Food Research 5 (Suppl. 2) : 107 - 112 (2021)
Journal homepage: http://www.myfoodresearch.com

FOOD RESEARCH

FULL PAPER

Chemical compounds and sensory characteristics of Arabica coffee (*Coffea arabica*) as a novel specialty coffee from Sinjai Regency, Indonesia

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Article history:
Received: 7 December 2020
Received in revised form: 28 July 2021
Accepted: 16 August 2021
Available Online: 31 August 2021

Keywords:
Arabica coffee,
Specialty coffee,
Chemical composition,
Sensory characteristics,
Altitude

DOI:
https://doi.org/10.26656/fr.2017.5(S2).001

Abstract

Specialty coffee is generally found in areas with an altitude around 1000 meters above sea level (m a.s.l.) and is known to have a different distinctive flavor. One of the coffee plantations in South Sulawesi that has the potential to upgrade its status as a specialty coffee is the Sinjai regency. The sensory quality and chemical characteristics are the most important component of specialty coffee. The purpose of the study was to evaluate the chemical compounds and sensory quality in Manipi coffee beans in South Sulawesi, which has the potential to be classified as specialty coffee. The coffee cherries were collected from two locations based on different altitudes namely MA1 = 1200 m a.s.l. and MA2 = 1400 m a.s.l. The coffee cherries directly processed the wet method referring to Enrekang Arabica as a reference sample EA1 = 1200 m a.s.l. and EA2 = 1400 m a.s.l. The results showed that the chemical content and quality of sensory in Manipi Arabica coffee beans were affected by altitude. MA2 had the highest protein content (13.26%), lipid (7.67%), and caffeine (1.42%), whereas green arabica coffee beans with the highest carbohydrate content was MA1 (23.38%). The Enrekang Arabica were similar in terms of Manipi Arabica coffee beans had the highest protein, lipid, and caffeine content at an altitude of 1400 m a.s.l. respectively (12.41%), (10.73%), and (1.32%). The sensory quality of MA1 is 85.75, relatively similar to MA2 is 85.25. The Manipi Arabica coffee beans showed a specific flavor, namely brown sugar and vanilla notes from both altitudes. It had the potential to be developed into specialty coffee with a cup test score > 80.

1. Introduction

Coffee is a commodity plantation product that has an important contribution to the global economy. Indonesia is the fourth-largest producer and exporter of coffee after Brazil, Vietnam and Colombia. As stated by Belitz *et al.* (2009) in early 2000, about 75% of the world coffee production came from Arabica and about 25% came from Robusta. Recent data from US Department of Agriculture (United State Departement of Agriculture, 2020) indicate that global coffee production in the last five years consisted of about 59% *Coffea arabica* and 41% *Coffea canephora*.

In the world market, Indonesian coffee commodities are known as specialty coffee through various coffee and civet coffee. Specialty coffee is a term given by the International Coffee Organization (ICO) which refers to several coffee populations that are grown under certain geographical conditions, which produce coffee with distinctive flavor and consistent of quality. Among Indonesian coffees that are classified as specialty coffee are Gayo coffee (Aceh), Toraja and Enrekang coffee (South Sulawesi), Lintong coffee (Lampung), Javanese coffee, and Kintamani coffee (Bali).

The popularity and attractiveness of the world towards specialty coffee, mainly due to its unique taste and supported by historical, traditional, social and economic factors (Ayelign and Sabally, 2013). The demand for specialty coffee continues to increase from year to year. In 2017 the export of specialty coffee increase was 17,71% compared to 2016 (Ministry of Trade, 2018). The main export destination countries for Indonesian specialty coffee are the United States (23.47%), Japan (8.7%) Germany (7.4%), Italy (7%), and Malaysia (5.9%) of the total market share. This is a great opportunity for Indonesia to add types of coffee that deserve international recognition as specialty coffee

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eISSN: 2550-2166

so that Indonesia's coffee trade in the world will increase (International Coffee Organization, 2016).

One of Indonesia's Arabica specialty coffee producing areas is in South Sulawesi, where there is Arabica coffee production specifically in the Tana Toraja and Enrekang regency. The coffee produced is known commercially to have the fine flavor of good acidity, smooth, very nice mellow, and good body. Toraja coffee is widely known and very popular, especially in Japan, the United States, and Germany (Ministry of Trade, 2018).

In the southern highlands, coffee beans production is in the Sinjai, Bulukumba, Bantaeng, and Gowa regency, which are located in the cool expanse of the foothills of the Bawakaraeng and Lompobattang mountains. Manipi is coffee produced from Sinjai regency with an altitude around 900-1400 m a.s.l. It has a distinctive taste and aroma and is not inferior to Toraja and Enrekang coffee (Yayasan Pensa Global Agromandiri, 2013). The Manipi coffee beans production is strongly suspected of having the characteristics of specialty coffee. This is supported by geographical factors such as the height of the growing from sea level (m a.s.l.), climate change, and soil nutrients which are very supportive and affect the production of coffee with specific aroma and flavor. According to Leonel and Philippe (2007) and Barbosa *et al*., (2012), that the higher altitude of Arabica coffee plants can produce a better quality of flavor. Previously reported studies also showed that high altitude, coffee plants take a longer time to mature, fully develop, and produce beans having good flavor and aroma (Caprioli *et al.,* 2014; Worku, *et al.,* 2018).

The potential flavor of coffee beans, apart from being determined by the physicochemical component. The chemical contents that play a role in the formation of flavor coffee include caffeine, amino acids, chlorogenic acids, lipids and their derivatives, minerals and volatile components (Bertrand *et al*., 2012; Yusianto *et al*., 2005). The purpose of this study was to evaluate the chemical compounds and sensory characteristics of Manipi coffee in South Sulawesi, which has the potential to be categorized as specialty coffee, apart from Enrekang and Toraja coffee (which were previously classified as specialty coffee by the ICO).

2. Materials and methods

2.1 Materials

The samples for assessment were prepared as dried coffee beans. Fully ripe (red) Arabica coffee berries were harvested from local farmer in Manipi, Sinjai Regency, South Sulawesi in July 2019. The coffee cherries were collected at two locations based on different altitudes, namely MA1 = 1200 m a.s.l. (Botolempangan village) and MA2 = 1400 m a.s.l. (Balakia village). The location determination is based on the criteria for the area to be proposed by its Geographical Indication and represents the southern highland area. In this study, Enrekang Arabica coffee beans were used as a reference sample, it is one of coffee specialty in South Sulawesi which is classified by the ICO.

2.2 Chemical analysis

2.2.1 Carbohydrate, protein, and lipid analysis

The chemical compounds of green coffee beans were evaluated in terms of carbohydrates, protein, and lipid. The carbohydrates content of the green coffee beans was determined following procedure 920.101 in AOAC (2012). The protein and lipid content of green coffee beans was analyzed respectively using approved procedure 920.53, and 963.15 in AOAC (2012) (Association of Official Analytical Chemists, 2012).

2.2.2 Caffeine analysis

Sample preparation and caffeine analysis according to the Perrone *et al*. (2008) methods. Sample (0.2 g) of ground coffee was suspended in 60 mL of boiling water and shaken at room temperature for 15 min at 300 rpm. The mixture was filtered through filter paper (Whatman No. 1) and washed with approximately 30 mL of water. Saturated aqueous basic lead acetate solution (2 mL) was added for clarification of the extract and the final volume was made up with water to 100 mL. The colloidal dispersion was then filtered through both filter paper (Whatman No. 1) and 0.22 mm cellulose ester membrane (Millipore, Brazil). The final extract was diluted with water (1:1) prior to LC-MS analysis.

Caffeine determination using Liquid Chromatography equipment (Shimadzu, Kyoto, Japan) comprised a LC-20AD quaternary pump, a CTO-20AS column oven and an autosampler SIL-20AC. This LC system was interfaced with an LC-MS 2020 mass spectrometer (Shimadzu, Kyoto, Japan) fitted with an electrospray ion source. Chromatographic separations were achieved using an HPLC column (150×2.0×5 mm), Waters, Milford, USA) maintained at a constant temperature of 40°C. The mobile phase consisted of 0.3% aqueous formic acid (eluent A) and methanol (eluent B), delivered at a flow rate of 0.2 mL/min. Before injection, the column was equilibrated with 25% B. Immediately after injection, this proportion was changed to 60% B until the end of the run at 6 mins. In between injections, 5 mins intervals were used for column re-equilibration with 25% B. The mass spectrometer was operated in the single ion monitoring (SIM) mode to detect caffeine ions. Identification of caffeine was performed by comparison with retention time and molecular weight of the respective standard. Data were acquired by LCMS solution software (Shimadzu Corp., version 2020) for the mass spectrometer.

2.3 Sensory evaluation

To assess the flavor or sensory characteristics of the coffee, cup tests were done by six certified coffee cuppers at the Indonesian Coffee and Cocoa Research Institute in Jember, East Java. A total of 150 g of green coffee beans were roasted using Probat machine with temperature 200°C for 10 mins. The roasted coffee beans were cooled at room temperature rapidly and stored in an airtight glass jar for about 12 h before grinding. The beans were then ground coarsely and placed in ceramic cups and covered. For aroma and taste assessment, 10 g of the ground samples were placed in ceramic mugs and added with 180 ml of hot water (about 93°C). The sensory quality assessed according to the Specialty Coffee Association of America's guidelines and cupping protocol (Specialty Coffee Association of America, 2015). The sensory attribute includes of flavor, fragrance, aftertaste, acidity, body, clean cup, sweetness, balance, uniformity, and overall. The cup score and taste notation were divided into four groups: 6.00 – 6.75 = good; 7.00 – 7.75 = very good; 8.00 – 8.75 = excellent; and 9.00 – 9.75 = outstanding (SCAA , 2015).

2.4 Statistical analysis

Data was analyzed using ANOVA and Duncan test if there was a significance at $P<0.05$ by the Windows SAS System V9.4.

3. Results and discussion

3.1 Chemical compounds

The chemical compounds of Arabica green beans such as carbohydrate, protein, lipid, and caffeine from different altitudes are presented in Table 1. The carbohydrate content in Manipi Arabica coffee beans was much higher in MA1 (23.38%) than MA2 (22.09%). Whereas Enrekang Arabica coffee beans had the highest carbohydrate content is EA2 (24.03%) and EA1 (22.49%). High altitude generally causes a decrease in ambient temperature. This reduces heat-induced stress in plants, increases the leaf to fruit ratio and net photosynthetic rate, and prolongs the berry maturation period (DaMatta and Ramalho, 2006; Vaast *et al.,* 2006). Under this situation, there is more carbohydrate supply to developing beans and time for bean filling.

As stated by Farah (2012), carbohydrates are major constituents of coffee and may account for more than 50% of the dry weight. The poly-, oligo-, di-, and monosaccharides can be divided into reducing and nonreducing sugars. Polysaccharides (soluble and insoluble) account for approximately 44% of dry matter in *C. Arabica* and 47% in *C. canephora*. Sucrose is important for coffee flavor and quality, it accounts for up to 9% of *C. Arabica* dry weight and approximately half of it in *C. canephora* (Kölling-Speer and Speer, 2005). Other carbohydrates such as fructose and glucose are mainly found in green beans and contribute to perceived coffee sweetness (Oestreich-Jansen, 2010). Carbohydrates are precursors for the Maillard reaction (in the case of sucrose, after inversion) and caramelization, which are important for coffee color and aroma development (Poisson *et al.,* 2017; Farah, 2021).

The highest protein content in Manipi Arabica coffee beans is MA2 (13.26%) and the lowest is MA1 (13.11%). It also happens in Enrekang Arabica where the highest protein content is EA2 (12.41%) and the lowest is EA1 (12.18%). According to the results by Figueiredo *et al*. (2013); Rodrigues *et al*. (2010) stated that higher altitude is in line with the increase of protein content. The protein content is influenced by the level of soil fertility. Protein and free amino acids are vital for coffee flavor since they are needed for the Maillard reaction. As stated by Farah (2012), the protein and free amino acids serve as precursors for the formation of volatile compounds such as furans, pyridines, pyrazines, pyrrols, aldehydes, and melanoidins.

The lipid content in Manipi and Enrekang Arabica coffee beans is influenced by the altitude where they are grown. In Manipi Arabica coffee beans, the lipid content in MA1 (5.98%) is lower than MA2 (7.67%). As well as Enrekang Arabica coffee beans, the lipid content in EA2 (10.73%) is higher than EA1 (7.80%). According to previous studies, the lipid content will increase at a higher altitude in the growing plantation area (Decazy *et al*., 2003; Howard, 2011) caused by synthesis of lipid is

Table 1. The chemicals characteristics in Manipi Arabica coffee beans from different altitudes

Variables	Carbohydrate (%)	Protein (%)	Lipid (%)	Caffeine (%)
MA1	23.38 ± 0.28^{bc}	13.11 ± 0.06^{a}	5.98 ± 0.02^{bc}	1.41 ± 0.03^{a}
MA2	22.09 ± 0.28^{d}	13.26 ± 0.08^{a}	7.67 ± 0.01^{bc}	1.42 ± 0.07^{c}
EA1	22.49 ± 0.28^{cd}	12.18 ± 0.01^{b}	7.80 ± 0.03^{bc}	1.31 ± 0.08^{d}
EA2	24.03 ± 0.80^{ab}	12.41 ± 0.05^{b}	10.73 ± 0.04^{ab}	1.32 ± 0.06^{b}

Values are presented as mean±SD. Values with different superscript within the column are significantly different.

eISSN: 2550-2166

more intensive than lower grown of beans (Bertrand *et al*., 2012). The lipid fraction in coffee, also known as coffee oil is divided into the oil-coated bean surface and triglycerides, as linoleic acid (40-45%) and palmitic acid (25-35%) (Muzaifa *et al.,* 2019).

In the present study, the caffeine content in MA1 (1.41%) and MA2 (1.42%) are relatively similar. The higher caffeine content in Manipi Arabica also happens in Enrekang Arabica coffee at an altitude of 1400 m a.s.l (1.31%). Caffeine was reported to have a contribution towards the bitterness of coffee and may give a physiological stimulating effect (Flament and Bessiere-Thomas, 2002; Muzaifa *et al.,* 2019).

In general, there were differences in growth that affect the chemical content of coffee beans. As stated by Howard (2011); Sridevi and Giridha (2013) at higher altitudes, coffee plants grown slower, take longer to mature and produced beans with higher chemical content. The results of Avelino *et al*. (2005); Figueiredo *et al*. (2013); Rodrigues *et al*. (2010) also concluded that the higher protein, caffeine, and lipid content in line with the altitude.

3.2 Sensory characteristics

The results of cup quality in Manipi and Enrekang Arabica coffee beans are presented in Figure 1. Based on the SCAA protocol, coffee samples that give a cup score ≥ 80 are classified as specialty coffee beans. In this study, Manipi Arabica coffee beans MA1 gave a higher cup score of 85.75, while MA2 gave a cup score of 85.25. Similarly, for the Enrekang Arabica coffee beans, EA1 had a higher cup score of 86.00 than EA2 gave a cup score of 83.88 (Table 2). In the present study, the Arabica coffee beans of Manipi and Enrekang showed the highest cup scores at an altitude of 1200 m a.s.l. This result was different by Camargo (2010); Figueiredo *et al*. (2013); Geromel *et al*. (2008); Joët *et al*. (2010); Vaast *et al*. (2006) which states that there is a positive correlation between altitude and cup quality. In this study, it is assumed that the Arabica coffee beans of Manipi and Enrekang at an altitude of 1400 m a.s.l. have a low level of soil fertility than 1200 m a.s.l. As stated by Decazy *et al*. (2003); Yadessa e*t al*. (2008), the flavor of coffee are influenced by the level of soil fertility.

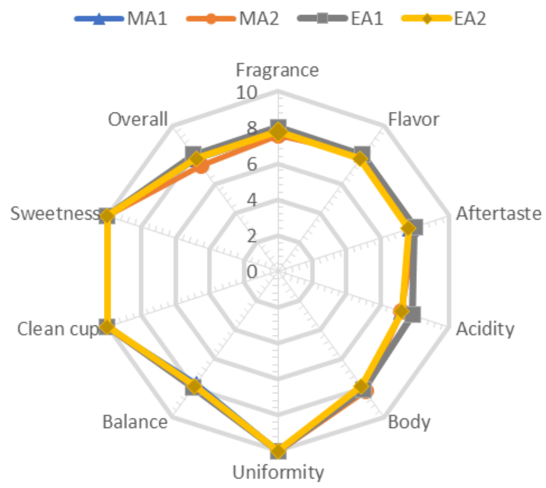

Figure 1. The flavor profile in Manipi Arabica coffee beans from different altitude

The Manipi Arabica coffee beans of MA1 gave more complex flavor notes such as caramelly, brown sugar, vanilla, and spicy, while MA2 have characters for brown sugar, vanilla, and spicy. The Manipi Arabica coffee beans showed a specific flavor, namely brown sugar and vanilla notes, it gave from both altitudes. The Enrekang Arabica coffee beans were identified with a specific flavor, namely chocolaty. The higher altitudes promote increasingly favorable taste qualities in coffee beans. According to Cheng *et al.* (2016), Sunarharum *et al.* (2014), and Avallone *et al*. (2002), coffee beans flavor is influenced by geographical location, climatic conditions,

Table 2. Cupping scores in Manipi Arabica coffee beans from different altitudes

Attributes	MA1	MA2	EA1	EA2
Fragrance	7.75	7.58	8.00	7.75
Flavor	8.00	8.00	8.00	7.75
Aftertaste	7.75	8.00	8.00	7.63
Acidity	7.25	7.25	7.88	7.25
Body	8.13	8.25	8.13	7.88
Uniformity	10.00	10.00	10.00	10.00
Balance	7.75	8.00	8.00	7.88
Clean cup	10.00	10.00	10.00	10.00
Sweetness	10.00	10.00	10.00	10.00
Overall	7.75	7.25	8.00	7.75
Taints/defect	-	-	-	-
Final score	85.75	85.25	86.00	83.88
Characters of flavor	Caramelly, Brown Sugar, Vanilla, Spicy	Brown Sugar, Vanilla, Spicy	Chocolaty, Spicy, Vanilla	Chocolaty, Herbal, Astringent, Spicy

soil quality, genotypes, and the processing method used. In general, Manipi plantations have the potential to produce coffee that can be classified as specialty coffee beans such as Enrekang if they are handled properly at postharvest. Better quality of coffee can be obtained, among others, through good processing with the physical appearance of the coffee beans that are not too defective.

4. Conclusion

The Arabica green coffee beans in Manipi showed the highest chemical content i.e. protein (13.26%), and lipid (7.67%) at an altitude of 1400 m a.s.l., while carbohydrate (23.38%) and caffeine (1.42%) at an altitude of 1200 m a.s.l. Some differences between previous studies, the cup quality gave higher score at altitude 1200 m a.s.l. (85.75) compare to 1400 m a.s.l. (85.25), it also happens in Enrekang (86.00). The Arabica coffee beans in Manipi have a specific flavor, namely brown sugar from both altitudes that were absent in Enrekang Arabica coffee beans. In general, the Arabica coffee beans in Manipi potential as a novel specialty coffee from Sinjai Regency.

Conflict of interest

The authors declare no conflict of interest.

Acknowledgments

This research was supported by the Agency for Research and Development, Ministry of Industry.

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