Sensory optimization of formulated coffee mix from pedada seed (*Sonneratia caseolaris*) and robusta coffee (*Coffea canephora*)

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Abstract. Pedada seed is one of potential anti-oxidant resources of coastal plants which is under-utilized. In this current study, pedada seed was formulated in to Robusta coffee to develop a novel coffee mix. The purpose of this study was to obtain the most ideal formula of pedada-Robusta coffee mix based on sensory evaluation using Just about Right (JAR) analysis of French-press brewed coffee mix. The best coffee mix formula was obtained for the mix of 1:1 proportion between pedada seed and Robusta coffee. There were 18 out of 19 sensory attributes of the best formula that sensorially accepted by the consumer respondents. Those included vegetative aroma, brown sugar aroma, musty aroma, sweet aroma, nutty aroma, cocoa aroma, citrus-fruit aroma, sweet taste, sour taste, body-mouth-feel, mouth-feel strength, nutty flavour, burnt flavour, chemical flavour, citrus-fruit flavour, beany flavour, roasted flavour and sweet flavour. The best pedada-coffee mix was also characterized as having mean particle size of 421.5±19.1 µm, total phenolic content of 21.55±0.21 mg GAE/g, antioxidant activity of 48.60±0.94%, caffeine content of 278.50 ± 4.95 mg/kg, total dissolved solids of 0.4±0.066% and colour with a value of L=17.0±0.0; a=18.6±0.9 and b=23.6±0.9.

1. Introduction

Manual brewed coffee is one of the drinks that poses high interest of coffee drinker. The uniqueness of coffee flavour is influenced by many factors, including soil quality, seed maturity, and geographical conditions of planting, production processes, processing, roasting, and brewing [1]. One of the potential ways to create uniqueness of coffee is by adding substitutes that may improve its sensory attributes, functional properties as well as may adjust the selling value of the coffee.

Non-coffee bean sources have been developed to partially substitute the bean such as rice, corn, papaya and snake fruit seeds. However, poor solubility and taste are still being main issues of non-coffee bean coffee, regardless most of them can be used as alternative to reduce the caffeine. Another potential resources that can be used to substitute the coffee beans is pedada seeds (*Sonneratia caseolaris*). These seeds can be obtained as a waste of pedada flour or syrup processes [2]. Therefore, the potential of pedada seeds as coffee substitute were investigated in this current study.
2. Material and methods

2.1. Material
The pedada seeds were obtained from the Rungkut mangrove forest while the Robusta coffee beans were obtained from Dampit, Malang. Material for analysis included: 96% methanol, DPPH, ciolteau follicular reagent 10%, 7.5% Na2CO3 and distilled water. The tools used for drying pedada fruit seeds in this study included analytical scales, cabinet dryers and pans. The tools used for analysis included analytical scales, UV-Vis spectrophotometers, coffee refractometers, HPLC, French Press, filter paper and erlenmeyer.

2.2. Methods
The coffee formula was then tested for its physicochemical characteristics including tests of caffeine content, for the HPLC method, water and methanol as eluents were used in a ratio of 3:7. [24]. Total phenol, the total phenol test used the Folin Ciocalteau method [24]. Antioxidant activity, analysis of antioxidant activity using the DPPH method [24]. Color, color analysis in this experiment using a color reader [24]. Total dissolved solids, total dissolved solids were tested using a hand-refractometer [24]. Particle size, characterization using PSA was used to determine the average size of silver nanoparticles. PSA uses the Dynamic Light Scattering (DLS) method that utilizes infrared scattering [24].

In the current study, sensory based optimization through JAR (Just About Right) method [3] was applied in conjunction with consumer acceptance test followed by penalty analysis [4, 5, 6, and 7]. There was 107 respondents were involved.

2.3. Experimental design and data analysis
Randomized Block Design was used with 3 replicates. The data were then analysed by ANOVA (Analysis of Variance) using Minitab 18 followed by Tukey post-hoc test with 95% confidence level. The sensory optimization was conducted through penalty analysis on XLSTAT. Penalty analysis was conducted by XLSTAT.

3. Result and discussion

3.1. Penalty analysis
The selection of alternatives in making coffee brewing from pedada fruit seeds (Sonneratia caselaris) is based on organoleptic test considerations. The best results chosen were brewed coffee formula with pedada and Dampit robusta coffee (1: 1).

As listed in Table 1, while 18 out of 19 tested attributes are considered acceptable, bitter taste is the only attribute which requires to be developed further for formulated coffee mix with pedada and Dampit robusta coffee (1: 1). This may be attributed by the fact that the formulated pedada coffee mix has significantly lower caffeine than that of Robusta coffee (p-value<0.05).

3.2. Physico-chemical analysis
3.2.1. Particle size. As shown in Table 2, it is known that the average value of the particle size of coffee formula powder is between 421,510-432,817 µm. The largest particle size is in the 100% robusta coffee formula at 432,817 µm and the smallest particle size in the ratio of the coffee beans to the pedada fruit: robusta coffee beans (1: 1) is 421,510 µm. Particle size influences sensory perception. Basically the coffee brewing process is an extraction process where the coffee brewing result is strongly influenced by the particle size and surface area of the particles that are in contact with the solvent. The particle size of coffee grounds is one of the factors that can influence the results of coffee steeping. Similar study using Dampit Robusta coffee reported that the size was 377.19 µm [3]. The particle size of the results of the test on the ground coffee formula is larger than the literature allegedly due to the use of different grinders as well as the use of different brewing methods [3, 11].
Table 1. Tabulated sensory attributes penalty analysis of pedada-robusta formulated coffee mix.

| Variable                | Pedada and Dampit robusta coffee (0: 1) | Pedada and Dampit robusta coffee (1: 0) | Pedada and Dampit robusta coffee (1: 1) | Pedada and Dampit robusta coffee (1: 2) | Pedada and Dampit robusta coffee (1: 3) |
|-------------------------|--------------------------------------|--------------------------------------|--------------------------------------|--------------------------------------|--------------------------------------|
| Vegetative aroma        | JAR                                  | JAR                                  | JAR                                  | JAR                                  | JAR                                  |
| Brown sugar aroma       | TL/THa                               | JAR                                  | TL/THa                               | TL/THa                               | TL/THa                               |
| Musty aroma             | JAR                                  | JAR                                  | JAR                                  | JAR                                  | JAR                                  |
| Sweet aroma             | JAR                                  | JAR                                  | TL/THa                               | TL/THa                               | TL/THa                               |
| Nutty aroma             | JAR                                  | JAR                                  | TL/THa                               | TL/THa                               | TL/THa                               |
| Cocoa aroma             | JAR                                  | JAR                                  | TL/THa                               | TL/THa                               | TL/THa                               |
| Citrus fruit aroma      | JAR                                  | JAR                                  | JAR                                  | JAR                                  | JAR                                  |
| Sweet taste             | TL/THa                               | JAR                                  | TL/THa                               | TL/THa                               | TL/THa                               |
| Sour taste              | TL/THa                               | TL/THa                               | JAR                                  | TL/THa                               | TL/THa                               |
| Bitter taste            | TL/THa                               | JAR                                  | TL/THa                               | TL/THa                               | TL/THa                               |
| Mouthfeel body          | JAR                                  | JAR                                  | JAR                                  | JAR                                  | JAR                                  |
| Mouthfeel strength      | TL/THa                               | JAR                                  | JAR                                  | JAR                                  | JAR                                  |
| Nutty flavor            | TL/THa                               | JAR                                  | TL/THa                               | TL/THa                               | TL/THa                               |
| Burnt flavor            | JAR                                  | JAR                                  | JAR                                  | JAR                                  | JAR                                  |
| Chemical flavor         | JAR                                  | JAR                                  | JAR                                  | JAR                                  | JAR                                  |
| Citrus fruit flavor     | JAR                                  | JAR                                  | JAR                                  | JAR                                  | JAR                                  |
| Beany flavor            | JAR                                  | JAR                                  | JAR                                  | JAR                                  | JAR                                  |
| Roasted flavor          | TL/THa                               | JAR                                  | JAR                                  | JAR                                  | JAR                                  |
| Sweet flavor            | JAR                                  | JAR                                  | TL/THa                               | TL/THa                               | TL/THa                               |

The Asterisk (*) shows the significant mean drop for non-JAR categories. TL= too low, TH= too high, JAR=Just About Right

Table 2. Physico-chemical characteristics of Pedada-Robusta formulated coffee mix.

| Coffee Formula (Pedada fruit seed : Robusta) | Particle Size (µm) | Total Phenolic Content (mg GAE/g) | Antioxidant Activity (%) | Caffeine (mg/kg) | Total Dissolved Solid (%) | L | a | b |
|---------------------------------------------|--------------------|----------------------------------|--------------------------|-----------------|---------------------------|---|----|----|
| 1 : 0                                       | 429.9±19.1a        | 13.90±0.2a                       | 52.03±0.6a               | 0.00±0.0a       | 0.18±0.0a                 | 29.60±0.9a | 17.80±1.3a | 34.80±3.9a |
| 1 : 1                                       | 421.5±19.1a        | 21.55±0.2a                       | 48.60±0.9a               | 0.03±0.0d       | 0.44±0.1b                 | 17.00±0.0b | 18.60±0.7b | 23.60±0.9b |
| 1 : 2                                       | 424.3±7.4a         | 23.12±0.1c                       | 44.47±1.4c               | 0.04±0.0c       | 0.46±0.0b                 | 12.80±0.5c | 16.80±1.1c | 16.00±0.7c |
| 1 : 3                                       | 429.89±2.6a        | 31.18±0.2a                       | 40.19±1.1d               | 0.05±0.0b       | 0.53±0.0b                 | 6.60±0.6d  | 12.60±1.7b | 8.40±0.3d  |
| 0 : 1                                       | 432.82±1.8a        | 26.05±0.3b                       | 33.96±1.4c               | 0.08±0.0d       | 0.95±0.1c                 | 5.00±0.7e  | 5.20±0.9e  | 4.80±1.3d  |

a Superscript within the same column indicates significant different at 95% confidence level. All values represent mean of 3 replicates ±standard deviation.

b Superscript within the same column indicates significant different at 95% confidence level. All values represent mean of 3 replicates ±standard deviation.

c Superscript within the same column indicates significant different at 95% confidence level. All values represent mean of 3 replicates ±standard deviation.

d Superscript within the same column indicates significant different at 95% confidence level. All values represent mean of 3 replicates ±standard deviation.

e Superscript within the same column indicates significant different at 95% confidence level. All values represent mean of 3 replicates ±standard deviation.
3.2.2. Total phenolic content. Based on the analysis of the various total phenol values in steeping of each coffee formula showed that the treatment of the difference in the formula of the coffee beans pedada fruit with robusta coffee beans significantly affected (p≤0.05) on the total phenol brewing coffee formula. In Table 2 the higher the concentration of coffee beans in the coffee brewing formulation, the total phenol value of the coffee formula tends to decrease. The low total value of phenols from pedada coffee beans is suspected due to the lack of phenolic compounds contained in the pedada fruit seeds. Pedada fruit has 24 components consisting of eight steroids, nine triterpenoids, three flavonoids, and four carboxyl benzene derivatives [12]. Furthermore, it was reported that the pedada fruit also contains several triterpenoids and sterols [13]. Robusta coffee beans are known to contain alkaloids, tannins, saponins and polyphenols [14]. The polyphenol compounds which are most contained in coffee are chlorogenic acid and caffeic acid [15].

3.2.3. Antioxidant activity. Based on the analysis of various types of steeping coffee formula, it shows that the different treatment of the coffee formula of the pedada fruit beans with robusta coffee beans has a significant effect (p≤0.05) on the antioxidant activity of the coffee formula brewing produced. It can be seen in Table 2 that the higher the concentration of pedada coffee beans in the formulation, the antioxidant activity of steeping coffee formulas is also increasing. This is evidenced by the results of the analysis of antioxidant activity of Dampit coffee beans and Robusta coffee beans (0: 1) produces the smallest antioxidant activity, 33.96%, while the 100% formula of Dampit coffee beans and Robusta coffee (1: 0) produce the highest antioxidant activity is 52.03%. This proves that the increase in the concentration of the coffee in the coffee beans can increase the antioxidant activity of the brewed coffee. It was reported that pedada contains steroid compounds, triterpenoids, flavonoids, alkaloids, saponins, tannins, phenols, sapogenins and carboxyl benzene derivatives [12] [16] [17] [18].

3.2.4. Caffeine. Caffeine (1,3,7-trimethylxanthine) is one of the most important alkaloid compounds in coffee beans [19]. Caffeine compounds contribute to the bitter taste of the coffee formula. The high and low levels of caffeine are used as a consideration for determining comparisons or recipes in mixing ground coffee. Based on the analysis of caffeine steeping levels of coffee formula shows that the difference in the treatment of the coffee beans with pedada coffee beans with Dampit robusta coffee were significantly different from the levels of caffeine steeping coffee formulas produced can be seen in Table 2. Based on Table 2 the higher the concentration of coffee beans pedada fruit added to the coffee formula, the caffeine content decreases. The formula of Dampit robusta coffee and robusta coffee (1: 0) based on the results of the caffeine test using the HPLC method does not contain caffeine and the highest caffeine content is in the coffee formula of pedada and robusta coffee (0: 1) of 0.08% . This result is far below the standard caffeine content in one cup of brewed coffee because according to [20], the standard content of caffeine in a cup of brewed coffee is 0.9-1.6% in arabica coffee, 1.4-2.9% in robusta coffee and 1.7% in Arabica and Robusta coffee blends. The research results are also in line with the results of research substituting zalacca seed powder with arabica coffee, the higher the concentration of zalacca seed powder substituted in Arabica coffee, the caffeine content of coffee will decrease [21].

3.2.5. Total dissolved solid. The level of smoothness is a factor that needs to be justified to get optimal brewing results. The smaller the size of the coffee grounds, the more optimally the coffee will be extracted, however, this process will produce a more bitter and astringent taste. Ground coffee granules have a large surface area so that the compounds that form aroma and taste are easily soluble in hot water [11]. Based on the Total Dissolved Solid (TDS) test, it was found that the Total Dissolved Solid of various coffee formulas ranged from 0.18 to 0.95%. The formula of pedada coffee beans with Dampit robusta coffee beans (0: 1) gets the biggest percentage that is 0.95% and the formula of pedada fruit seeds with the smallest Dampit coffee beans (1: 0) is 0.18% can be seen in Table 2. The results of the Total Dissolved Solid test showed that the smaller the concentration of Dampit Robusta coffee in steeping coffee formulas, the lower the solubility value. These results are in line with the results of the percentage of Total Dissolved Solid pedada fruit formula with the lowest Dampit robusta coffee beans
then when the coffee fruit concentration of pedada beans increases in the brewing coffee formula the percentage of Total Dissolved Solid steeping coffee formula decreases. The results of the Total Dissolved Solid test on various types and mixes of coffee differed, namely a mixture of 70% robusta coffee (from Africa and India) and 30% arabica (from South America) (% TDS = 0.90), 100% arabica (% TDS = 0.80), 100% Indonesian Arabica coffee beans (% TDS = 0.82), 100% Kenyan Arabica coffee beans (% TDS = 0.73), 100% Guatemalan Arabica coffee beans (% TDS = 0.76), 100% Arabica coffee beans (% TDS = 0.8), 100% Indian Arabica coffee beans (% TDS = 0.81), and 100% Colombian Arabica coffee beans (% TDS = 0.78) [22]. These results indicate that the percentage of Total Dissolved Solid is influenced by the type of coffee beans used and in line with the results of this study that each coffee formula has a different percentage of Total Dissolved Solid.

3.2.6. Appearance test. Based on Table 2 it is known that the brightness intensity of the pedada fruit seeds formula with the highest Dampit robusta coffee beans (1: 0) (L = 29.6) and the lowest intensity in the formula of the pedada fruit seeds with Dampit robusta coffee beans (0: 1) (L = 5.00). Differences in notation between coffee formulas (p-value<0.05) indicate that differences in coffee formulas produce different brightness levels. The increasing concentration of Dampit Robusta coffee in steeping coffee formulas results in a darker color. The higher the value of L or close to 100 indicates the color of the sample tends to be white or bright [23].

The value of greenish color intensity in the formula of pedada fruit seeds with Dampit robusta coffee beans (1: 0) the highest (a = 17.80) and the lowest intensity in the formula of pedada fruit seeds with Dampit robusta coffee beans (0: 1) (a = 5.20). The difference in notation between coffee formulas (p-value<0.05) indicates that different coffee formulas produce different greenish color intensities. The increasing concentration of Dampit Robusta coffee in steeping coffee formulas results in a denser or older green color.

The intensity of the yellowish color formula of the pedada fruit seeds with Dampit robusta coffee beans (1: 0) the highest (b = 34.80) and the lowest intensity in the formula of the pedada fruit seeds with Dampit robusta coffee beans (0: 1) (b = 4.80). The difference in notation between coffee formulas (p-value<0.05) indicates that different coffee formulas produce different yellowish color intensities. The higher the concentration of Dampit Robusta coffee in steeping coffee formulas, the intensity of the yellow color decreases which makes the color of the coffee looks darker.

4. Conclusions

The most optimum coffee formula is the formula of pedada fruit coffee beans and Dampit robusta coffee (1: 1), from 19 sensory attributes, there are 18 attributes that have been optimum (p-value≥0.05) and 1 attribute not yet optimum (p-value< 0.05). Physico-chemical properties of the coffee formula pedada fruit seeds: Robusta Dampit coffee (1: 1) which has a mean particle size of 421.5 ± 19.1 µm, a total phenol value of 21.55 ± 0.21 mg GAE / g, activity antioxidant of 48.60 ± 0.94%, caffeine content of 278.50 ± 4.95 mg / kg lower than the caffeine content of the coffee formula of pedada fruit seeds and Dampit Robusta coffee (0: 1) of 817.00 ± 1.41 mg / kg, total dissolved solids were 0.44 ± 0.066% TDS and color with a value of L = 17.0 ± 0.0; a = 18.6 ± 0.9 and b = 23.6 ± 0.9.

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