It is also important to note that depreciation of total phenolic content was followed by improvement of antioxidant activity. This may suggest that non-phenolic antioxidant compound may present in coffee leaf tea. The decrease of total phenolic content may also be caused by the occurrence of volatile components such as evaporated phenols, decomposition of phenol compounds, and complex formation between phenol components and other components (Legowo et al., 2021). As seen in Table 3, the present of non-phenolic antioxidant may be contributed by organic acids as MW3 with the highest hardness resulted the largest pH differences. However, further investigation is still required to confirm this observation.

Sensory characterization of coffee leaf tea affected by different water hardness

It was observed that there were 6 attributes out of 26 attributes (Table 4) that significantly affected by different mineral water used for brewing ($p<0.05$). Those included fruity aroma, marine aroma, sweet aroma, bitter taste, burnt flavour, and astringent mouth-feel. It was also found that the higher level of water hardness lead to more intense fruity and marine aroma (p-value<0.05). Meanwhile the lower level of water hardness tended to enhance sweet aroma and astringent mouth-feel (p-value<0.05) of cold infused coffee leaf tea. It is also interested to note that bitter taste and burnt flavour was intensified by medium water hardness.

Table 3. The changing of mineral water pH due to cold infused brewing

Mineral water	pH		pH differences
	Before	After	
MW1	7.1±0.1	5.4±0.3	1.7±0.2
MW2	5.8±0.2	4.8 ±0.2	1.0±0.0
MW3	9.0±0.6	5.9±0.1	3.0±0.6

Data represents mean values of 3 replicates ± standard deviation

Table 4. Significant sensory attributes of coffee leaf tea as affected by different water hardness

Atribut	p-value	MW1	MW2	MW3
Fruity Aroma	0.000	0.43[a]	0.38[a]	1.01[b]
Marine Aroma	0.000	1.22[b]	0.82[a]	1.62[c]
Sweet Aroma	0.000	0.28[a]	1.12[b]	0.40[a]
Bitter Taste	0.000	3.00[a]	1.05[c]	1.58[b]
Burnt Flavour	0.000	2.68[a]	1.93[b]	1.13[c]
Astringent Mouth-feel	0.000	1.43[a]	2.28[b]	1.23[a]

Different notations show significantly different responses based on Fisher Post-hoc test at 95% confidence level. (MW2 and MW3 represent low and high hardness mineral water consecutively, while the MW1 represents the medium one)

Conclusion

It was found that level of water hardness is positively correlated to TPC but negatively correlated to brewing temperature as well as water and coffee leaf powder ratio. It was also found that the higher level of water hardness, both fruity and marine aroma tended to be more intense (p-value<0.05). Meanwhile the lower level of water hardness tended to enhance sweet aroma and astringent mouth-feel (p-value<0.05) of cold infused coffee leaf tea.

Declarations

Conflict of interests The authors declare no competing interests.

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