Sensory Quality and Hedonic Level Of Sigararutang Arabica Coffee Brew On Varied Processing Treatment

Deliana P Agriawati[1], Tommy Purba[2], Hendri F.P. Purba[3], Perdinanta Sembiring[4], Nurmalia[1], Khadijah EL Ramija[1], Alfonso Sitorus[5], Nurhafsah[6], Jhon David Haloho[3], Justus Elisa Loppies[7]

[1] Agency for the Assembly and Modernization of Agriculture of North Sumatra, Medan, 20143, Indonesia
[2] Research Center for Cooperative, Corporation, and People's Economy, Indonesian National Research and Innovation Agency, Jakarta 12710, Indonesia
[3] Research Center for Process Technology, Indonesian National Research and Innovation Agency, Serpong, South Tangerang 15314, Indonesia
[4] Research Center for Horticulture, Indonesian National Research and Innovation Agency, Cibinong-Bogor, West Java 16911, Indonesia
[5] Research Center for Food Crops, Indonesian National Research and Innovation Agency, Cibinong-Bogor, West Java 16911, Indonesia
[6] Research Center for Equipment Manufacturing Technology, Indonesian National Research and Innovation Agency, Serpong, South Tangerang 15314, Indonesia
[7] Research Center for Sustainable Industrial and Manufacturing Systems, Indonesian National Research and Innovation Agency, Serpong, South Tangerang 15314, Indonesia

Received: 20 0ctober 2025

Accepted: 09 December 2025

***Correspondent Email:**
author@email.ac.id

Abstract: *Sigararutang as one of Indonesia's Arabica coffees has superior characteristics such as delicious taste, large bean size and pest resistant. Coffee quality is set during cultivation, but post-harvest processing has a significant impact. Independent processing efforts to generate specialty coffee at the farmer level have the potential to improve farmer welfare. This study aimed to: 1) determine the potential of dry and wet processing (Full wash, Semi wash, Natural, Honey, and Wine) in producing Sigararutang specialty coffee and 2) determine the effect of processing and roasting types on consumer preferences. The research was conducted in Gurgur, Toba Samosir Regency, and the Post-Harvest Laboratory of AIAT North Sumatra. The results showed that 4 out of 5 types of processing were able to produce specialty Sigararutang coffee. The cupping test results for each processing method were as follows: 85.25 for full and semi wash, 84.75 for honey, 84.5 for natural, and 78.13 for wine. Based on the hedonic test, the highest taste and aroma preferences for each method were 66.6 and 61.9% for light roasting in honey and semi-wash processing; 2) 72.3 and 63.6% for medium roasting in full and semi-wash processing; 3) 63.4 and 81.1% for dark roasting in honey and semi-wash processing and natural and honey. The Friedman test results revealed that the processing method had only a significant effect on the level of preference for the aroma of dark roasted coffee.*

Keywords: *Sigararutang, coffee, Arabica, specialty*

1. INTRODUCTION

Arabica coffee is a type of coffee that grows well at altitudes of 1,000 to 1,500 masl, in temperatures ranging from 18 to 21°C, and within a geographical zone between 20° North Latitude and 20° South Latitude. Therefore, North Sumatra Province, located between 0° and 5° North Latitude, is a potential region for Arabica coffee cultivation (Marbun et al, 2020). North Sumatra Province was the second-largest producer of Arabica coffee in Indonesia during the 2018–2022 period, with an average production of 66,051 tons of green coffee. The main Arabica-producing regions in North Sumatra include North Tapanuli, Simalungun, Humbang Hasundutan, Dairi, and Karo Regencies (Susanti & Putra, 2022). The uniqueness of North Sumatran coffee has been recognized since the colonial era, largely due to price differences in traditional markets—coffee from North Sumatra tends to fetch higher prices compared to other Indonesian coffees. Coffee cultivation in North Sumatra is still managed traditionally, and the most commonly developed varieties are Arabica Ateng and Sigararutang (Susila, 2005).

The Sigararutang coffee variety, officially released in 2005 by the Ministry of Agriculture, is a natural hybrid between the Blawan Pasoemah (BLP) and the Citamor varieties. Its parent tree plant originated from Batu Gajah Village, Paranginan, Lintong, Humbang Hasundutan Regency. Sigararutang coffee exhibits a semi-dwarf growth habit, with dark green mature leaves and reddish-brown young leaves (Girsang et al, 2005). Farmers named it "Sigararutang" based on its fast production cycle (1–2 years) and its ability to bear fruit year-round (Susila, 2005). The beans are elongated and round, classified as large-sized, with 100 beans weighing approximately 20.4 grams (Randriani and Dani, 2018). Arabica coffee is characterized by a central groove that curves downward, elongated beans, a moderately convex shape, and a lighter color at the bean tip compared to other coffee types. It also has a lower yield, reaching only 18–20%

(Rachmawati & Gunanti, 2023). Despite being processed locally and traditionally the postharvest handling of Sigararutang coffee produces unique sensory qualities that contribute to its distinctive flavor and aroma. According to Susila (2005), local coffee processing systems in North Sumatra have been implemented effectively. The process includes harvesting, floating, pulping, fermentation, washing, initial drying, wet parchment hulling, re-drying, and storage.

Harvesting coffee cherries is a selective activity aimed at producing high physical quality in coffee beans, which in turn influences the flavor and chemical composition of the beans during post-harvest processing (Yusianto & Nugroho, 2014). After harvesting, postharvest processes are carried out, including the separation of coffee beans from other fruit components, which is categorized as primary processing (Franca & Oliveira, 2019). Farmer practices and climatic conditions have resulted in primary coffee processing methods in Indonesia that differ from those used in several other coffee-producing countries. Indonesia employs four main coffee processing methods: (1) full wash–dry hulling, (2) full wash–wet hulling, (3) semi-wet processing (also known as the pulp natural process), and (4) dry processing (Yusianto & Nugroho, 2014).

Each layer surrounding the coffee bean during processing can influence the bean's chemical composition. Therefore, coffee producers use various fruit treatment methods to achieve specific flavor profiles. However, fruit processing not only affects flavor precursors but can also impact the content of functional compounds. The cherries are processed immediately after harvest to limit unwanted fermentation and reduce contamination. The most commonly used methods are natural processing and fully washed processing (Halagarda & Obrok, 2023). Coffee beans generally still contain only precursor compounds that will later develop into characteristic flavor components during processing (Cardoso et al., 2023). Due to the high complexity nature of coffee characteristics, no analytical method currently exists that can fully assess coffee quality other than sensory evaluation. This is supported by Stephenson (2015), who stated that humans possess an exceptionally refined ability to detect and distinguish substances introduced into the mouth, and no sophisticated instrument matches the multifunctional capacity of the human oral and olfactory systems.

The application of various coffee fruit processing methods is one of the key approaches to obtaining high-quality coffee beans. Based on this consideration, it is necessary to conduct a study on several coffee processing techniques to produce beans and ground coffee of superior quality and consistency. This research investigates the impact of different raw material processing methods—namely dry (full washed), wet (semi washed), wine, natural, and honey processes—on the organoleptic quality of Arabica coffee, specifically in terms of color, texture, aroma, and taste. The objectives of this study are: (1)To identify the flavor profile of Sigararutang coffee produced through various processing methods, and (2) To determine consumer preference levels for brewed Sigararutang coffee processed using different techniques.

2. MATERIALS AND METHODS

Sigararutang Arabica coffee cherries were sourced from experimental plots at the Gurgur Agricultural Technology Assessment and Development Installation (IP2TP), situated in the Balige District of Toba Samosir Regency, North Sumatra. Laboratory-based analyses and postharvest processing were conducted both at IP2TP Gurgur and at the postharvest laboratory of the North Sumatra Assessment Institute for Agricultural Technology (AIAT). The study utilized plastic basins, high-density polyethylene (HDPE) bags, sacks, a digital weighing scale, and plastic tarpaulins as primary materials for fruit handling and processing.

Coffee Processing Treatments

Five coffee cherry processing treatments were applied: full-wash processing, semi-wash processing, natural sun-drying, "wine" fermentation, and honey processing. All procedures followed the recommendations of the Coffee and Cacao Research Center (Puslitkoka), Jember.

Natural processing.

In the natural process, coffee cherries were sun-dried, followed by hulling, and subsequently dried again until the moisture content reached 10–12%.

Full-wash processing.

The full-wash method consisted of sorting, pulping, washing, fermentation, a second washing, drying, hulling, and final drying to reach a moisture content of 10–12%.

Semi-wash processing.

In the semi-washed process, cherries underwent sorting, pulping, fermentation, and a single washing step prior to drying, hulling, and final drying to a moisture content of 10–12%.

Honey processing.

The honey process involved pulping to remove the outer skin, followed by drying, hulling, and additional drying until the beans reached 10–12% moisture.

Wine processing.

For the "wine" process, sorted coffee cherries were fermented in airtight plastic containers for one month, followed by drying, hulling, and final drying to 10–12% moisture content.

Roasting.

Roasting was performed using a Probat type Probatone 5 roaster, applying three roasting levels.

Sensory Evaluation

Flavor profiling of the coffee samples was conducted at the Indonesian Coffee and Cacao Research Institute (ICCRI) Jember Laboratory following the cupping standards of the Specialty Coffee Association of America (SCAA). The total sensory score obtained from the cupping protocol was used to classify the specialty grade of each sample.

A consumer hedonic test was also performed to evaluate brewed coffee produced from the three roasting levels. The test involved 30 untrained panelists, who assessed aroma, flavor, and overall acceptability using a hedonic scale. Coffee samples were served in a randomized order to minimize bias.

Data from the hedonic test were analyzed using descriptive statistics and nonparametric methods, with the Friedman test applied to detect differences in preference among processing and roasting treatments.

3. Results and Discussions

3.1 Variability in Flavor Quality

The final cupping scores for the Arabica Sigararutang brew quality in this study ranged from 78.13 to 85.25. Based on the total quality score defined by the Specialty Coffee Association of America (SCAA), the green beans of the Sigararutang Pucuk Merah variety produced through the four processing methods—both wet and dry—qualified as specialty coffee, as all samples scored above 80. More specifically, according to SCAA (2015), the specialty categories obtained in this study were very good for the natural and honey processes and excellent for the full-wash and semi-wash processes.

The difference in final scores among the four processing methods—full wash (FW), semi-wash (SW), natural (NA), and honey (HO)—was relatively small. However, overall, the sensory attributes of coffee brewed from beans processed using wet methods (full wash and semi-wash) were higher than those produced through dry methods (Table 1). Although the full-wash and semi-wash processes yielded similar final scores, the flavor attribute of the semi-wash treatment was generally superior to that of the full wash.

The cup quality of Sigararutang coffee processed using the semi-wash method was among the highest, particularly for the acidity and balance parameters, as well as several other attributes, although some scores were comparable to one or more other processing methods. These findings differ from those reported by Pan et al. (2021), who stated that full-wash processing resulted in higher final scores and higher values for nearly all sensory parameters compared to semi-wash, except for body. Consistent with Pan et al. (2021), Sunarharum et al. (2018) also highlighted the superiority of full-wash processing in producing higher-quality coffee, as indicated by higher final scores and higher values for all sensory attributes except sweetness.

The high or low acidity scores given by panelists for full-wash and semi-wash coffees are associated with the presence of sour notes in the brewed coffee, which, if too strong, may reduce consumer preference. Supporting this, semi-wash processed coffee is reported to exhibit lower acidity with sweeter, cleaner, and more consistent flavor characteristics, as well as a lighter body (Hameed et al., 2018; Volcafe, 2012). Referring to pH as an indicator of acidity level, Sinaga et al. (2021) reported that full-wash processing produces coffee with a higher pH value compared to other methods, including semi-wash and natural processing.

Treatment/ Parameter	Full wash	Semi wash	Natural	Honey	Wine
Aroma	7,88	7,88	7,75	7,75	7,75
Flavor	7,63	7,88	7,75	7,88	7,25
Aftertaste	7,63	7,75	7,75	7,75	7,63
Acidity	7,63	7,88	7,75	7,75	7,75
Body	8	8,13	8	8,13	7,75
Uniformity	10	10	10	10	10
Balance	7,63	7,88	7,75	7,75	7,5
Clean cup	10	10	10	10	5
Sweetness	10	10	10	10	10
Taster's score	7,63	7,88	7,75	7,75	7,5
Final score	85,25	85,25	84,5	84,75	78,13

Notes:
1) Quality scale for sensory attributes: 6-<7.00 = good; 7-<8 = very good; 8-<9 = excellent; 9-<10 = outstanding;10 = perfect
2) Total score classification: <80= Not specialty grade ; 80,00-84,99= very good specialty; 85-89,99= excellent specialty; 90,00- 100,00= outstanding specialty.

Table 1. Flavor Profile of Sigararutang Coffee Across Five Processing Techniques

Balance is a sensory attribute that reflects the equilibrium among four other sensory attributes: aroma, flavor, aftertaste, and body (Muzaifa et al., 2021). As an attribute whose evaluation encompasses multiple aspects, assessing or determining balance can be challenging (Kustiari et al., 2018). Mestdagh et al. (2017) further explain that the evaluation of balance in brewed coffee is closely related to the physiology of human perception, particularly when aroma or flavor molecules interact with taste and olfactory receptors. Moreover, it is elaborated that this perceptual physiology is influenced by perception thresholds, the equilibrium of which depends on several factors such as the solubility of flavor molecules, the particle structure of the coffee, the chemical structure of the extracted compounds, and the duration of extraction. In this study, the lowest balance scores were observed in the wine and full wash processing methods. As described above, both processing methods exhibited dominance of a particular attribute, as indicated by marked differences in the scores among attributes—especially flavor and aftertaste for full wash, and flavor for wine. The low flavor score in the wine processing method can be attributed to excessive and uncontrolled fermentation, as noted by Haile & Kang (2019), which may promote the proliferation of spoilage microorganisms and the production of various chemical compounds, there by diminishing the quality of both the flavor and aroma of the coffee.

Green beans of the Sigararutang variety produced using the wine (W) processing method in this study did not meet the specialty grade criteria because the final cupping score was below 80 (Table 1). The low values obtained for clean cup, flavor, body, and balance contributed substantially to the reduced overall score of the wine process. Although natural fermentation is intended to enhance wine-like aroma and flavor notes without masking the intrinsic characteristics of the coffee (Dairobbi et al., 2017), inaccuracies during fermentation can lead to defects such as off-odors ("stinker") and undesirable sourness, both of which are generally rejected by consumers (Girma & Sualeh, 2022).

Such inaccuracies may arise from various factors that directly or indirectly influence the fermentation process, including pH, microbial composition, environmental conditions, temperature, water contamination, coffee cherry variety and origin, as well as harvest and postharvest management practices such as picking, handling, and storage (Woldesenbet et al., 2020). Processing and drying conditions also play a critical role in determining the final sensory quality (Chalfoun et al., 2018). Furthermore, previous studies have shown that fermentation duration and the type of fermentation medium significantly affect microbial activity and the resulting flavor profile.

Wine coffee is produced through an extended natural fermentation process, typically 10–40 days longer than standard natural processing, and requires high-quality cherries grown at elevations above 1,500 m asl to develop optimal sensory attributes (Ramadhan & Maligan, 2020). In relation to these requirements, the inability of the wine method in this study to produce specialty-grade Sigararutang coffee may be associated with suboptimal cherry quality due to the growing elevation being below 1,200 m asl.

The use of plastic sacks as the fermentation medium in this study is also suspected to have contributed to the failure to achieve specialty-grade quality. Fermentation in plastic sacks is aerobic and poorly controlled, leading to excessive microbial growth, uneven fermentation, and darker bean coloration. Such limitations ultimately impair sensory quality, particularly the clean cup attribute, which has been reported to decrease by up to 100% under these conditions (Sulaiman et al., 2021). In the present study, a similar but smaller reduction (50%) in clean cup was observed.

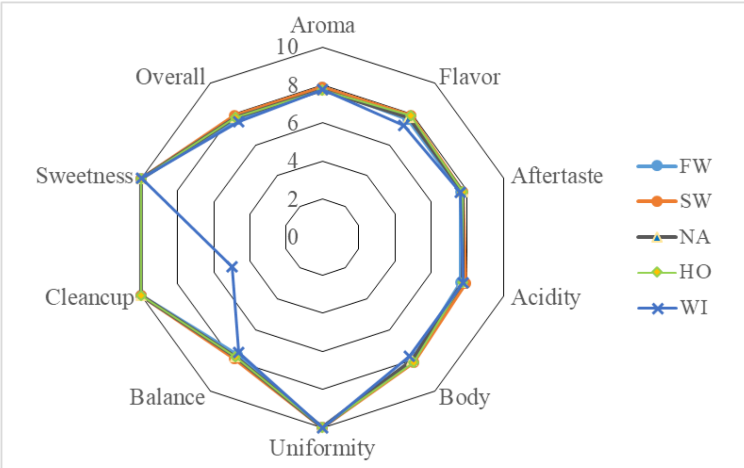


Figure 1. Flavour profile of Sigararutang Coffee brewed using five processing method

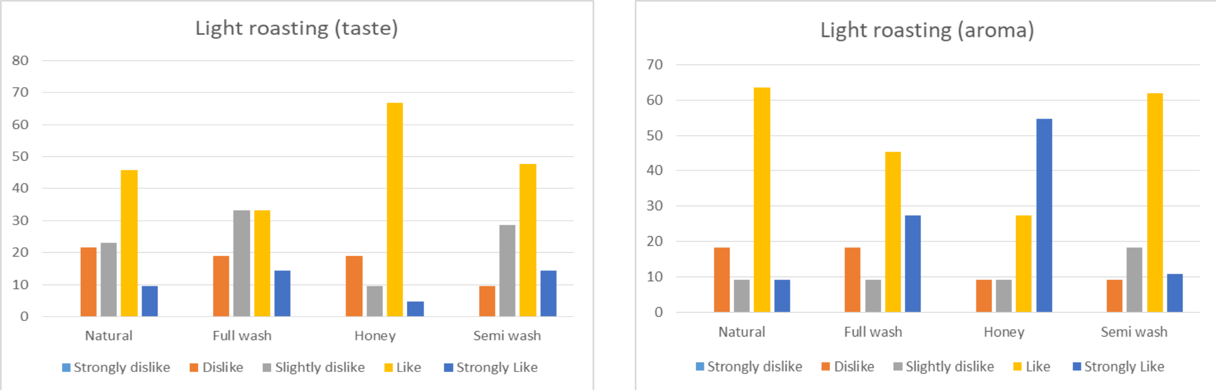
3.2 Consumer Preference for Brewed Coffee

The hedonic test in this study was conducted to determine consumer preference for combinations of processing methods and roasting levels. The consumers selected as panelists were coffee drinkers with sufficient knowledge and experience to describe coffee flavor attributes. In addition to fermentation, roasting—which involves pyrolysis and Maillard reactions—constitutes another key postharvest process that greatly contributes to the development of coffee flavor and aroma (Dharmawan et al., 2018). Coffee beans are typically roasted to three levels: light, medium, and dark, each producing distinct aromatic and flavor characteristics. Achieving these profiles requires careful control of factors such as temperature, roasting time, and agitation (Pratama et al., 2021).

More specifically, Arumsari et al. (2021) describe that light roast, produced at 193–199 °C, yields beans with light brown color, a dry and non-oily surface, higher acidity, and higher caffeine content. Medium roast, produced at around 204 °C, is generally the most preferred due to its sweet flavor, pronounced smoky aroma, darker color, lower caffeine content, and overall balanced flavor and acidity. Meanwhile, dark roast, produced at 213–221 °C, results in the darkest color, an oily surface, a predominantly bitter taste, and a heavier body.

Available online at https://conference.lppm.unila.ac.id/index.php/icsiger
DOI: https://doi.org/10.23960/icsiger

a. Brewed Coffee Processed with the Light Roasting Method



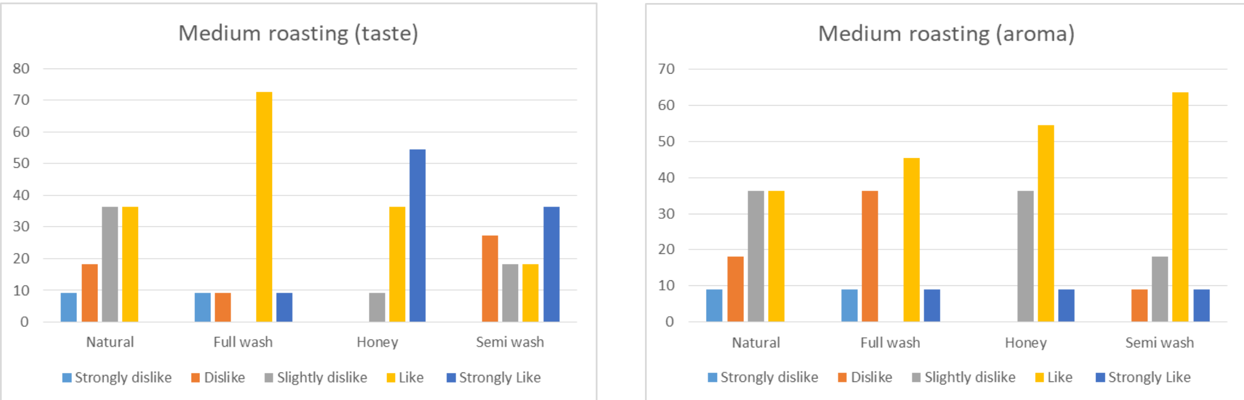
(a) (b)

Figure 2. Panelists' preference profiles for the taste (a) and aroma (b) of brewed coffee processed with light roasting.

Based on Figure 2a, light-roasted honey-processed coffee achieved the highest consumer preference for taste (66.6% like), outperforming other processing treatments. In contrast, when evaluated for aroma, semi-washed coffee showed the highest preference level (61,9% like) compared with the other processing methods (Figure 2b).

b. Brewed coffee processed with the medium roasting method

Based on Figure 3a, the medium-roasted coffee processed using the full-wash method obtained the highest liking percentage for taste (72.3%) compared with the other processing methods. Meanwhile, as shown in Figure 3b, the semi-wash treatment received the highest liking percentage for aroma (63,6%).

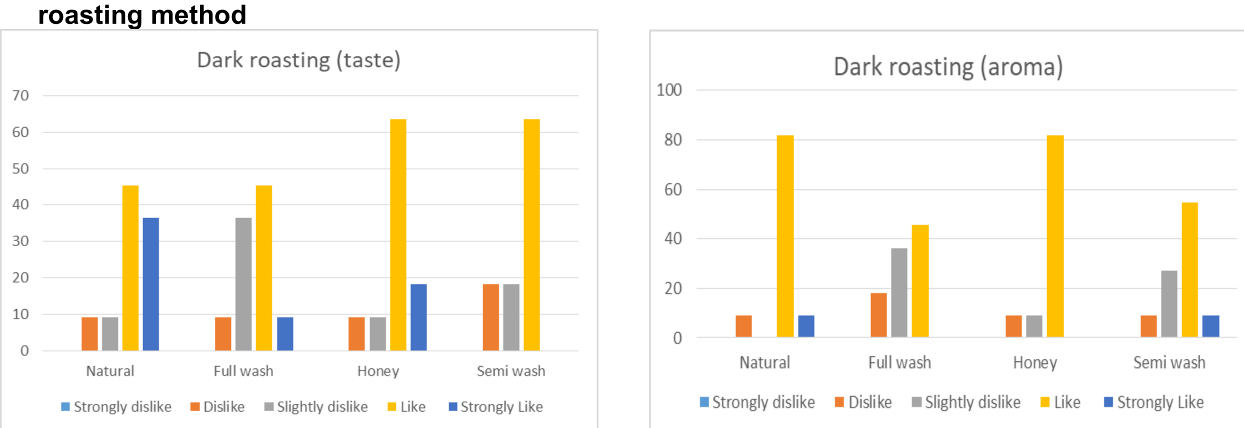


(a)

(b)

Figure 3. Panelists' preference profiles for the taste (a) and aroma (b) of coffee brewed using the medium-roasting method (medium roasted).

c. Coffee brew processed using the dark-roasting method



(a)

(b)

Available online at https://conference.lppm.unila.ac.id/index.php/icsiger
DOI: https://doi.org/10.23960/icsiger

Figure 4. Preference profile of panelists for the taste (a) and aroma (b) of brewed coffee processed with dark roasting.

Based on Figure 4a, for dark-roasted coffee, the natural and semi-wash processes received the highest preference scores for taste (63.4% liked). Meanwhile, for aroma, the natural and honey processes showed the highest preference levels for dark-roasted coffee with 81,1%.

Differences in sensory attributes of brewed coffee are influenced by growing environment conditions, processing methods, and drying techniques. When conducted properly, the drying of coffee beans produces good physiological quality and results in the best brewing quality (Taveira et al., 2015).

Processing Method	Roasts Levels		
	Light	Medium	Dark
	Mean Rank		
Natural	2,45	2,32	3,12
Full Wash	2,45	3,41	2,00
Honey	2,29	2,64	2,50
Semi Wash	2,81	3,59	2,38
Wine		3,05	
Asymp.sig	**0,426**	**0,199**	**0,034**

Note: *Asymp. Sig < 0.05 indicates that the panelists' evaluations of the different processing methods were significantly different.*

Table 2. Differences in coffee processing methods on the preference level for the aroma of dark-roasted brewed coffee

The differences in the effects of roasting levels and coffee processing methods on consumer preference for brewed coffee were statistically analyzed using the Friedman test, as presented in Table 2. The Friedman test results indicated that the processing method had a significant effect on the aroma preference of dark-roasted coffee brews.

During light roasting, part of the coffee bean surface begins to turn brown, and the L* value decreases to approximately 44–45. As roasting progresses to the medium level, the L* value decreases markedly to around 38–40. In dark roasting, the color of the roasted beans becomes increasingly close to black because hydrocarbon compounds undergo pyrolysis and convert into elemental carbon. Meanwhile, sugars undergo caramelization, causing the final L* value of dark-roasted beans to reach 34–35 (Mulato, 2002).

4. CONCLUSIONS

The results of this study showed that from five processing methods just four out of the were able to produce Sigararutang coffee with specialty-grade quality. Based on the hedonic test, it was found that light roasting, the highest preferences for taste and aroma (66.6% and 61.9%, respectively) were associated with honey and semi-wash processing; medium roasting, the highest preferences for taste and aroma (72.3% and 63.6%, respectively) were observed in full-wash and semi-wash processing; and the last for dark roasting, the highest preferences for taste and aroma (63.4% and 81.1%, respectively) were associated with honey and semi-wash, as well as natural and honey processing. The Friedman test indicated that from five coffee processing method just the dark-roasted coffee only had a significant effect on aroma preference in.

ACKNOWLEDGMENTS

We gratefully acknowledge Jintamin Saragih, Head of IP2TP Gurgur, and the Laboratory staff AIAT North Sumatera, for providing facilities and valuable assistance throughout the research. This study was supported by funding from the Indonesian State Budget (APBN 2019)..

REFERENCES

Arumsari, A. G., Surya, R., Irmasuryani, S., & Sapitri, W. (2021). Analisis Proses Roasting pada Kopi. Jurnal Beta Kimia, 1(2), 98–101. http://ejurnal.undana.ac.id/index.php/jbkHalaman%7C98

Cardoso, W. S., Dias, S. R., Coelho, V. S., Pereira, L. L., Fioresi, D. B., & Pinheiro, F. de A. (2023). Maillard reaction precursors and arabica coffee (Coffea arabica L.) beverage quality. Food and Humanity, 1(January), 1–7. https://doi.org/10.1016/j.foohum.2023.01.002

Chalfoun, S. M., Angélico, C. L., & Resende, M. L. V. de. (2018). Brazilian Coffee Quality: Cultural, Microbiological and Bioactivity Aspects. World Journal of Research and Review, 6(1), 50–58.

Dairobbi, A., Irfan, I., & Sulaiman, I. (2018). Kajian Mutu Wine Coffee Arabika Gayo. Jurnal Ilmiah Mahasiswa Pertanian, 3(4), 822-829.

Dharmawan, A., Cahyo, F., & Widyotomo, S. (2018). Determining Optimum Point of Robusta Coffee Bean Roasting Process for Taste Consistency. Pelita Perkebunan (a Coffee and Cocoa Research Journal), 34(1), 59–65. https://doi.org/10.22302/iccri.jur.pelitaperkebunan.v34i1.308

Farah, A., Monteiro, M.C., Calado, V., Franca, A.S. and Trugo, L.C. (2006) 'Correlation between cup quality and chemical attributes of Brazilian coffee', Food Chemistry, 98, pp. 373-380

Franca, A. S., & Oliveira, L. S. (2019). Coffee. In Integrated Processing Technologies for Food and Agricultural By-Products (pp. 413–438). Elsevier Inc. https://doi.org/10.1016/B978-0-12-814138-0.00017-4

Girma, B., & Sualeh, A. (2022). A Review of Coffee Processing Methods and Their Influence on Aroma. International Journal of Food Engineering and Technology, 6(1), 7–16. https://doi.org/10.11648/j.ijfet.20220601.12

Girsang, B., Kamaluddin, Sipayung, A., Sentosa, H. B., Asrul, Rohadi, Situmorang, T. S., Robinson, Y., Purnomo, H., & Hulupi, R. (2005). PELEPASAN VARIETAS KOPI SIGARARUTANG SEBAGAI VARIETAS UNGGUL.

Haile, M., & Kang, W. H. (2019). The Role of Microbes in Coffee Fermentation and Their

Impact on Coffee Quality. Journal of Food Quality, 2019. https://doi.org/10.1155/2019/4836709

Halagarda, M., & Obrok, P. (2023). Influence of Post-Harvest Processing on Functional Properties of Coffee (Coffea arabica L.). Molecules, 28(21). https://doi.org/10.3390/molecules28217386

Hameed, A., Hussain, S. A., Ijaz, M. U., Ullah, S., Pasha, I., & Suleria, H. A. R. (2018). Farm to Consumer: Factors Affecting the Organoleptic Characteristics of Coffee. II: Postharvest Processing Factors. Comprehensive Reviews in Food Science and Food Safety, 17(5), 1184–1237. https://doi.org/10.1111/1541-4337.12365

Kustiari, T., Setyoko, U., Arieni, D., & Prayitno. (2018). Arabica Coffee Bean Quality Test With Wet Processing (Full Wash Processing) System At" Sejahtera Bersama" Farmers Group, Panti Sub-District, Jember Regency, East Java. Proceeding of the 1st International Conference on Food and Agriculture, 46–54. https://publikasi.polije.ac.id/index.php/ProceedingICOFA/article/viewFile/1272/863

Marbun, P., Nasution, Z., Hanum, H., & Karim, A. (2020). The classification, characteristics, and assessment of soil profile fertilon coffea arabica productivity in north sumatra. Bulgarian Journal of Agricultural Science, 26(3), 622–632.

Mestdagh, F., Glabasnia, A., & Giuliano, P. (2017). The Brew-Extracting for Excellence. In The Craft and Science of Coffee (pp. 355–380). https://doi.org/10.1016/B978-0-12-803520-7.00015-3

Mulato, S. 2002. Simposium Kopi 2002 dengan tema Mewudjukan Perkopian Nasional Yang Tangguh Melalui Diversifikasi Usaha BerwawasanLingkungan dalam Pengembangan Industri Kopi Bubuk Skala KecilUntuk Meningkatkan Nilai Tambah Usaha Tani Kopi Rakyat. Pusat Penelitian Kopi dan Kakao Indonesia. Denpasar

Muzaifa, M., Abubakar, Y., Febriani, Abubakar, A., & Hasni, D. (2021). Mutu Sensoris Kopi Luwak Asal Dataran Tinggi Gayo. AGROINTEK : Jurnal Teknologi Industri Pertanian, 15(3), 817–824.

Pan, T., Nian, Y., Xiang, R., Jia, R., Liu, L., & Wang, R. (2021). Quality Analysis of Coffee Bean Treated by Sunning and Water Washing processing. IOP Conference Series: Earth and Environmental Science, 792(1). https://doi.org/10.1088/1755-1315/792/1/012050

Pratama, Y., Dirgayussa, I. G. E., Simarmata, P. F., & Tambunan, M. H. (2021). Detection roasting level of lintong coffee beans by using euclidean distance. Bulletin of Electrical Engineering and Informatics, 10(6), 3072–3082. https://doi.org/10.11591/eei.v10i6.3153

Rahmawati, I., & Gustiani, L. T. (2023). Analisis Kafein pada Kopi Arabika (Coffea arabica L .) Gununghalu Teknik Light Roasting, Medium Roasting, dan Dark Roasting. Jurnal Kimia Padjajaran, 1(2), 66–73.

Ramadhan, R. L., & Maligan, J. M. (2018). Pengaruh Lama Fermentasi dan Fermentasi dan Kehalusan Bubuk Sajian Tubruk Wine Kopi Arabika (Coffea arabica). Prosiding Seminar Nasional Teknologi Pangan, Oktober, 33–40.

Randriani, E., & Dani. (2018). Pengenalan Varietas Unggul Kopi (Cetakan II). INDONESIAN AGENCY FOR AGRICULTURAL RESEARCH AND DEVELOPMENT (IAARD) PRESS.

SCAA. (2015). SCAA Protocols Cupping Specialty Coffee. http://www.scaa.org/?page=resources&d=coffee-protocols

Sinaga, H., Nurminah, M., & Hilman, and A. (2021). Gayo coffee processing with natural, semi-washed and full-washed methods. E3S Web of Conferences, 332. https://doi.org/10.1051/e3sconf/202133201012

Stephenson, T. (2015). The Curious Barista's Guide to Coffee (J. Charles (ed.)). Ryland Peters & Small.

Sulaiman, I., Erfiza, N. M., & Moulana, R. (2021). Effect of Fermentation Media on the Quality of Arabica Wine Coffee. IOP Conference Series: Earth and Environmental Science, 709(1). https://doi.org/10.1088/1755-1315/709/1/012027

Sulaiman, I., Erfiza, N. M., & Moulana, R. (2021). Effect of Fermentation Media on the Quality of Arabica Wine Coffee. IOP Conference Series: Earth and Environmental Science, 709(1). https://doi.org/10.1088/1755-1315/709/1/012027

Sunarharum, W. B., Yuwono, S. S., & Nadhiroh, H. (2018). Effect of different post-harvest processing on the sensory profile of Java Arabica coffee. Advances in Food Science, Sustainable Agriculture and Agroindustrial Engineering, 1(1), 9–13. https://doi.org/10.21776/ub.afssaae.2018.001.01.2

Susanti, A. A., & Putra, R. K. (2022). Outlook Komoditas Perkebunan Kopi 2022. In Outlook Komoditas Perkebunan Kopi 2022

Susila, W. R. (2005). Targeted Study of the Arabica Coffee Production Chain in North Sumatra (The Mandheling Coffee). In Food and Agriculture Organization (FAO) United Nation.

Taveira, JDS., Borém, FM, Oliveira, PD., Giomo, GS, Isquierdo, EP, Fortunato, VA. 2015. Post-harvest effects on beverage quality and physiological performance of coffee beans. Embrapa Café-Artigo em periódico indexado (ALICE).

Volcafe. (2012). Insight Special : Brazilian Coffees. April, 1–4.

Woldesenbet, B., Sualeh, A., Mokonen, N., &

Endris, S. (2008). Coffee Diversity and Knowledge Coffee Processing and Quality Research in Ethiopia. Proceeding of ANational Workshop Four Decades of Coffee Research and Development in Ethiopia, June, 307–316. https://www.researchgate.net/publication/341901571

Yusianto, Y., & Nugroho, D. (2014). Mutu fisik dan citarasa kopi Arabika yang disimpan buahnya sebelum di-pulping. Pelita Perkebunan, 30(2), 137–158.