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The effect of formulation with ginger (*Zingiber officinale* var. Roscoe) and different brewing techniques on physicochemical and organoleptic characteristics of cascara tea

Wenny Bekti Sunarharum*, Ajeng Khorirodatul Djannah, Ngesti Ekaning Asih

Department of Food Science and Biotechnology, Faculty of Agricultural Technology, Universitas Brawijaya, Malang, Indonesia

KEYWORDS

Cascara tea
Coffee pulp
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ABSTRACT

The utilization of coffee cherry pulp, one of coffee processing waste, into tea (or known as cascara tea) is still limited regardless of its potential. Cascara tea flavor could be improved, such as by the addition of spices. Besides the addition of spices, the brewing techniques may also contribute to the properties of brewed cascara tea and consumer acceptance This study aimed to determine the effect of formulation (the ratio between cascara and ginger) and the different brewing techniques on the physicochemical and organoleptic characteristics of cascara tea. The best treatment was also determined. This study was conducted in Nested design with 2 factors i.e. brewing techniques (decoction and infusion) and ratio of cascara and ginger (9:1; 7:3; 5:5). Data analysis was performed using Minitab 17 and the best treatment was chosen by Multiple Attribute Zeleny method. The results showed that the ratio between cascara and ginger, as well as brewing techniques had a significant effect (α = 0.05) on total phenolic content, caffeine content, pH, color (L*, a* and b* value), and organoleptic parameter (except for taste, aftertaste, and overall). The best treatment was obtained from cascara tea with ratio of cascara and ginger =7: 3, brewed using the decoction technique. It offered total phenolic content of 27.73 mg GAE/g; caffeine content of 1.93 mg/g; pH of 6.1; Lightness (L*) 40.1; redness (a) 12.4; and yellowness (b*) 25.6.

Introduction

Coffee popularity has led to an increase in coffee production and coffee-related industries worldwide, including in Indonesia. In 2018, Indonesian coffee production has reached 756 thousand tons (BPS, 2020). Since coffee cherry contains 45% of pulp (Das and Venkatachalapathy, 2016), and the majority used for beverages is coffee beans, it is estimated that the total wasted pulp may reach 340.2 thousand tons. Coffee pulp has low economic value due to its limited utilization as organic fertilizer and animal feed (Khalil, 2016). However, this pulp can be processed into cascara tea to add its economic value. Cascara can be consumed as herbal tea. This product had been developed and consumed not only in Indonesia but also in other countries such as in Latin American Countries, as reported by DePaula et al. (2022). Other researchers have studied bottled pasteurized cascara tea beverages (Jiamjariyatam et al. 2022) and developed another product, such as cascara kombucha (Rohaya et al., 2023). Although cascara tea has been sold in the market, it is still not gaining as much popularity as regular tea from *Camellia sinensis* leaves. Therefore, there is more potential for developing cascara or cascara-based products.

The simplest way to improve cascara tea is suggested by adding other natural ingredients. Preliminary research was conducted to determine whether adding other ingredients may increase consumer preference for cascara tea by testing commercial products and cascara tea obtained from the local farmers. The result has indicated that cascara tea needs flavor improvement. According to Garis et al. (2019), cascara tea has a sour aroma and a slightly sweet taste. Other plant materials may be added into tea to improve its sensory properties, such as the addition of lemon peel (Sunarharum, et al. 2021). This preliminary survey had also been carried out to evaluate preference on plant materials or ingredients to be added into

*Corresponding author
E-mail address: wbsunarharum@ub.ac.id

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cascara tea. Based on the result, as many as 315 out of 359 respondents chose ginger as the alternative ingredient to improve the cascara tea aroma and therefore, ginger was utilized in this study.

Besides tea formulation or the ingredients used, brewing is another important step in tea beverage making to translate dried tea into a consumable beverage like that of coffee. Whilst coffee brewing methods may include decoction, infusion, and pressure methods (Sunarharum et al., 2014), the most common brewing techniques for tea are decoction (boiling tea with hot water) and (infusion (brewing tea with hot water). The decoction technique involves continuous contact between the tea and hot water and maintaining its temperature. On the other hand, the infusion technique is done by soaking dry tea in hot water for a certain time. These two techniques aimed to extract bioactive compounds from tea (Tipduangta et al., 2019), such as phenolic compounds and antioxidants (Koczka et al., 2016). It is interesting to study the influence of these two different techniques on brewed tea characteristics. Therefore, this research objective was to study the effect of formulation between cascara and ginger and the different brewing techniques on the cascara tea's physicochemical and organoleptic characteristics. The best treatment was also chosen as the most potential to be further studied and commercialized.

Research Methods

Materials

The raw materials were fresh and sundried COBRA (Colombia Brazil) Arabica coffee (*Coffea arabica*) pulp from KUD Karangploso, Malang, East Java and fresh white ginger (*Zingiber officinale* var. Roscoe) obtained from the local market. Chemicals used were analytical standards such as caffeine powder (Sigma Aldrich), Calcium carbonate ($CaCO_3$) (Merck), chloroform, gallic acid powder, Folin Ciocalteu, $NaCO_3$ 75% (Merck), and distilled water.

Methods

This research was carried out in two stages i.e the preliminary study and the formal experiment. The preliminary study was performed by an online survey to know consumer feedback on the need of cascara flavor improvement and the ingredients preferred as alternatives in the formula. The results indicated a need for flavor improvement, and the ingredient chosen was ginger (chosen by 315 out of 359 respondents). The formal experiment was conducted in Nested design with two factors i.e. the ratio between cascara and ginger (9:1; 7:3; 5:5 and the brewing techniques (decoction and infusion). Analyses were conducted in four replications.

Cascara with ginger tea formulation and preparation

For the cascara with ginger tea formulation, the raw fresh ginger was sorted, washed, rubbed, peeled, and cut into thin pieces before drying in a cabinet dryer (50°C, 4 h). Dried ginger and dried cascara (sundried) were ground coarsely and sifted (4 mesh) separately. Each ingredient was weighed according to the ratio between cascara : ginger (9:1; 7:3; and 5:5) and stored in a sealed pouch before further brewing and analysis.

The dried cascara with ginger tea formulas were further brewed using two different techniques (infusion and decoction) based on Sunarharum et al. (2021) using a dry formula: water ratio of 1:100. For the decoction technique, the dried cascara tea formula was poured into hot boiling water (~90°C) and the temperature was maintained at 90°C to boil the tea for 3 mins. For the infusion technique, hot water (~80°C) was poured into the dried cascara tea formula and let it steep for 3 mins. The brewed tea was then filtered and used for further analysis.

Physicochemical and organoleptic analysis

a. Color

sample was placed in a clear container and the lightness (L*), redness (a*), and yellowness (b*) were evaluated using Konica Minolta Color reader CR-10 Plus (Japan).

b. pH

pH of the brew was measured by using a calibrated benchtop pH meter.

c. Moisture content

Moisture content was analyzed using oven method (AOAC, 2007).

d. Total phenolic content

Gallic acid standard curve was made by diluting a series of concentrations (0; 5; 10; 15; 20, and 25 mg/L) in water. A 2 mL sample was added with 1 mL Folin Ciocalteu reagent and incubated for 3 minutes. A 1 mL Na_2CO_3 7.5% was added into the mixture, homogenized, and incubated for 15 minutes. The absorbance was measured with a UV-VIS spectrophotometer at 740 nm (Modified from Sharma et al., 2011).

e. Caffeine content

A 0.01 g caffeine powder was diluted into 50 mL, and 1 mL of the dilution was diluted into 10 mL.

Final dilution was used for the standard curve by diluting into a series of concentrations (0, 5, 8, 11, 14 ppm). A 50 ml sample was added with 1 g $CaCO_3$ and stirred. The mixture was then transferred into a separatory funnel, added with 15 ml chloroform, and mixed until it formed two separate layers. The clean solution was used for further process. Repeat the previous steps 2 times. The obtained clear solution was heated to evaporate the remaining solvent and added with 10 mL aquades. A 1 mL mixture was diluted into 10 ml. The absorbance was measured with a UV-VIS spectrophotometer at 272 nm (Modified from Maramis et al., 2013).

f. Organoleptic

Evaluation was performed by using hedonic scaling (Lim, 2011). Each sample was coded differently and given to 100 untrained (consumer) panelists. They were asked to score for six sensory attributes (i.e., color, appearance, aroma, taste, aftertaste, and overall) using 1-9 points hedonic scale. The hedonic scales for degree of likeness used were 1 (extremely dislike), 2 (very dislike), 3 (dislike), 4 (slightly dislike), 5 (neutral), 6 (slightly like), 7 (like), 8 (very like), and 9 (extremely like).

Statistical analysis

Data were collected and tabulated using Microsoft Excel 2013. Analysis of variance (ANOVA) with a confidence interval of 95% and *t*-test, Fisher LSD post-hoc or Tukey HSD analysis was performed by Minitab 17 Statistical Software (Minitab Inc., State College, Pennsylvania, USA). The best treatment was analyzed using the multiple attribute method (Zeleny, 1982).

Results and Discussion

Raw materials characteristics

The raw materials evaluated were the fresh raw materials and the dried form. Moisture content, color (L*, a*, and b*), pH, and total phenolic content of cascara and ginger can be seen in Table 1. Table 1 indicated that drying process decreased the moisture content of dried cascara and ginger. It is important to note that the drying process for ginger was carried out in the laboratory using a cabinet dryer, while cascara pulp was sundried by the producers. Therefore, the moisture content of cascara is higher than that of ginger. The fresh and dried ingredients were significantly different (α=0.05) for all parameters evaluated, i.e., moisture content, lightness (L*), redness (a*), and yellowness (b*). The significant decrease in moisture was due to the drying process. Another parameter evaluated for cascara was the pH, where both fresh and dried cascara have a pH of ~4. This low pH was suggested contributed by aliphatic acid in the pulp and the changes during drying. For the color parameter, dried materials were darker due to exposure to heat during drying. Total phenol was analyzed only for the dried ginger, and the result indicates a total phenolic content of 5.54 mg GAE/g, lower than that of reported by Idris et al. (2019) at 7.8 mg GAE/g. Different values of total phenolic might be influenced by post-harvest treatment, processing, geographical origin, drying conditions, and temperature (Andriyani et al., 2015; Riandani et al., 2022).

Physicochemical characteristics of brewed cascara with ginger tea formula

This section explains the physicochemical characteristics of brewed cascara with ginger tea formula. Based on the results, different brewing techniques gave a significant effect (α=0.05) on all parameters assessed. Previous research by Saklar et al. (2015) had reported that the extracted chemical compounds in brewed tea depends on the brewing process. Tea particle size, the ratio between dried tea and water, and brewing temperature can influence this brewing process. The decoction technique produces cascara with ginger tea in a darker color as it has lower L* and b* values, higher a* value, higher total phenol and caffeine contents as compared to the infusion technique (Table 2). It is mainly due to higher temperatures in the decoction technique (90°C), which was maintained in 3 mins compared to the infusion (80°C) with 3 mins steeping time. This process allows more extraction of chemical components from the tea into the water such as polyphenols, that based on Yadav et al. (2020) may contribute to color and astringent taste.

The decoction technique also produced cascara tea with lower pH and higher total phenolic and caffeine content than the infusion technique. The reason is that higher temperature accelerates the extraction, and therefore increases the amount of water-soluble components as explained by Tounekti et al. (2013), including polyphenols and caffeine in cascara. The water-soluble components with higher release rates due to heating may include catechins and their oxidation products (Tounekti et al., 2013).

Table 3 indicates that particularly cascara tea obtained from both brewing techniques with a ratio of 9:1 has the highest total phenolic and caffeine content. The higher the ratio of cascara, the higher the total phenolic and caffeine since cascara is the major contributor to polyphenols and caffeine in the formula. Ginger has only contributed a little since it contains less than 10 mgGAE/g (in this research, it was only 5.54 mgGAE/g). While based on Coronel et al. (2004), cascara contains 37.9 mgGAE/g of phenolic. However, the caffeine content of cascara was lower than that of coffee. Different species have been mentioned to contribute to the variability of caffeine content in cascara (Riandani et al., 2022).

The red coffee cherry pulp contains a high number of polyphenols and other antioxidants (Geremu et al. (2016). Polyphenols classes identified in coffee cherry pulp are flavan-3-ols, flavonols, anthocyanidins (Coronel et al., 2004), and hydroxycinnamic acids (Elba et al., 2017). The examples of phenolic compounds reported may include gallic acid, protocatechuic acid, chlorogenic acid, and rutin (Heeger et al., 2017), epicatechin, isochlorogenic acid, catechin, and ferulic acid (Ramirez-Martinez, 1988). The major polyphenols in ginger are gingerols, which can be transformed into corresponding shogaols with heat treatment or long-time storage (Mao et al., 2019). As the cascara ratio increased, the brew's color became darker. This is also potentially due to the darker brown color of the dried cascara (L*=23.60 ± 3.40) compared to the dried ginger (L*=70.20 ± 4.70). Meanwhile, the pH value decreased by adding more cascara due to the contribution of aliphatic acids from coffee pulp contributing in decreasing the brew's pH.

Table 1. Raw materials characteristics

Parameter	Cascara		Ginger	
	Fresh	Dried	Fresh	Dried
Moisture content (%)	84.17 ± 0.23 ^{a}	11.95 ± 0.05 ^{b}	90.73 ± 0.03 ^{a}	7.43 ± 0.91 ^{b}
Lightness (L*)	31.41 ± 1.11 ^{a}	23.60 ± 3.40 ^{b}	77.00 ± 3.40 ^{a}	70.20 ± 4.70 ^{b}
Redness (a*)	11.05 ± 2.02 ^{a}	4.80 ± 1.80 ^{b}	-2.60 ± 0.20 ^{b}	2.90 ± 1.60 ^{a}
Yellowness (b*)	9.38 ± 3.86 ^{a}	3.20 ± 1.90 ^{b}	28.00 ± 3.30 ^{b}	30.90 ± 5.20 ^{a}
pH	4.2 ± 0.11 ^{b}	4.38± 0.05 ^{a}	-	-
Total phenolic content (mg GAE/g)	-	-	-	5.54 ± 0.34

Notes: Data mean ± standard deviation (n=3), Different notation showed significant difference, comparison was made between fresh vs dried for cascara and ginger (*t*-test, α=0.05)

Table 2. Physicochemical characteristics of brewed cascara with ginger tea formula

Brewing Techniques	Lightness (L*)	Redness (a*)	Yellowness (b*)	pH	Total Phenolic Content (mg GAE/g)	Caffeine Content (mg/g)
Infusion	52.89 ± 7.50 ^{b}	5.98 ± 2.40 ^{b}	29.98 ± 4.63 ^{b}	6.59 ± 0.27 ^{b}	14.92 ± 1.10 ^{b}	0.86 ± 0.16 ^{b}
Decoction	39.43 ± 4.38 ^{a}	12.43 ± 3.35 ^{a}	25.15 ± 6.30 ^{a}	6.28 ± 0.74 ^{a}	27.17 ± 10.67 ^{a}	1.87 ± 0.53 ^{a}

Notes: Data mean ± standard deviation (n=4). Different notation showed significant difference (Fisher LSD, α=0.05).

Table 3. The effect of brewing techniques and ratio on physicochemical characteristics of cascara tea

Brewing Techniques	Ratio	Lightness (L*)	Redness (a*)	Yellowness (b*)	pH	Total Phenolic Content (mg GAE/g)	Caffeine Content (mg/g)
Infusion	9:1	44.42 ± 2.25 ^{b}	8.55 ± 0.73 ^{a}	25.52 ± 2.45 ^{c}	6.30 ± 0.08 ^{b}	15.54 ± 0.54 ^{a}	1.02 ± 0.04 ^{a}
	7:3	55.58 ± 4.15 ^{a}	5.55 ± 0.48 ^{b}	29.65 ± 1.80 ^{b}	6.65 ± 0.19 ^{a}	15.50 ± 0.33 ^{a}	0.85 ± 0.04 ^{b}
	5:5	58.68 ± 1.90 ^{a}	3.83 ± 0.34 ^{c}	34.77 ± 3.21 ^{a}	6.83 ± 0.26 ^{a}	13.72 ± 0.46 ^{b}	0.71 ± 0.05 ^{c}
Decoction	9:1	34.75 ± 1.24 ^{c}	15.80 ± 0.55 ^{a}	18.65 ± 1.07 ^{c}	5.63 ± 0.15 ^{c}	37.36 ± 1.27 ^{a}	2.37 ± 0.04 ^{a}
	7:3	40.13 ± 0.73 ^{b}	12.38 ± 0.73 ^{b}	25.58 ± 1.72 ^{b}	6.13 ± 0.22 ^{b}	27.73 ± 1.82 ^{b}	1.93 ± 0.10 ^{b}
	5:5	43.43 ± 0.47 ^{a}	9.10 ± 0.70 ^{c}	31.23 ± 0.43 ^{a}	7.08 ± 0.10 ^{a}	16.44 ± 0.95 ^{c}	1.32 ± 0.09 ^{c}

Notes: Data mean ± standard deviation (n=4). Different notation showed significant difference (Fisher LSD, α=0.05).

Organoleptic evaluation

There were 6 (six) attributes i.e. color, appearance, aroma, taste, aftertaste, and overall assessed using hedonic scaling (Table 4). The result showed that both cascara: ginger ratio and brewing techniques factors had a significant effect (α=0.05) on likeness of certain attributes such as color, appearance, and aroma. However, there were no significant differences found in taste, aftertaste, and overall.

The highest likeness score of color and appearance was obtained from cascara tea brewed with decoction at a ratio of 9:1, whereas the highest score of aroma was from infusion technique at an equal ratio (5:5). Higher amount of cascara with a little amount of ginger produced the darker cascara tea brew with a better perceived general appearance by panelists. It seems that for visual appearance panelists prefer the brew with darker color and clear appearance. However, the preference for aroma might differ since the addition of more ginger seems to increase degree of likeness when decoction technique was utilized. Gingerols and shogaols compound, which may contribute to pungent notes in ginger (Pratap et al., 2017). Ginger may balance sour taste from cascara and therefore may increase preference. Besides, acidic compounds in cascara, such as protocatethuic acid and chlorogenic acid, contribute to the acidity of cascara tea (Nurhayati et al., 2020).

Best Treatment

The parameters calculated for choosing the best treatment were total phenolic content, caffeine content, color, pH, and six organoleptic characteristics (i.e., color, flavor, taste, aftertaste, appearance, and overall). Cascara with ginger tea formula with the ratio of cascara: ginger = 7:3 brewed using the decoction technique was found to be the best treatment. The physicochemical and organoleptic characteristics of this best treatment are shown in Table 5.

Table 4. Organoleptic characteristics of cascara tea

Brewing Techniques	Ratio (cascara:ginger)	Color	Appearance	Aroma	Taste	Aftertaste	Overall
Infusion	9:1	6.15 ± 1.38 ab	6.07 ± 1.35 a	5.71 ± 1.43 ab	5.64 ± 1.43	5.77 ± 1.58	5.95 ± 1.25
	7:3	5.56 ± 1.55 bc	5.63 ± 1.41 abc	5.37 ± 1.45 b	5.37 ± 1.46	5.61 ± 1.43	5.56 ± 1.33
	5:5	4.98 ± 1.61 c	5.07 ± 1.47 c	5.63 ± 1.50 ab	5.41 ± 1.71	5.07 ± 1.56	5.50 ± 1.51
Decoction	9:1	6.26 ± 1.89 a	6.14 ± 1.71 a	5.40 ± 1.65 b	5.42 ± 1.97	5.43 ± 1.75	5.79 ± 1.63
	7:3	6.14 ± 1.59 ab	5.97 ± 1.36 ab	5.88 ± 1.36 ab	5.50 ± 1.61	5.58 ± 1.74	5.81 ± 1.47
	5:5	5.73 ± 1.45 ab	5.47 ± 1.41 bc	6.21 ± 1.71 a	5.49 ± 2.02	5.39 ± 1.75	5.75 ±1.74

Notes: Score in hedonic scale 1: Dislike extremely, 2: Dislike very much, 3: Dislike moderately, 4: Dislike slightly, 5: Neutral, 6: Like slightly, 7: Like moderately, 8: Like very much, 9: Like extremely. Average score of organoleptic attributes cascara tea with ginger± standard deviation. Different notation showed significant difference (Tukey HSD, α=0.05)

Table 5. Physicochemical and organoleptic characteristics of the best treatment

Parameter	Value
Physicochemical	
Lightness (L*)	40.13 ± 0.73
Redness (a*)	12.38 ± 0.73
Yellowness (b*)	25.58 ± 1.72
pH	6.13 ± 0.22
Total phenolic content (mg GAE/g)	27.73 ± 1.82
Caffeine content (mg/g)	1.93 ± 0.10
Organoleptic	
Color	6.26 ± 1.59
Appearance	6.14 ± 1.36
Aroma	5.88 ± 1.36
Taste	5.42 ± 1.61
Aftertaste	5.43 ± 1.74
Overall	5.79 ± 1.47

Notes: Physicochemical characteristic data mean ± standard deviation (n=4), Organoleptic characteristic data mean ± standard deviation (n=100)

Conclusions

In conclusion, the different ratios between cascara and ginger had a significant effect on all physicochemical characteristics such as in color parameters (i.e., lightness (L*), redness (a^), and yellowness (b*)), pH, total phenolic content, and caffeine. Despite the ratio of the formula, brewing techniques (infusion vs decoction) also had a significant effect on all physicochemical characteristics. Therefore, the difference in the brew characteristics was more prominent when the decoction brewing technique was applied. The treatments also influenced the organoleptic preference mainly on the brew's color, appearance, and aroma. The best treatment based on the Zeleny method was from the formula with the ratio between cascara and ginger of 7:3, brewed using the decoction method. This best treatment offered a total phenolic content of 27.73 mg GAE/g; caffeine content of 1.93 mg/g; pH of 6.1; Lightness (L*) of 40.1; redness (a^) of 12.4; and yellowness (b*) of 25.6.

Declarations

Conflict of interests The authors declare no competing interests.

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