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Sensory Profile on Robusta Coffee by Rate-All-That-Apply (RATA)

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Abstract

Coffee flavor strongly influences consumers preference. Geographical location is one factor influencing the flavor of Robusta coffee. Descriptive sensory using RATA was used to differentiate the sensory profiles of several Robusta coffees. Sensomic approach by Principal Component Analysis (PCA) successfully differentiated Robusta coffee from Jember Regency, East Java, Indonesia. It showed that Robusta from different growing locations has specific sensory characteristics. Robusta coffee from Gunung Malang, Tanggul, and Pakis was characterized by sweet and acid aromas, while coffee from Kemiri was characterized by sweet and sour taste, brown color, bitter aroma, and rough mouthfeel. Meanwhile Sidomulyo I and Sidomulyo II coffees, which were grown near each other and at similar altitudes, have similar characteristics, although the process was different. Both coffees have bitter aftertastes and bodies, burnt aromas, astringent flavors, and high levels of bitterness. In contrast, Robusta from Rowosari, Tugusari, and Badean were characterized by low sweetness, sourness, bitter aroma, and rough mouthfeel.

Keywords: Sensory, caffeine, RATA, Robusta

INTRODUCTION

Both the quality and flavor of coffee are influenced by the region in which it is grown (Toledo *et al*., 2017). Caporaso *et al*. (2018) mentioned that different geographic locations caused differences in the concentration of caffeine and chlorogenic acid. Indonesia is one of the coffee-producing countries (BPS, 2020). Until 2018, Indonesia's coffee production was dominated by Robusta coffee, around 81.18% (PDSP, 2018). Jember is one of the region in Indonesia that has potential as Robusta coffee producer, it contributes around 3,210 tons in 2017 (Ditjenbun, 2017). Several sub- districts with potential as Robusta coffee producers in Jember, East Java, Indonesia, include Panti, Bangsalsari, Silo, and Tanggul. According to BPS in 2019, coffee production in Sumberjambe reached 10.85 tons; Panti 19.77 tons; Bangsalsari 99.70 tons; Silo 78.86 tons; and Tanggul 40.90 tons.

In addition to geographical position, coffee variety and postharvest treatment also affect the diversity of chemical composition and the flavor of coffee (Moon & Shibamoto, 2009). Chemical compounds such as caffeine and chlorogenic acid play a role in sour and bitter tastes. Putri & Dellima (2022) mentioned that caffeine contributes to bitter taste for about 10-30% in the brewed coffee. Meanwile, chlorogenic acid is a major secondary metabolite in coffee beans and is formed from caffeic acid and quinic acid (Farhaty & Muchtaridi, 2016).

Both caffeic acid and quinic acid have been reported as components that play an essential role in coffee's sour flavor (Ardiansyah *et al*., 2018). Coffee selection by consumers is strongly influenced by its flavor. Coffee flavor profiles can be analyzed using descriptive sensory tests. Rate-All-That-Apply (RATA) is descriptive sensory tests that can provide the intensity measurements of sensory attributes. In addition, this method can detect wider sensory attributes. This method is a development of the previous method, check all that apply (CATA), where the previous method needed to determine the intensity for each attribute selected (Ares *et al*., 2014). Furthermore, Traill *et al*. (2019) reported that panelists could effectively assess visual differences through this method. The advantage of the RATA method is the opportunity given to describe how much intensity of sensory attributes in a product (Ares *et al*., 2014). This method has been widely used to differentiate sensory profiles on food products, such as sensory profiles of Dampit Robusta coffee based on different brewing techniques and particle sizes of ground (Fibrianto & Ramanda, 2018); sensory profiles of cascara tea produced in Latin America (De Paula *et al*., 2022); and sensory profiles of Bali Kintamani coffee based on roasting treatment and brewing method (Fibrianto, 2018). Principle component analysis (PCA) has been widely used to specify product profile characteristics, compare, categorize, and differentiate the sensory profiles of several food products, including durian (Belgis *et al*., 2016).

Information on the sensory profile and chemical characteristics of Robusta coffee in Jember Regency as a coffee producer is essential to increase better broader marketing. Therefore, research on the Robusta coffee sensory profile from Jember needs to be conducted.

MATERIALS AND METHODS

Materials

Robusta coffee (green beans) was obtained from local farmers group in five districts of Jember, East Java, Indonesia. They were harvested in October-November, 2021. All the Jember Robusta coffee samples were processed by dry method, except Sidomulyo II Robusta were processed by wet method. The information regarding coffee types and growing places are shown in Table 1. Coffee beans were roasted using a 5-kg capacity roaster (Eiko Coffee Roaster) on medium roast at 212 ^{0}C for 12 minutes with a stirring speed of 60 rpm. All coffee samples experienced "first crack" which indicates the coffee beans are getting bigger and the color becomes medium dark brown after roasting. The coffee beans were then ground to fine size with an electric grinder with a 250 g capacity (Brother BCG600 ct).

Table 1. Single origin of Robusta coffee from Jember regency

Sample	Origin	Altitude (m asl)	Method
Gunung Malang	Gunung Malang Village, Sumberjambe Sub district	446-625	Dry Process
Pakis	Pakis Village, Panti Sub district	450-625	Dry Process
Badean	Badean Village, Bangsalsari Sub district	500	Dry Process
Kemiri	Kemiri Village, Panti Sub district	450-600	Dry Process
Rowosari	Rowosari Village, Sumberjambe Sub district	450	Dry Process
Tugusari	Tugusari Village, Bangsalsari Sub district	54	Dry Process
Sidomulyo I	Sidomulyo Village, Silo Sub district	500 - 1000	Dry Process
Sidomulyo II	Sidomulyo Village, Silo Sub district	500 - 1000	Wet Process
Tanggul	Darungan Village, Tanggul Sub district	600	Dry Process

Sources: Adek, 2019; Muhardin, 2019; Sendy, 2015; Ananta, 2019; Fardani, 2015; Ardi, 2011; Pranatagama, 2015.

Descriptive Sensory

Rate-All-That-Apply (RATA)

Descriptive sensory testing was conducted by focus group discussion (FGD) members consisted of five (two males and three females) selected panelists from Department Agricultural Product Technology, University of Jember. They were selected based on their health condition and their coffee-drinking habits. The sensory attributes obtained from the FGD are shown in Table 2, then used for the RATA test. At the RATA sensory test 57 selected untrained panelists (38 males and 19 females), 19-36 years old, were selected. The preparation stage starts with brewing 13 g ground coffee with 180 mL hot water (T = ±92 ^{0}C) into a container (T = 36.7-40.5 ^{0}C) and then 15 mL coffee solution is poured into a glass labeled with a random three-digit code. Drinking water was provided for each sample change. The test used a scale from 0-7 in which the intensity levels were as follows: 0 = none; 1 = very weak; 2 = weak; 3 = relatively weak; 4 = neutral; 5 = relatively strong; 6 = strong; 7 = extreme (Adawiyah *et al*., 2020).

Caffeine Analysis

Fifty grams of coffee powder that had been filtered with 200 mesh strainer was dissolved in 25 mL of distilled water, then stirred for one hour (Belay *et al*., 2007), then heated at 90 ^{0}C for 10 minutes, and filtered using 102 filter paper (15-20 µm). Caffeine content measurement started with 25 mL of filtrate was added with 25 mL dichloromethanes (Merck, Darmstadt, Germany) then diluted in separatory funnel. Twenty-five milliliters filtrate were mixed with 25 mL of dichloromethane then diluted. Then after 10-15 minutes the solution separated into two parts, which were water and dichloromethanes containing caffeine. This step was repeated four times until the caffeine was completely dissolved. Next, dichloromethane was put back from the 100 mL measuring flask into the funnel separator and then shake for 10-15 minutes. Dichloromethane was then put into a 100 mL volumetric flask and diluted with 100 mL dichloromethanes. Five mL of solution was then inserted in a cuvette then measured absorbance at 275 nm wavelength (Belay *et al*., 2007). The absorbance was then calculated using the following formula:

Caffeine content (%) =

$$\frac{\text{consentration}\left(\frac{mg}{L}\right) \text{x dilution volume (L)x DF}}{\text{Sample Weight (g)}}\ x\ \frac{1}{100}$$

Notes: Concentration (mg/L) = Linear regression (y = bx+a); DF = Dilution Factor

Table 2. Descriptive sensory RATA attributes of Robusta coffee

Atributes	Description
Sweet (aroma)	associated with sucrose or honey
Acid (aroma)	associated with vinegar or orange fruit
Bitter (aroma)	associated with medicine
Burnt (aroma)	associated with burnt rice or something scorched or burnt
Sweet (taste)	associated with sucrose solution
Astringency (taste)	associated with dry sensation associated with immature permissions or black/ green tea
Sour (taste)	associated with citric acid solution
Bitter (taste)	associated with caffeine solution
Burnt (taste)	associated with burnt rice or something scorched
Body (mouth feel)	A strong but pleasant full mouth feel characteristic as opposed to being thin
Rough (mouth feel)	A thick and muddy (turbid) mouth feel in the oral cavity
Aftertaste bitter (mouth feel)	A long-lasting bitter taste (1 min)

Source: Michaela *et al*., 2013

Chlorogenic Acid

One gram of ground coffee was added to 40 mL of distilled water, then heated at 100 ^{0}C for 15 minutes. After cooling at room temperature, it was transferred to a volumetric flask. After that, distilled water was added up to 100 mL, then filtered using filter paper. Ten milliliters of filtrate was dissolved with distilled water to 50 mL volume and filtered with membrane filter pore size 0.45 µm diameter 13 mm. Chlorogenic acid measurement was performed by injecting 1 mL chlorogenic acid standard solution into LC-MS (Shimadzu LC-MS 2020). Furthermore, 1 mL of each coffee sample solution was injected into the LC-MS under the same conditions. The column used was waters Spherisorb 5 mm SAX 4.6 x 150 mm analytical column; the mobile phase consisted of filtered water and methanol (70% : 30%); the flow rate was 1.0 mL min^{-1}; column's temperature was 50 ^{0}C (BSN, 2004). Mass spectrometry can selectively detect many compounds by the separation process, ionization, mass separation, and the recording of forming ions (Karasek & Clement, 2012). Then qualitative and quantitative mass spectra detection and scanning were done to store mass spectra data in the instrument system for analysis.

Data Analysis

Sensory and volatiles results were analyzed using Multivariate Data Analysis by Principal Component Analysis (PCA) using Microsoft Excel XLSTAT 2019.

RESULTS AND DISCUSSION

Descriptive Sensory

Descriptive sensory analysis by RATA testing aims to characterize Robusta coffee based on the panelist perspectives (Stone *et al.*, 2020). The sensory profile of Jember origin Robusta is shown in Figures 1 and 2. All samples have attributes of aroma (sweet, acid, bitter, and burnt), taste (sweet, astringency, sour, and bitter), color (brown), and mouth-feel (body, rough, and aftertaste) with varied intensity.

Gunung Malang Robusta shows the lowest intensity of burnt aroma and bitter taste value. Likewise, Gunung Malang Robusta had the lowest value for all types of mouth feel, namely body, rough, and bitter aftertaste. The intensity of bitter taste could be caused by the caffeine content. Gunung Malang Robusta also had the lowest caffeine content (1.71%) compared to the other samples.

Jember Robusta coffee had sweetness value categorized as weak in the range of (2.58-3.11). Pakis Robusta was found to have the highest sweet taste (3.11) compared to other. The sweetness in coffee might be caused by the carbohydrate degraded during roasting into simple sugars such as sucrose Redgwell & Fisher (2006). The location of growth, climate and post-harvest treatment have an effect on the carbohydrate content of coffee as one precursor to the development of sweet taste in coffee.

Badean Robusta coffee had the highest inten- sity of sweet aroma (3.96), but the acid aroma (2.71), brown color (4.29), and sweet taste (2.58) were the lowest. The sweet aroma in coffee can be caused by the presence of some compounds contribute to sweet aroma. Caporaso *et al.* (2018) mention that 3-methyl-1,2-cyclopen- tanedione, dihydro-2-methyl-3(2H)-furanone, pyrazine, 4-ethyl-2-methoxyphenol and 5H-5-methyl-6,7-dihydrocyclopenta-pyrazine and furfural provides sweet odor in Robusta and Arabica coffee.

Kemiri Robusta had the highest intensity of burnt aroma (4.15), brown color (5.20), bitter taste (5.31), and body (4.80). The burnt aroma in coffee might be contributed by some compounds. Caporaso *et al*. (2018) and Lopes *et al*. (2021) mentioned that 2-methoxyphenol, 2-furanmethanol, pyridine, and 4-ethyl-2-methoxyphenol had burnt aroma on Robusta and Arabica coffee. While the brown color in coffee is formed by the presence of melanoidin, which results from the Maillard reaction and caramelization during roasting (Kaswindi *et al*., 2017). The differences in color intensity could be caused by the green bean color differences, which could be influenced by coffee planting altitude (Cassamo *et al*., 2022). Campa *et al*., (2005); Buffo & Cardelli-Freire, (2004) reported that high intensity of bitter taste and mouthfeel body on coffee was related to the presence of caffeine. Kemiri Robusta had a higher caffeine content value (2.07%) than Gunung Malang Robusta (1.70%) and Tanggul Robusta (1.89%).

In contrast with the previous coffee, Rowosari Robusta had the lowest sour taste (3.61). This coffee lacked dominant characteristics in its sensory, but the most noticeable was the lowest sour taste of all Jember coffees. Although the sourness score of Jember coffee was in the range of 3.61-4.35 which was categorized as relatively weak to relatively strong. Likewise, Tugusari coffee did not have prominent sensory attributes, which could be noticed that this coffee had the lowest intensity of bitter aroma (4.07); based on the descriptive scale, it was considered neutral.

Sidomulyo I Robusta was found to have the highest bitter aftertaste intensity (5.18). The bitter aftertaste in coffee may be influenced by the content of caffeine, tannin, and phenol compounds in coffee, as mentioned by Ni'mah *et al*. (2021). As previously discussed, the caffeine content in Sidomulyo I coffee was relatively high, second only to Sidomulyo II (2.11%). Sidomulyo II Robusta had the lowest intensity of sweet aroma (3.29) but had the highest bitter aroma (4.56), astringency (4.22), and rough mouthfeel (4.75). The bitter aroma in Robusta coffee could be caused by pyridine group compounds (Caporaso *et al*., 2018). Coffee's astringency taste was also influenced by chlorogenic acid and its derivative products (Buffo & Cardelli-Freire, 2004). It clearly could be seen by the higher chlorogenic acid of Sidomulyo II Robusta (5.97%) than Tanggul Robusta (5.27%).

Tanggul Robusta was known for having the highest intensity of acid aroma (3.45) and sour taste (4.35) but had the lowest astringency (3.55) and bitter taste (4.49). The acid aroma of Robusta coffee could be derived from the presence of 2-methyl-2 heptanal (Naef & Jaquier, 2006). The presence of a sour taste in coffee was caused by simple aliphatic acid compounds such as acetic acid, citric acid, malic acid, and pyruvic acid, which are derived from derivatives of chlorogenic acid which are fragmented during roasting (Abubakar *et al*., 2021). In addition, the coffee's acidity level is also influenced by green bean fermentation (Santosa *et al*., 2020).

PCA analysis showed that Robusta coffee of Gunung Malang, Tanggul, and Pakis were characterized by sweet and acid aromas. The compounds associated with sweet aroma were 3-methyl-1,2-cyclopentadiene and 5H-5-methyl-6,7-dihydrocyclopentapyrazi-ne. Furfural was also associated with sweet aroma (Caporaso *et al*., 2018). An acid aroma might result from 2-methyl-2-heptenal (Naef & Jaquier, 2006). Kemiri Robusta was characterized by a sweet and sour taste, brown color, bitter aroma, and rough mouthfeel. Robusta coffee of Rowosari, Tugusari, and Badean coffee are in quadrant three, opposite to quadrant two, indicating they have a low intensity of sweetness, sourness, brown color, bitter aroma, and rough mouthfeel attributes. Robusta coffee of Sidomulyo I and Sidomulyo II were characterized by bitter and rough body aftertaste, burnt aroma, astringency, and higher bitter- ness. Robusta coffee of Sidomulyo I and Sidomulyo II were in the same quadrant with similar sensory characteristics, although different post-harvest treatments. These coffees were grown at the highest planting altitude of 500-1000 meters above sea level. Ferreira *et al*. (2022) mentioned that regions with a higher altitude generally have prominent sensory values such as flavor, aroma, and body com- pared to coffees grown at lower altitudes. These information may be useful development and commercialization of robusta coffee in the future.

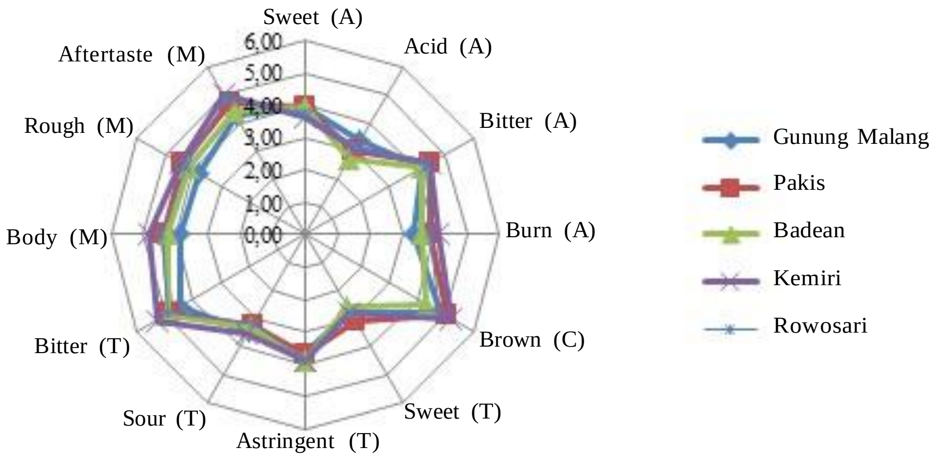

Figure 1. Spider-web RATA sensory test Robusta coffee of Gunung Malang, Pakis, Badean, Kemiri, and Rowosari

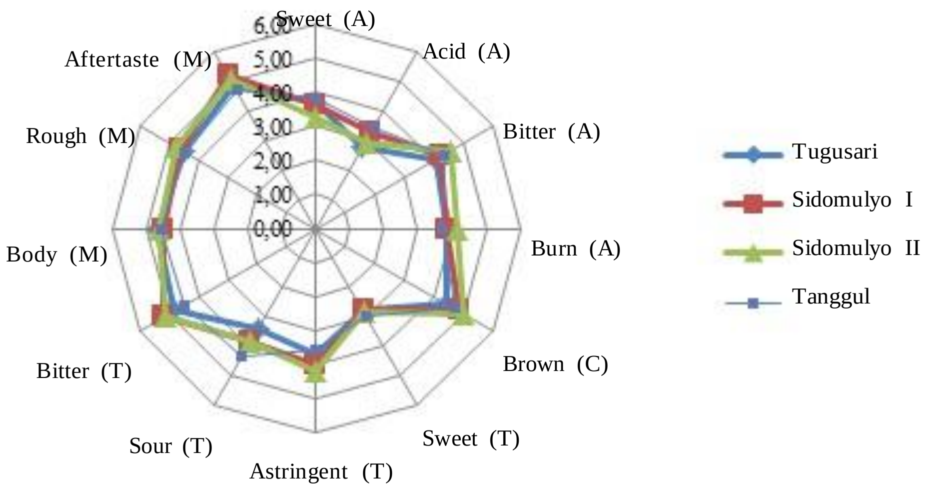

Figure 2. Spider-web RATA sensory test of Robusta coffee of Tugusari, Sidomulyo I, Sidomulyo II, dan Tanggul

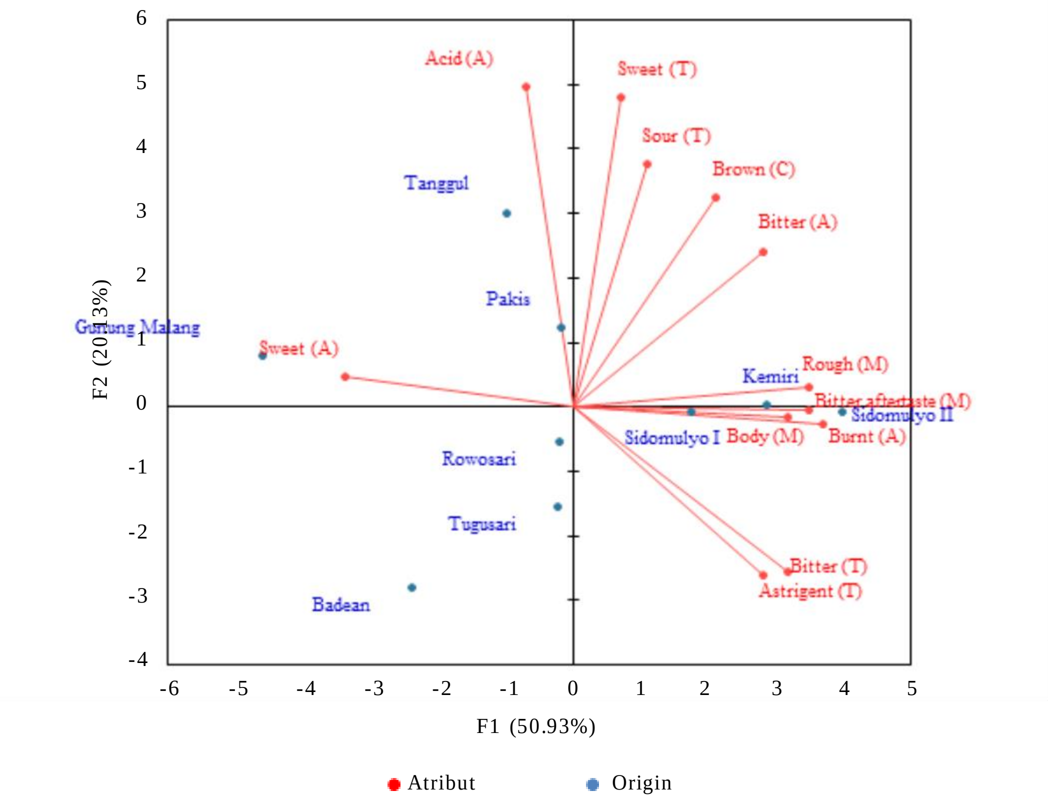

Figure 3. Biplot PCA descriptive sensory Jember Robusta coffee

Caffeine Content

Caffeine in coffee beans provides a distinctive flavor, contributing to the bitter taste of brewed coffee. The value of caffeine content in the different coffee origins can be seen in Table 3. Caffeine levels of Jember Robusta coffee were in the range of 1.71-2.15%. The coffee planting altitude had an effect on caffeine contents. As mentioned earlier, Tugusari Robusta was grown at a lower altitude than those in Gunung Malang. Robusta Tugusari was grown at an altitude of 54 m asl, while Gunung Malang Robusta was higher at 463 m asl. The same thing was also reported by Girma *et al*. (2020). Kamal *et al.* (2021) and Girma *et al.* (2020) mentioned that the lowest coffee planting height has the highest caffeine content. Coffee growth altitudes might affect rainfall and temperatures (Ping *et al*., 2013; Saeed *et al*., 2014). Higher elevations have higher air temperatures and rainfall (Sari *et al*., 2013; Van Beusekom *et al*., 2015). These temperature and precipitation differences affect the organic matter decomposition and soil chemical composition. Furthermore, it affects the plant growth (including secondary metabolites) in fruit ripening (Somporn *et al*., 2012; Herlina *et al*., 2017; Evans, 2002; and Tarakanita *et al*., 2019).

Chlorogenic Acid Content

Chlorogenic acid is the largest secondary metabolite found in coffee beans, in general chlorogenic acid is formed from caffeic acid and quinic acid (Clifford, 1999). Chlorogenic

Table 3. Average Robusta coffee caffeine and chlorogenic acid content based on origin

Origin	Caffeine content (%)	Chlorogenic content (%)
Gunung Malang	1.71	5.18
Pakis	2.04	5.62
Badean	1.89	5.21
Kemiri	2.08	5.84
Rowosari	2.10	5.98
Tugusari	2.15	6.02
Sidomulyo I	2.11	5.17
Sidomulyo II	2.01	5.98
Tanggul	1.89	5.27

acid contributes to the final acidity, astringency and bitterness balance of coffee. Chlorogenic acid levels in Robusta coffee samples were shown in Table 3. The difference in chlorogenic acid levels in each coffee might be due to the different altitude of coffee cultivation. Mintesnot & Dechassa (2018) mentioned that chlorogenic acid levels were higher in coffees grown at lower planting altitudes. The same thing was also shown in Tugusari Robusta coffee grown at a lower altitude compared to Sidomulyo I Robusta , which had a higher level of chlorogenic acid. It was caused by the warmer temperature in lowland areas, resulting in a faster coffee fruit ripening process (Mintesnot & Dechassa, 2018). In addition, genetic factors, cultivars, cultivation practices, climate, soil type, and the surrounding environment can also influence differences in chlorogenic acid content in coffee beans (Belay & Gholap, 2009). However, other factors such as genetics, soil fertility, climate and other factors might also contribute.

CONCLUSIONS

Metabolomic approach based on sensory descriptive test by RATA sensory attributes successfully differentiated Robusta coffee from Jember. Robusta coffee of Gunung Malang, Tanggul, and Pakis were characterized by sweet and acid aromas, while Robusta Kemiri was characterized by a sweet and sour taste, brown color, bitter aroma, and rough mouthfeel. Robusta coffee of Sidomulyo I and Sidomulyo II were characterized by bitter mouthfeel aftertaste and body, burnt aroma, astringency taste, and high bitterness. In contrast, Robusta of Rowosari, Tugusari, and Badean were characterized by low sweetness, sourness, bitter aroma, and rough mouthfeel. The coffee caffeine and chlorogenic acid content differences indicated that cultivation location could influence the Robusta coffee flavor profile. This information may be useful for further development and commercialization of robusta coffee.

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REFERENCES

Abubakar, Y.; S. Sabariana; R. Rasdiansyah & D. Hasni (2021). Sensory characteristic of espresso coffee prepared from Gayo Arabica coffee roasted at various times and temperatures. *The 2nd International Conference on Agriculture and Bio-industry IOP Conf. Series: Earth and Environmental Science*, 667, 12048.

Adawiyah, D.B.; O.M. Tjiptoputri & Lince (2020). Profil sensori sediaan pemanis dengan metode Rate-All-That-Apply (RATA). *Jurnal Mutu Pangan*, 7, 38–45.

Adek, W.Q. (2019). *Identifikasi dan inventarisasi jenis tumbuhan epifit di kaki Gunung Raung Desa Gunung Malang Kecamatan Sumberjambe Kabupaten Jember*. Thesis. Muhammadiyah University of Jember, Jember, Indonesia.

Ananta, Y.P. (2019). *Analisis faktor yang mempengaruhi pendapatan petani kopi rakyat di Desa Rowosari Kecamatan Sumber Jambe Kabupaten Jember*. Thesis. University of Jember, Jember, Indonesia.

Ardi, R.D.A. (2011). Analisis kesehatan keuangan pemerintah daerah dalam mendukung pelaksanaan otonomi daerah. Thesis. University of Jember, Jember, Indonesia.

Ardiansyah, D.; H. Tjota & W. El. Kiyat (2018). Review: peran enzim dalam meningkatkan kualitas kopi. *Jurnal Penelitian Ilmu-Ilmu Eksakta*, 19(2), 86–91.

Ares, G.; B. Fernanda; V. Leticia; S.C. Rafael; G. Ana; P. Benedicte; C. Denise; Hunter; Amy; G. Paisley & R.J. Sara (2014). Evaluation of a rating-based variant of Check-All-That-Apply (CATA). *Food Quality and Preference*, 36, 87–95.

Belay, A.; T. Kassahun; R. Mesfin & A. Araya (2007). Measurement of caffeine in coffee beans with UV/vis spectrometer. *Food Chemistry*, 108, 310–315.

Belay, A. & A.V. Gholap (2009). Characterization and determination of chlorogenic acids (CGA) in coffee beans by UV-Vis Spectroscopy. *African Journal of Pure and Applied Chemistry*, 3(11), 234–240.

Belgis, M.; C.H. Wijaya; A. Apriyantono; B. Kusbiantoro & N.D. Yuliana (2016). Physichemical differences and sensory profiling of six lai (*Durio kutejensis*) and four durian (*Durio zibethinus*) cultivars indigenous Indonesia. Interternational. *Food Research Journal*, 23, 1466–1473.

BPS (2020). *Statistik Kopi Indonesia 2020*. Badan Pusat Stastistik. Jakarta.

BPS Jember (2021). *Kabupaten Jember dalam Angka 2021*. Badan Pusat Statistik Kabupaten Jember. Jember, Indonesia.

BSN (2004). *SNI-01-3542-2004: Kopi Bubuk*. Badan Standar Nasional. Jakarta, Indonesia.

Buffo, R.A. & C. Cardelli Freire (2004). Coffee flavour: an overview. *Flavour and fragrance journal*, 19, 99–104.

Campa, C.; S. Doulbeau; S. Dussert; S. Hamon & M. Noirot (2005). Diversity in bean caffeine content among wild coffea species: Evidence of a discontinuous distribution. *Food Chemistry*, 91, 633–637.

Caporaso, N.; M.B.Whitworth; C. Cui & I.D. Fisk (2018). Variability of single bean coffee volatile compounds of Arabica and Robusta roasted coffees analysed by SPME-GC-MS. *Food Research International*, 108, 628–640.

Cassamo, C.T.; A.V.J. Mangueze; A.E. Leitao; I.P. Pais; R. Moreira; C. Campa; R. Chhiulele; F.O. Reis; I. Marques; P.S. Campos; F.C. Lidon; F.L. Partelli; A.I.R. Barros & C. Ramalho (2022). Shade and altitude implications on the physical and chemical attributes of green coffee beans from Gorongosa Mountain, Mozambique. *Agronomy*, 12(2540).

Clifford, M.N. (1999). Chlorogenic acids and other cinnamates: nature, occurrence and dietary burden. *Journal of The Science of Food Agriculture*, 79, 362–372.

DePaula; Juliana; C. Sara; Cunha; C. Adriano; L. Amanda; Sales; R. Ildi; F. José; M.P.L.V.O. Isabel; Ferreira; A.L. Marco; Miguel & F. Adriana (2022). Volatile fingerprinting and sensory profiles of coffee cascara teas produced in Latin American countries. *Foods*, 11, 3144.

Ditjenbun (2017). *Statistik Perkebunan Indonesia*. Sekretariat Direktorat Jenderal Perkebunan. Jakarta, Indonesia.

Evans W.C. (2002). Production of crude drugs in: pharmacognosy, 15th ed. *Elsevier Science Limited*. Part 3 (9), 61–66.

Fardani, L. (2015). *Analisis efesiensi pemasaran dan strategi pemasaran Jahe Gajah* (*Zingiber offinale Rosc.*). Thesis. University of Jember, Jember, Indonesia.

Farhaty, N. & Muchtaridi (2016). Tinjauan kimia dan aspek farmakologi senyawa asam klorogenat pada biji kopi: review. *Farmaka Suplemen*, 14(1), 214–227.

Ferreira, D.S.; M.E. da Silva; W.R. Ribeiro; C.A. Filete; D.T. Castanheira; B.C.P. Rocha; A.P. Moreli; E.C. da Silva; R.C. Guarconi; F.R. Partelli; & L.L. Pereira (2022). Association of altitude and solar radiation to understand coffee quality. *Agronomy*, 12(8), 1885.

Fibrianto, K. & M.P.A.D. Ramanda (2018). Perbedaan ukuran partikel dan teknik penyeduhan kopi. *Jurnal Pangan dan Agroindustri*, 6, 12–16.

Fibrianto, K.; Y.R. Febryana & E.S. Wulandari (2018). Effect of brewing technique and particle size of the ground coffee on sensory profiling of brewed Dampit Robusta coffee. *In IOP Conference Series: Earth and Environmental Science*, 1, 131.

Girma, B.; A. Gure & F. Wedajo (2020). Influence of altitude on caffeine, 5-caffeoylquinic acid, and nicotinic acid contents of Arabica coffee varieties. *Journal of Chemistry*, 1–7.

Herlina., S.A.; Aziz; Kurniawati & D.N. Faridah (2017). Changes of thymoquinone, thymol, and malondialdehyde content of Black Cumin (*Nigella sativa* L.) in response to Indonesia tropical altitude variation. *Hayati Journal of Biosciences*, 24, 156–161.

Kamal B.K.; B. Acharya; A. Srivastava; P. Madhav (2021). Effect of different altitudes in qualitative and quantitative attributes of green coffee beans (*Coffea arabica*) in Nepal. *International Journal of Horticulture, Agriculture and Food Science* (IJHAF), 5(3), 1–7.

Karasek, F.W. & R.E. Clement (2012). *Basic gas chromatography-mass spectrometry*. Waterlo: Elsevier Science.

Kaswindi, B.S.; R. Putra; R. Khathir (2017). Kajian mutu kopi Arabika Gayo dengan perlakuan variasi suhu dan lama penyangraian. *Jurnal Ilmiah Mahasiswa Pertanian Unsyiah*, 2(2), 416–422.

Lopes, G.R.; S. Petronilho; A.S. Ferreira; M. Pinto; C.P. Passos; E. Coelho; C. Rodrigues; C. Figueira; S.M. Rocha; & M.A. Coimbra (2021). Insights on single-dose espresso coffee capsules' volatil profile: from ground powder volatils to prediction of espresso brew aroma properties. *MDPI Foods*, 10(10), 2508.

Michaela, T.L.; Kreuml; M. Dorota; P. Bettina & K. Juergen (2013). Changes in sensory quality characteristics of coffee during storage. *Food Science & Nutrition*, 1(4), 267– 272.

Mintesnot, A. & N. Dechassa (2018). Effect of altitude, shade, and processing methods on the quality and biochemical composition of green coffee beans in Ethiopia. *East African Journal of Sciences*, 12, 87–100.

Moon, J.K. & T. Shibamoto (2009). Role of roasting conditions in the profile of volatile flavor chemicals formed from coffee beans. *Journal of Agricurtural and Food Chemistry*, 57, 5823–5831.

Muhardin (2019). *Sosial-Budaya petani kopi rakyat Desa Badean Kecamatan Bangsalsari Kabupaten Jember Tahun 2000–2017.* Thesis. University of Jember, Jember, Indonesia.

Naef, R. & A. Jaquier (2006). *New aldehydes and related alcohols in fresh lemon peel extract (Citrus limon L.). Flavour Fragr. Journal*, 21, 768–771.

Ni'mah, M.W.; U.H.A. Hasbullah & E.I. Retnowati (2021). Production of Robusta instant coffee powder with variation of fillers. *Agrointek*, 15(3), 932–942.

Ping, C.; J. Gary; Michaelson; A. Cynthia; Stiles & G. González (2013). Soil characteristics, carbon stores, and nutrient distribution in eight forest types along an elevation gradient, Eastern Puerto Rico. *Ecological Bulletins*. 54, 67–86.

PDSIP (2018). *Outlook Kopi*. Pusat Data dan Sistem Informasi Pertanian, Sekretariat Jendral–Kemenetrian Pertanian. Jakarta.

Pranatagama, M.F. (2015). *Efisiensi dan bauran pemasaran usaha tani kacang tanah di Desa Darungan Kecamatan Tanggul Kabupaten Jember*. Thesis. Univesity of Jember, Jember, Indonesia.

Putri M.K. & B.R. Dellima (2022). Pengaruh daerah tempat tumbuh terhadap kadar kafein biji kopi Robusta (*Coffea canephora*). *Jurnal Ilmu Kesehatan Bhakti Setya Medika*, 7(1), 33-42.

Redgwell, R. & M. Fischer (2006). Coffee carbohydrates. *Brazilian Journal of Plant Physiology*, 1, 165–174.

Saeed, S.; M.Y.K. Barozai; A. Ahmad & S.H. Shah (2014). Impact of altitude on soil physical and chemical properties in Sra Ghurgai (Takatu Mountain Range) Quetta, Balochistan. *International Journal of Scientific & Engineering Research*, 5(3), 730–735.

Santosa, K.M.; S. Supriyadi; Anggrahini & Y. Rahmadian (2020). Sensory analysis, caffeine, chlorogenic acid and non-volatil taste compounds of Arabica coffee (*Coffea arabica*) fermented with sugar addition for brew taste. *Indonesian Food and Nutrition Progress*, 17(2), 37–44.

Sari, N.P.; T.I. Santoso & S. Mawardi (2013). Sebaran tingkat kesuburan tanah pada perkebunan rakyat kopi Arabika di dataran tinggi Ijen-Raung menurut ketinggian tempat dan tanaman penaung. *Pelita Perkebunan*, 29(2), 93–107.

Sendy, A.Y. (2015). *Analisis Faktor-faktor yang Mempengaruhi Fertilisasi pada Wanita Usia Subur di Desa Kemiri, Panti Kabupaten Jember*. Thesis. University of Jember, Jember, Indonesia.

Somporn, C.; A. Kamtuo; P. Theerakulpisut & S. Siriamornpun (2012). Effect of shading on yield, sugar content, phenolic acids and antioxidant property of coffee beans (*Coffea arabica* L. cv. Catimor) harvested from North-Eastern Thailand. *Journal Science Food Agriculture*, 92(9), 1956–1963.

Stone, H.; R.N. Bleibaum & H.A. Thomas (2020). *Sensory Evaluation Practices*. Academic Press. Masachusetts, USA.

Tarakanita, D.N.S.; T. Satriadi & A. Jauhari (2019). Potensi keberadaan fitokimia kamalaka (*Phyllanthus emblica*) berdasarkan perbedaan ketinggian tempat tumbuh. *Jurnal Sylvia Scienteae*, 2 (4), 645–654.

Toledo, P.R.A.B.; M.M.R. Melo; H.R. Pezza; A.T. Toci; L. Pezza & C.M. Silva (2017). Descriminant analysis for unveiling the origin of roasted coffee sample: A tool for quality control of coffee related product. *Food Control*, 73, 164–174.

Traill, R.M.; M.S. Luckman; N.A. Fisk & M. Peng (2019). Application of the Rate-All-That-Apply (RATA) method to differentiate the visual appearance of milk powders using trained sensory panels. *International Dairy Journal*, 97, 230–237.

Van Beusekom, A.E.; G. González & M.M. Rivera (2015). Short-term precipitation and temperature trends along an elevation gradient in Northeastern Puerto Rico. *Earth Interactions*, 19(3), 1–3.

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