

Quality Assessment and Comparative Analysis of Malinau Coffee Among Indonesian Specialty Coffees

Adi Sutrisno¹, Etty Wahyuni¹, Dwi Santoso^{2,✉}, Mohammad Wahyu Agang¹, Deny Titing², Erwan Kusnadi¹, Tjahjo Tri Hartono³, Mas Davino Sayaza⁴, Elida Novita⁵, Rahmat Pramulya⁶, Devi Maulida Rahmah⁷

¹ Department of Agribusiness, University of Borneo Tarakan, North Kalimantan, INDONESIA.

² Department of Agrotechnology, University of Borneo Tarakan, North Kalimantan, INDONESIA.

³ Department of Environmental Science, University of Ibn Khaldun, Bogor, INDONESIA.

⁴ Environmental Research Center, University of Ibn Khaldun, Bogor, INDONESIA.

⁵ Department of Agriculture Engineering, University of Jember, Jember, INDONESIA

⁶ Department of Agriculture, University of Teuku Umar, Aceh, INDONESIA

⁷ Department Agroindustrial Technology, University of Padjajaran, Bandung, INDONESIA

Article History:

Received : 11 January 2025

Revised : 26 February 2025

Accepted : 10 Maret 2025

Keywords:

Malinau coffee,
North Kalimantan,
Quality improvement,
Robusta,
Specialty coffee.

Corresponding Author:

✉ dwisantoso@borneo.ac.id

(Dwi Santoso)

ABSTRACT

Malinau Robusta coffee demonstrates untapped potential within the specialty coffee market. This study aims to evaluate the quality of Malinau coffee comprehensively and benchmark it against prominent specialty coffees such as Gayo, Toraja, and Kintamani. A descriptive quantitative method was employed to analyze critical parameters including caffeine content, moisture level, defect value, impurity level, grain size, and flavor profile. Coffee samples were gained from nine coffee-producing villages in Malinau Regency, involving 28 farmers covering 190 ha of coffee plantations. The results identified distinct strengths of Malinau coffee, notably its low moisture level (10.2%) and high caffeine content (1.94%) among the samples, offering a strong and intense flavor profile including chocolatey, a bitter aftertaste, and fruity undertones. Challenges for Malinau coffee includes high defect value (65.7/300 g) and impurity level (0.6%), which undermine its marketability in premium segments. To bring Malinau coffee up to par with other established specialty coffees, improvements in post-harvest handling are needed, particularly sorting, quality control and consistent processes methods. By adopting innovative cultivation and processing, Malinau coffee holds strong potential as a competitor of specialty coffee, both for domestic and global markets while highlighting its unique regional identity.

1. INTRODUCTION

Indonesia is known as one of the largest coffee producing countries in the world, with various types of local coffee that have unique and distinctive flavors (Gumulya & Helmi, 2017; Sunarharum *et al.*, 2019; Ramadhana *et al.*, 2024). Several local coffees, such as Gayo from Aceh, Toraja from Sulawesi, and Kintamani from Bali, have long dominated the national and international specialty coffee market. Each type of coffee has unique characteristics, both in terms of taste profile, chemical content and physical quality, so that it is able to attract the attention of global consumers (Giacalone *et al.*, 2019; Santoso & Egra, 2018). These characteristics are greatly influenced by environmental factors such as altitude, temperature, rainfall, and the condition of the soil where the coffee grows. These environmental variations contribute to differences in coffee's physical attributes and quality, including bean size, caffeine content,

acidity, and flavor complexity, which ultimately determine the prominence of a coffee in the specialty market. However, behind the popularity of these coffees, there are other types of coffee that have great potential but have not received much attention, one of which is Malinau coffee from Malinau Regency, North Kalimantan. Malinau coffee is a type of Robusta coffee that grows in the Indonesia-Malaysia border region, with agro-climatic conditions that support the growth of quality coffee plants. Malinau Regency has unique ecological characteristics, including soil conditions, rainfall patterns and humidity which can influence the growth of coffee plants and produce a different flavor profile compared to coffee from other areas. According to a report from the East Kalimantan Plantation Service, the border area in Malinau Regency has superior potential in developing agricultural and plantation commodities, including coffee, with market orientation across districts, and even abroad (Koespramoedya *et al.*, 2003). In addition, the 'Kaltara Brewing' event initiated by the Tourism Department in collaboration with Bank Indonesia revealed that super Robusta coffee produced by local farms from Malinau has an attractive taste and extraordinary quality.

In an increasingly competitive specialty coffee industry, it is important to evaluate the position of Malinau coffee compared to other superior local coffees. This analysis not only aims to identify the comparative advantages of Malinau coffee, but also provides strategic input to improve its quality so that it can compete in domestic and global markets. With an integrated approach, Malinau coffee has a great opportunity to become one of Indonesia superior coffees that is able to compete with other local coffees that are already well-known. Based on these problems, this research aims to comprehensively evaluate the quality of Malinau coffee and compare it with other superior local Indonesian coffees, in order to identify its development potential as one of Indonesia's specialty coffees which has high competitiveness in the global market. Results of this research are expected will provide scientific information regarding the characteristics of Malinau coffee, which can be a basis for farmers and coffee industry players in improving production quality. In addition, this research is also expected to support marketing and promotion strategies for Malinau coffee as a specialty product with competitive advantages, both for domestic and international markets.

2. MATERIALS AND METHODS

2.1. Location and Sampling

A quantitative descriptive approach was applied to evaluate the quality of Malinau coffee and compare it with other specialty coffees in Indonesia. The research was carried out in Malinau Regency, North Kalimantan, involving nine main coffee producing villages, including Long Berini, Long Atual, Long Kemuat, Long Alango, Long Titi, Harapan Maju, Punan Setarap, Petulang, Long Bila, and Kalamok (Figure 1). A total of 28 farmers with a total coffee land area of 190 ha was selected purposively as respondents based on the level of coffee productivity in each village. Most of the coffee plantation locations were in the outermost villages of Malinau District which directly borders Nunukan District. Coffee bean samples were processed using traditional drying methods commonly used by local farmers. Sampling was carried out using a stratified random sampling technique to ensure the diversity of coffee characteristics that was analyzed.

2.2. Parameter Analysis

The parameters to be analyzed included caffeine content, damage level, and flavor profile (cupping).

a) Caffeine content

Caffeine content was measured using UV-Vis spectrophotometry with a wavelength of 275 nm, following the method used by (Hardi *et al.*, 2019). Coffee samples were prepared through an extraction process using chloroform solvent to separate active compounds, as explained in research (Jeszka-Skowron *et al.*, 2015). This process was carried out three times in repetition for each sample to ensure consistency of results.

b) Damage Level

The level of damage was calculated using the defect value method with a weight of 300 grams per sample, including categories of damage caused by insects, fungi, broken seeds and foreign objects. This methodology was adopted from (Cortés-Macías *et al.*, 2022) to ensure that all visual damage parameters were measured objectively. This analysis aims

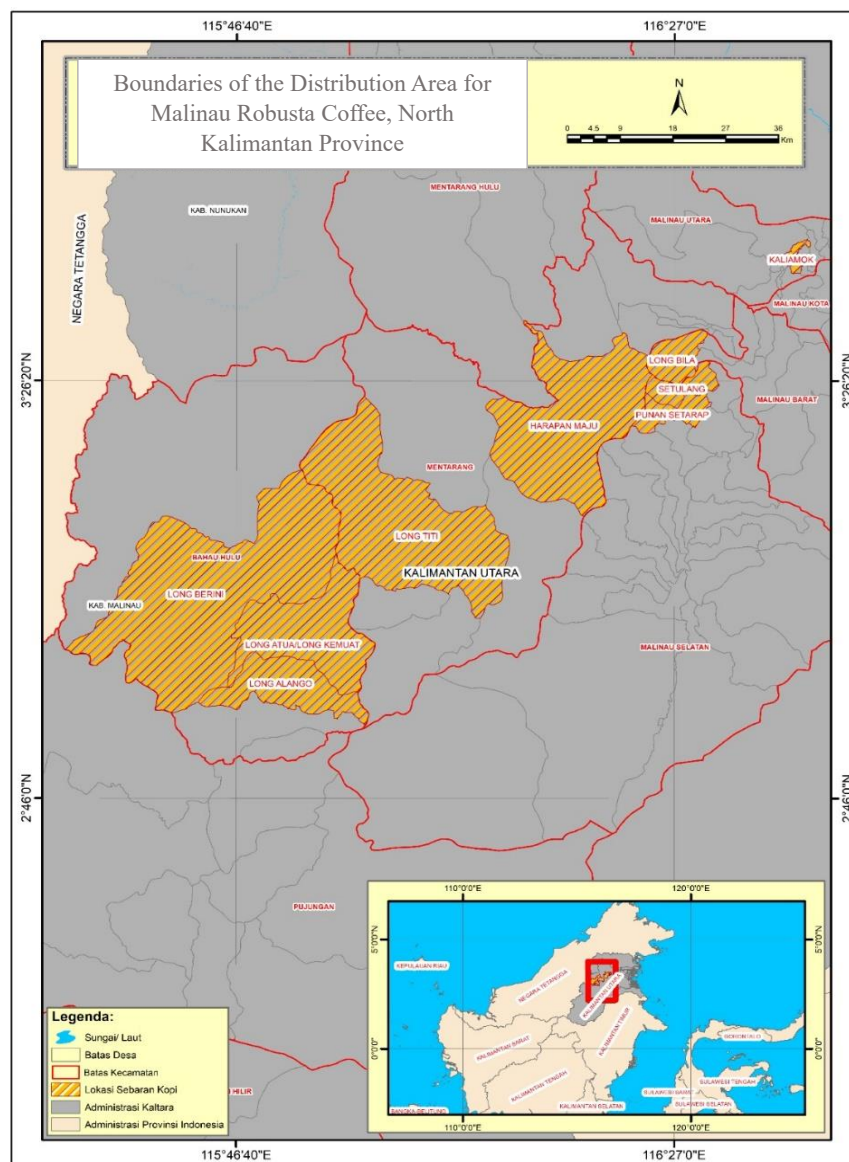


Figure 1. Map of research location with 9 villages coffee producing

to identify critical points in the post-harvest process that affect coffee quality. Coffee samples were spread out on a bright surface. Live insects, rotten beans and moldy beans were calculated through sensory methods. Rotten seeds were identified based on their dark black color, soft texture, or unpleasant odor. Moldy seeds were observed for white, green, or gray spots. If necessary, microscopic analysis or microbiological tests was performed for further identification. This calculation help to determine the quality of coffee based on applicable standards.

c) Flavor Profile (Cupping)

The taste profile was tested by five certified panelists using the Specialty Coffee Association (SCA) protocol at the Indonesian Coffee and Cocoa Research Center (PUSLITKOKA), focusing on the parameters of aroma, taste, aftertaste, acidity, body, balance and sweetness (Angeloni *et al.*, 2021; Nascimento *et al.*, 2024). Each panelist gave scores based on a scale of 1-100, and the data obtained was processed to get the average of each parameter.

2.3. Analysis

Descriptive tests were used to analyze the physical and chemical parameters of each type of coffee, such as caffeine content, moisture and defect value. This analysis aims to describe variations in coffee quality based on location factors. Descriptive data provides an overview of the distribution of values and patterns for each parameter, making it possible to identify the unique characteristics of Malinau coffee compared to other coffees. This approach is in line to [Fakhruddin \(2020\)](#), who shows that environmental variations influence the physical attributes of coffee.

3. RESULTS AND DISCUSSION

3.1. Malinau Coffee Among the Specialty Coffees

Local coffee production in Indonesia during 2021–2023 period shows dynamic fluctuation, which is attributed to various factors such as changes in climate conditions, cultivation techniques, and fluctuations in market demand. The decline in production that occurred in several types of coffee, such as Gayo and Toraja Coffee, indicates that there are challenges in sustainable production. This may be influenced by climate change which has an impact on soil fertility levels, erratic rainfall, and attacks by pests or plant diseases. In line with the findings of [\(Sujatmiko & Ihsaniyati, 2018\)](#), climate change can reduce coffee productivity, especially in highland areas which depend on certain weather conditions. On the other hand, the increase in production for Kintamani, Flores, and Mandailing specialty coffees shows success in implementing better cultivation techniques or expanding production land.

Studies by [\(Byrareddy *et al.*, 2019; Sott *et al.*, 2020; Kittichotsatsawat *et al.*, 2021\)](#) highlight the importance of adopting modern technology and sustainable farming techniques in increasing coffee productivity. The success of increasing production can also reflect the effectiveness of farmer training, the use of superior seeds, and increased access to markets through government and private sector support. Coffee production which tends to be stable in types such as Java Coffee and Papua Wamena indicates the sustainability of an established agricultural system. However, as explained by [\(Borrella *et al.*, 2015; Levy *et al.*, 2016; Anhar *et al.*, 2021\)](#), production stability needs to be monitored, especially by ensuring the availability of resources such as water, organic fertilizer and adequate labor. Overall, the dynamics of local coffee production show the need for different strategies for each type of coffee. Coffee that is experiencing a decline in production requires intervention in the form of farmer training, improving cultivation techniques, and mitigating the impacts of climate change. Meanwhile, coffee production whose production is increasing or stable needs to continue to be supported to maintain its sustainability.

Figure 1 presents Malinau coffee beans. The quality of Malinau coffee is detailed in Table 1 with a comparison to other various local Indonesian coffees based on several main parameters, such as levels of live insects, rot, and fungus, (IRF), water content (WC), grain size (GS), defect value (DV), level of impurities, broken seeds, and foreign objects (IBFO), as well as taste profile. This data shows the advantages and disadvantages of each type of coffee, which can be the basis for developing the quality of Malinau coffee to make it more competitive in the specialty coffee market.



Figure 2. Malinau coffee beans

Table 1. Comparison of the quality of Malinau coffee with other local Indonesian coffee

No	Specialty Coffee	Variety	IRF (%)	WC (%)	GS (%)	DV (g)	IBFO (%)	Flavor Profile	References
1	Malinau Coffee	Robusta	0.1	10.2	62 (small)	65.7	0.6	Chocolatey, bitter aftertaste, fruity	Test results
2	Gayo Coffee	Arabica	0.2	11.5	90	28.3	0.1	Floral, fruity	(Aprilia <i>et al.</i> , 2018; Hardi <i>et al.</i> , 2019; Fahmy, 2020; Pamungkas <i>et al.</i> , 2021)
3	Java Coffee	Robusta	0.1	12	87	40	0.3	Balanced, chocolatey	(Gumulya & Helmi, 2017; Fahmy, 2020)
4	Kintamani Coffee	Arabica	0.15	12	80	31.7	0.25	Citrus, light	(Fibrianto <i>et al.</i> , 2018; Mangku <i>et al.</i> , 2019; Handayani <i>et al.</i> , 2022; Wijaya <i>et al.</i> , 2022)
5	Toraja Coffee	Arabica	0.1	11.5	85	23.3	0.2	Earthy, spicy	(Rizky <i>et al.</i> , 2016; Darwis <i>et al.</i> , 2024; Loppies <i>et al.</i> , 2024; Mafazi <i>et al.</i> , 2024)
6	Flores Coffee	Arabica	0.2	12	90	35	0.3	Herbal, sweet	(Nadhirah <i>et al.</i> , 2016; Fahmy, 2020; Mafazi <i>et al.</i> , 2024)
7	Wamena Papuan Coffee	Arabica	0.3	11.8	88	36	0.4	Earthy	(Mangiwa <i>et al.</i> , 2015; Ginting & Kartiasih, 2019; Sukandar <i>et al.</i> , 2024)
8	Mandailing Coffee	Arabica	0.2	12	84	30	0.2	Chocolatey, sweet, balanced	(Nadhirah <i>et al.</i> , 2016; Ginting <i>et al.</i> , 2022; Rince, 2021)
9	Aceh Coffee	Robusta	0.1	11.7	89	43.3	0.1	Earthy, herbal, strong	(Agustina <i>et al.</i> , 2019; Maleachi, 2024)

3.2. Comparative Assessment

Malinau coffee is a type of Robusta, which is characterized by a stronger, bitter taste and a higher caffeine content than Arabica. As Robusta coffee grown in the North Kalimantan region, Malinau coffee has unique potential due to its environmental conditions and processing process. When compared to Arabica coffee, such as Gayo or Kintamani, Robusta tends to be more resistant to extreme weather and plant diseases. This makes it the main choice for farmers in mid-altitude areas, such as Malinau. However, Robusta is often underappreciated in the premium market, despite having loyal consumer base. The existence of Malinau coffee as a representative of Robusta in this research provides an important perspective on the advantages and challenges of local coffees. Through better processing, Malinau coffee has the potential to compete with other specialty coffees in the coffee market.

3.2.1. Live Insects, Rot, Fungi

Malinau coffee has a low percentage of live insects, rot and mold, namely 0.1%. This value is equivalent to several other specialty coffees such as Toraja coffee (Darwis *et al.*, 2024; Loppies *et al.*, 2024; Mafazi *et al.*, 2024). This shows that Malinau coffee has gone through a fairly good post-harvest process, so that the risk of biological contamination can be minimized. Even though the percentage is low, it is still necessary to pay attention to storage and processing methods to maintain quality. Malinau's tropical environmental conditions, such as high humidity, can be a challenge if the drying and storage processes are not carried out properly. This quality is a distinct advantage for Malinau coffee, especially when compared with Papua Wamena Coffee, which has the highest value in this parameter (0.3%). By maintaining this value, Malinau coffee can continue to be promoted as coffee with high hygiene standards.

3.2.2. Water Content

The water content of Malinau coffee is 10.2%, which is the lowest value among all samples. This indicates that the Malinau coffee drying process is carried out optimally, so as to prevent mold growth and maintain stability during storage. Compared to other coffees, such as Java Coffee and Flores Coffee which have a water content of 12%, Malinau coffee shows superiority in post-harvest management. However, water content that is too low must also be

monitored so that the coffee beans do not become too brittle during storage or processing (Taveira *et al.*, 2015; Poltronieri & Rossi, 2016; Getaneh *et al.*, 2020). This low water content is one of the selling points of Malinau coffee, because it shows that the processing process meets international standards. This is important to increase the competitiveness of Malinau coffee in the specialty coffee market.

3.2.3. Grain Size

Malinau coffee beans are classified as small, with 62% passing through the sieve. This value is much lower than other coffees, such as Gayo Coffee and Flores Coffee, which reach 90%. The small grain size of Malinau coffee may be caused by soil conditions or the Robusta variety used. Smaller beans can affect the roasting process, because they require more attention to ensure even roasting results (Taveira *et al.*, 2015; Schenker & Rothgeb, 2017; Johandri, 2017; Das *et al.*, 2023). However, this small size is not always a weakness, because the taste of coffee is also influenced by other factors, such as the natural flavor profile and post-harvest processing (Haile & Kang, 2019; Velásquez & Banchón, 2023). Small bean size can be a challenge for Malinau coffee. However, with promotions that highlight its unique flavor profile, Malinau coffee still has the opportunity to attract certain markets.

3.2.4. Defect Value

Malinau coffee had the defect value in this study, namely 65.7 grains per 300 grams. This is the highest as compared to other coffees, such as Toraja coffee (23.3). The high defect value indicates the presence of more broken beans, black beans, or foreign objects. Defect factors can be caused by less stringent sorting processes or less than optimal harvest conditions (Fufa *et al.*, 2019; Guimarães *et al.*, 2019). A high defect value can reduce the competitiveness of Malinau coffee in the premium market. Therefore, efforts need to be made to improve the sorting process and quality control during post-harvest. By implementing selective harvesting methods, manual or mechanical sorting of beans, and the use of density-based sorting tools, the value of these defects can be reduced so that the quality of the coffee increases. Apart from that, implementing controlled fermentation and drying using a drying house or mechanical dryer can reduce the risk of rotten and moldy beans. Even though it has a high defect value, Malinau coffee still has great potential if processed using the honey process or washed process technique, which has been proven to improve the quality of taste and attract the interest of specialty coffee consumers.

3.2.5. Impurities, Broken Nuts, Foreign Objects

The impurity level of Malinau coffee was 0.6%, which was the highest value in this study. This high number indicates the need to pay more attention to the process of separating foreign objects during processing. Compared to other coffees, such as Gayo and Mandailing coffee which only have a value of 0.1%, Malinau coffee needs to improve hygiene standards. High levels of impurities can affect the final taste of the coffee, as impurities such as broken beans or foreign objects can produce undesirable flavors (Guimarães *et al.*, 2019; Cordoba *et al.*, 2020; Getaneh *et al.*, 2020; Velásquez & Banchón, 2023; Al-Ghamdi *et al.*, 2024). Therefore, using modern sorting equipment such as gravity separators or optical sorters, implementing stricter manual sorting, and using more hygienic washing and drying methods can be a solution to improving the quality of Malinau coffee. Apart from that, educating farmers about the importance of selective picking and separating foreign objects from the harvest stage is also needed to reduce dirt levels from the start.

3.2.6. Flavor Profile

Malinau coffee has a chocolatey taste with a bitter and fruity aftertaste. This flavor profile reflects the typical characteristics of Robusta grown in tropical environments such as Malinau. The presence of a fruity taste indicates a unique potential that can be enhanced through certain processing techniques. Compared to coffee like Gayo which has a floral and fruity taste, Malinau coffee has a stronger taste which is suitable for certain consumers. This makes Malinau coffee an alternative for those looking for coffee with a more intense taste. This taste profile is also an opportunity to market Malinau coffee as a product with unique local characteristics. With more controlled processing, the potential for this chocolatey and fruity taste can be further developed.

3.3. Cupping Score (Scale 1-100)

Malinau coffee received a cupping score of 76.88 (Figure 3), which is the lowest value compared to other coffees. This score shows that the taste profile of Malinau coffee is still below international specialty coffee standards, namely a minimum of 80 out of 100 based on an assessment by a certified Q Grader. However, as Robusta coffee, this value is quite competitive, considering that Robusta tends to have a stronger and bitter taste than Arabica (Cordoba *et al.*, 2020; Freitas *et al.*, 2024; Sulaiman *et al.*, 2024). With better processing, such as the honey process or fermentation control method, the cupping score value of Malinau coffee can be increased significantly (Basalong *et al.*, 2020).

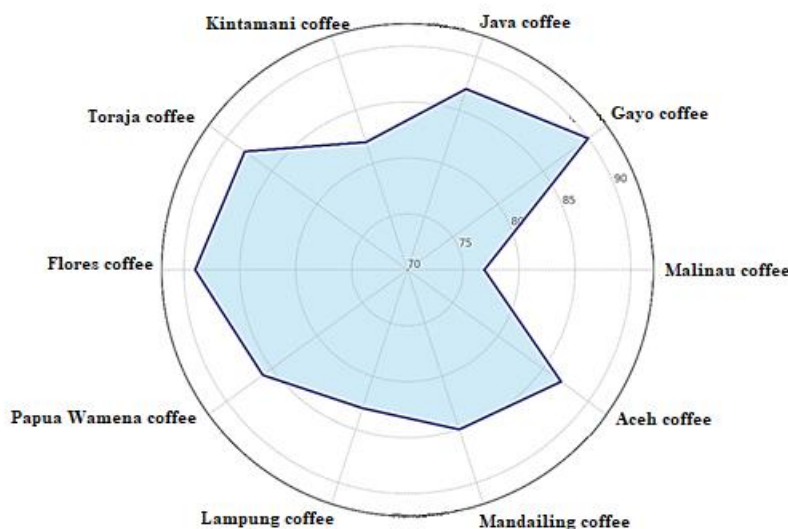


Figure 3. Cupping score value for different specialty coffee samples in Indonesia

In the post-harvest process of Malinau Robusta coffee, there are several crucial stages that can improve the quality of the cupping score. More controlled fermentation, both in the washed and honey process methods, can increase flavor complexity and reduce the dominance of the bitter taste that is often characteristic of low quality Robusta (Farah, 2019). Stricter sorting, both before and after drying, is important to eliminate defective beans that can significantly reduce cupping scores (Loppies *et al.*, 2024). In addition, optimal drying with a more consistent method, such as gradual drying or using a mechanical dryer with controlled temperature, can maintain the stability of the water content and prevent the appearance of off-flavors due to uneven fermentation. With improvements in the fermentation, sorting and drying stages, Malinau coffee cupping scores have the potential to increase significantly. This will not only make it more competitive in the specialty coffee market, but also strengthen the identity of Malinau coffee as high quality Robusta coffee with a distinctive taste character.

3.4. Caffeine Level

With a caffeine content of 1.94%, Malinau coffee has the highest caffeine content among the other specialty coffees (Figure 4). This higher caffeine content provides an advantage for consumers looking for coffee with a strong stimulant effect, typical of the Robusta type. This research shows that Malinau coffee has the highest caffeine content compared to other coffees in this study. This value is in line with the characteristics of Robusta, which naturally has a higher caffeine content than Arabica. For comparison, Arabica coffee such as Gayo and Kintamani has an average caffeine content of 1.2%. This high caffeine content gives Malinau coffee a competitive edge, especially for consumers looking for strong stimulant effects and intense flavor. The high caffeine content of coffee is also closely related to the cultivation practices and post-harvest processing (Cordoba *et al.*, 2020; Das, 2021; Munyendo *et al.*, 2021; da Silva *et al.*, 2022; Al-Ghamdi *et al.*, 2024; Freitas *et al.*, 2024; Sulaiman *et al.*, 2024). Less than optimal drying and fermentation processes can affect the stability of caffeine levels (Leblanc, 2021; Mugerwa, 2021). Apart from that, other parameters such as the level of seed damage (defect value) of 65.7 per 300 grams and impurity

content of 0.6% indicate the potential for improving post-harvest quality. Reducing defect values and impurities through more standardized processing can contribute to increasing the consistency of caffeine levels, so that the selling value of Malinau Coffee can be further increased.

The high caffeine content also supports the taste profile of Malinau Coffee, which is distinctive with a combination of chocolatey, fruity and bitter aftertaste. This flavor profile further enhances the intense character resulting from the

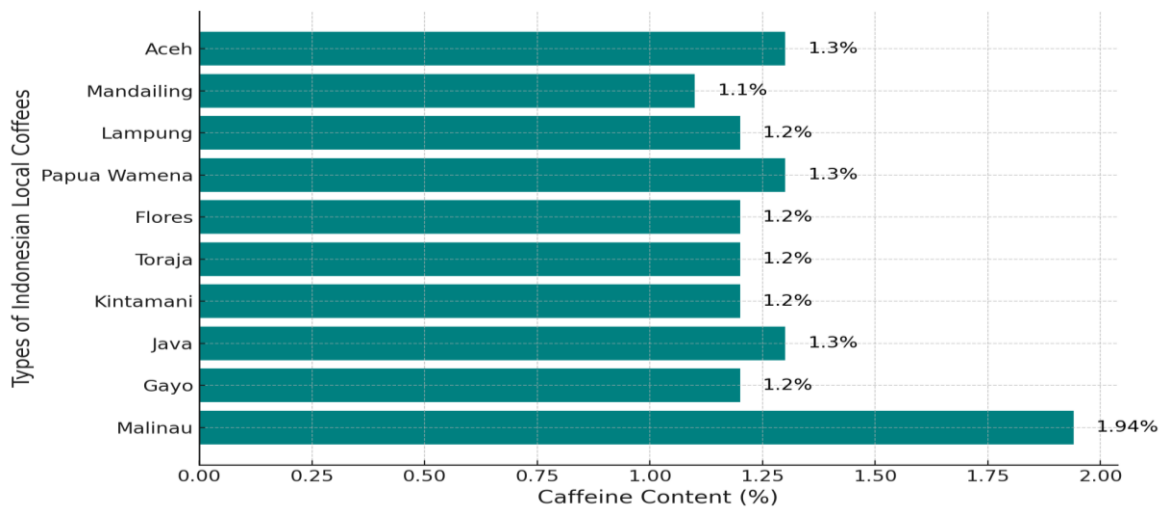


Figure 4. Caffeine content of different specialty coffees in Indonesia

dominant caffeine content. With a promotional strategy that emphasizes the strength and distinctive taste of Robusta. With better post-harvest processing to reduce defect value and impurity levels, the consistency of caffeine levels and overall quality of this coffee can be further guaranteed, thereby increasing competitiveness in the specialty coffee market, both domestically and internationally. Malinau coffee is still less well known than other specialty coffees. The main challenges are farmers switching to more profitable palm oil and pepper, as well as limited market access and post-harvest infrastructure. Incentives, quality improvements, post-harvest standardization and marketing strategies are needed to be more competitive.

4. CONCLUSION

Based on the research results, it can be concluded that Malinau coffee has several advantages, such as low water content (10.2%) which indicates good post-harvest processing, as well as high caffeine content (1.94%) which is in accordance with Robusta characteristics. The chocolatey taste profile with a bitter and fruity aftertaste also highlights the unique potential of this coffee to be further developed as a specialty coffee product. Malinau coffee, however, faces challenges such as defect values (65.7/300 g) and impurity levels (0.6%) which are higher than other coffees. With improvements in sorting, processing and post-harvest innovation, Malinau coffee has a great opportunity to compete in the premium market, especially by highlighting its local uniqueness.

ACKNOWLEDGMENT

Funding for this work was supported by Ministry of Education, Culture, Research and Technology of the Republic of Indonesia through the Directorate of Research, Technology and Community Service (DRTPM) based on Decree Number 001/UN51.9/SP2H/KATALIS/2024 and Agreement/Contract Number 010/E5/PG.02.00/PL.BATCH.2/2024. The author would like also to thank to the Institute for Research and Community Service (LPPM) of the University of Borneo Tarakan for facilities and laboratory equipment provided, and to the North Kalimantan Provincial Government for its support and cooperation in providing accurate data for this research.

REFERENCES

- Agustina, R., Nurba, D., Antono, W., & Septiana, R. (2019). Pengaruh suhu dan lama penyangraian terhadap sifat fisik-kimia kopi Arabika dan kopi Robusta. *Prosiding Seminar Nasional Inovasi Teknologi untuk Masyarakat*, 285–299.
- Al-Ghamdi, S., Alfaifi, B., Elamin, W., & Lateef, M.A. (2024). Advancements in coffee manufacturing: From dehydration techniques to quality control. *Food Engineering Reviews*, **16**, 513–539. <http://dx.doi.org/10.1007/s12393-024-09383-5>
- Angeloni, S., Mustafa, A.M., Abouelenein, D., Alessandrini, L., Acquaticci, L., Nzekoue, F.K., Petrelli, R., Sagratini, G., Vittori, S., Torregiani, E., & Caprioli, G. (2021). Characterization of the aroma profile and main key odorants of espresso coffee. *Molecules*, **26**(13), 3856. <http://dx.doi.org/10.3390/molecules26133856>
- Anhar, S., Rasyid, U.H.A., Muslin, A.M., Baihaqi, A., Roma, R., & Abubakar, Y. (2021). Sustainable Arabica coffee development strategies in Aceh, Indonesia. *IOP Conference Series Earth and Environmental Science*, **667**(1), 012106. <http://dx.doi.org/10.1088/1755-1315/667/1/012106>
- Aprilia, F.A., Ayuliansari, Y., Putri, T., Azis, M.Y., Camelina, W.D., & Putra, M.R. (2018). Analisis kandungan kafein dalam kopi tradisional gayo dan kopi lombok menggunakan hplc dan spektrofotometri UV-Vis. *Biotika*, **16**(2), 38–39. <https://doi.org/10.24198/bjib.v16i2.19829>
- Basalong, A.A., Amado, V.Y., & Talbino, H.L.B. (2020). Effects of the different postharvest processing methods on the occurrence of ochratoxin a and cupping quality of arabica coffee. *Mountain Journal of Science And Interdisciplinary Research*, **80**(1), 87–97. <https://doi.org/10.70884/mjsir.v80i1.267>
- Borrelli, I., Mataix, C., & Carrasco-Gallego, R. (2015). Smallholder farmers in the speciality coffee industry: Opportunities, constraints and the businesses that are making it possible. *IDS Bulletin*, **46**(3), 29–44. <http://dx.doi.org/10.1111/1759-5436.12142>
- Byrareddy, V., Kouadio, L., Mushtaq, S., & Stone, R. (2019). Sustainable production of Robusta coffee under a changing climate: a 10-year monitoring of fertilizer management in coffee farms in Vietnam and Indonesia. *Agronomy*, **9**(9), 499. <https://doi.org/10.3390/agronomy9090499>
- Cordoba, N., Fernandez-Alduenda, M., Moreno, F.L., & Ruiz, Y. (2020). Coffee extraction: A review of parameters and their influence on the physicochemical characteristics and flavour of coffee brews. *Trends in Food Science & Technology*, **96**, 45–60. <https://doi.org/10.1016/j.tifs.2019.12.004>
- Cortés-Macias, E.T., López, C.F., Gentile, P., Girón-Hernández, J., & López, A.F. (2022). Impact of post-harvest treatments on physicochemical and sensory characteristics of coffee beans in Huila, Colombia. *Postharvest Biology and Technology*, **187**, 111852. <https://doi.org/10.1016/j.postharvbio.2022.111852>
- da Silva, C.S., Coelho, A.P.de.F., Lisboa, C.F., Vieira, G., & Teles, M.C.de.A. (2022). Post-harvest of coffee: factors that influence the final quality of the beverage. *Revista Engenharia Na Agricultura – REVENG*, **30**, 49–62. <http://dx.doi.org/10.13083/reveng.v30i1.12639>
- Darwis, N.I.Z., Khalid, N.I.I., Dariyanti, E.W., Harun, M.A., & Rimantho, D. (2024). Kandungan flavonoid pada ampas kopi toraja untuk mengimpikan jerawat pada remaja. *Prosiding Seminar Nasional Pembangunan dan Pendidikan Vokasi Pertanian*, **5**(1), 1210–1221. <https://doi.org/10.47687/snppvp.v5i1.1193>
- Das, P.P., Duarah, P., & Purkait, M.K. (2023). *High-Temperature Processing of Food Products: Fundamentals of Food Roasting Process*. Woodhead Publishing, 103–130.
- Das, S. (2021). Post-harvest processing of coffee: An overview. *Coffee Science*, **16**, 1–7. <http://dx.doi.org/10.25186/v16i.1976>
- Fahmy, Y.A. (2020). Karakteristik Sensori Kopi Indikasi Geografis. [Undergraduate Thesis], Universitas Bakrie.
- Fakhrudin, M.H. (2020). Pengaruh suhu penyeduhan moka terhadap karakterisasi fisik, kimia dan sifat organoleptik kopi dampit dan kopi Ijo Tulungagung. [Undergraduate Thesis], Universitas Brawijaya.
- Farah, A. (2019). *Flavor Development during Roasting: Drying and Roasting of Cocoa and Coffee*. CRC Press.
- Fibrianto, K., Umam, K., & Wulandari, E.S. (2018). Effect of roasting profiles and brewing methods on the characteristics of Bali Kintamani coffee. *Proceedings of the International Conference on Food, Agriculture and Natural Resources (FANRes 2018)*, 193–196. <https://doi.org/10.2991/fanres-18.2018.40>
- Freitas, V.V., Borges, L.L.R., Castro, G.A.D., Almeida, L.F., Crepalde, L., Kobi, H.d.B., Vidigal, M., Santos, M.H.d., Fernandes, S.A., Maitan-Alfenas, G.P., & Stringheta, P. (2024). Influence of roasting levels on chemical composition and sensory quality

- of Arabica and Robusta coffee: A comparative study. *Food Bioscience*, **59**(6), 104171. <http://dx.doi.org/10.1016/j.fbio.2024.104171>
- Fufa, B.O., Etana, M.B., & Aga, M.C. (2019). Review on post-harvest and green bean coffee processing in Ethiopia. *Polish Journal of Natural Science*, **9**(9), 38–42. <http://dx.doi.org/10.31080/ASAG.2019.03.0536>
- Getaneh, E., Fanta, S.W., & Satheesh, N. (2020). Effect of broken coffee beans particle size, roasting temperature, and roasting time on quality of coffee beverage. *Journal of Food Quality*, **2020**(1), 8871577. <https://doi.org/10.1155/2020/8871577>
- Giacalone, D., Degn, T.K., Yang, N., Liu, C., Fisk, I., & Münchow, M. (2019). Common roasting defects in coffee: Aroma composition, sensory characterization and consumer perception. *Food Quality and Preference*, **71**, 463–474. <https://doi.org/10.1016/j.foodqual.2018.03.009>
- Ginting, A.A., Lubis, S.N., & Kesuma, S.I. (2022). Keunggulan komparatif dan kompetitif kopi Arabika di Kabupaten Karo, Sumatera Utara, Indonesia. *Agro Bali: Agricultural Journal*, **5**(3), 592–600. <https://doi.org/10.37637/ab.v5i3.1045>
- Ginting, C.P., & Kartiasih, F. (2019). Analisis ekspor kopi Indonesia ke negara-negara ASEAN. *Jurnal Ilmiah Ekonomi dan Bisnis*, **16**(2), 143–157. <https://doi.org/10.31849/jieb.v16i2.2922>
- Guimarães, R.J., Borém, F.M., Farah, A., & Romero, J.C.P. (2019). *CHAPTER 2: Coffee Growing and Post-harvest Processing*. The Royal Society of Chemistry. <https://doi.org/10.1039/9781782622437-00026>
- Gumulya, D., & Helmi, I. S. (2017). Kajian budaya minum kopi Indonesia. *Jurnal Dimensi Seni Rupa dan Desain*, **13**(2), 153–172. <https://doi.org/10.25105/dim.v13i2.1785>
- Haile, M., & Kang, W.H. (2019). The harvest and post-harvest management practices' impact on coffee quality. *Coffee-Production and Research*, 1–18.
- Handayani, P.T., Kepramareni, P., & Kusuma, I.G.A.E.T. (2022). The analysis of the quality of the physical environment, service and product on revisit intention through customer satisfaction at a coffee shop in Kintamani-Bali, *European Journal of Business and Management Research*, **7**(6), 115–119. <https://doi.org/10.24018/ejbmr.2022.7.6.1621>
- Hardi, A., Ichwana, I., & Khathir, R. (2019). Kajian pengering kopi gayo semi basah menggunakan alat pengering tipe hohenheim. *Jurnal Ilmiah Mahasiswa Pertanian*, **4**(4), 362–371.
- Jeszka-Skowron, M., Zgoła-Grześkowiak, A. & Grześkowiak, T. (2015). Analytical methods applied for the characterization and the determination of bioactive compounds in coffee. *European Food Research and Technology*, **240**, 19–31. <https://doi.org/10.1007/s00217-014-2356-z>
- Johandri, V. (2017). Heat and mass transfer model for a coffee roasting process. [Master Thesis], North-West University (South Africa), Potchefstroom Campus.
- Kittichotsawat, Y., Jangkrajarn, V., & Tippayawong, K.Y. (2021). Enhancing coffee supply chain towards sustainable growth with big data and modern agricultural technologies. *Sustainability*, **13**(8), 4593. <https://doi.org/10.3390/su13084593>
- Koespramoedya, D., Mukti, S.H., Jaloeis, A., Nuami, M., Buamona, A., & Djamaludin, F. (2003). *Strategi dan Model Pengembangan Wilayah Perbatasan Kalimantan*. Direktorat Pengembangan Kawasan Khusus dan Tertinggal Deputi Bidang Otonomi Daerah dan Pengembangan Regional, Jakarta.
- Leblanc, C. (2021) Factors affecting the quality and shelf life of specialty *Coffea arabica* green coffee. [Theses], North Carolina State University.
- Levy, D., Reinecke, J., & Manning, S. (2016). The political dynamics of sustainable coffee: contested value regimes and the transformation of sustainability. *Journal of Management Studies*, **53**(3), 364–401. <https://doi.org/10.1111/joms.12144>
- Loppies, J.E., Assa, A., Winanda, E., Utami, R.R., Rosniati, Smith, H., & Wahyudi, R. (2024). Physical quality and flavor profile of Arabica coffee beans (*Coffea arabica*) from Seko, South Sulawesi as a specialty coffee. *IOP Conference Series: Earth and Environmental Science*, **1338**(1), 012048. <http://dx.doi.org/10.1088/1755-1315/1338/1/012048>
- Mafazi, N., Jalil, Z., & Yusibani, E. (2024). Karakterisasi kopi unggulan Indonesia jenis Arabika sangrai medium to dark menggunakan Fourier Transform Infra Red. *Jurnal Teori dan Aplikasi Fisika*, **12**(02). <https://doi.org/10.23960/jtaf.v12i02.397>
- Maleachi, S. (2024). Analisis pengelolaan panen dan pasca panen kopi sebagai faktor–faktor yang mempengaruhi kualitas biji kopi Robusta di Kota Pagar Alam. *Jurnal Global Ilmiah*, **1**(7), 482–488. <https://doi.org/10.55324/jgi.v1i7.67>
- Mangiwa, S., Futwembun, A. & Awak, P.M. (2015). Kadar asam klorogenat (CGA) dalam biji kopi Arabika (*Coffea arabica*) asal Wamena, Papua. *Hydrogen: Jurnal Kependidikan Kimia*, **3**(2), 313–317. <https://doi.org/10.33394/hjkk.v3i2.690>

- Mangku, I.G.P., Wijaya, I.M.A.S., Pytra, G.P.G., & Permana, D.G.M. (2019). The bioactive compounds formation of “Kintamani” Arabica coffee bean during dry fermentation. *Journal of Biological and Chemical Research*, **36**(2), 45–52.
- Mugerwa, F. (2021). Potential of Spontaneous Microbial Fermentation Isolates to Improve Fermentation and Cup Quality of Wet Processed Arabica Coffee (*Coffea arabica*). [Dissertations], Kyambogo University.
- Munyendo, L.M., Njoroge, D.M., Owaga, E.E., & Mugendi, J.B. (2021). Coffee phytochemicals and post-harvest handling—A complex and delicate balance. *Journal of Food Composition and Analysis*, **102**(1155), 103995. <http://dx.doi.org/10.1016/j.jfca.2021.103995>
- Nadhirah, N., Alimuddin, A., & Saleh, C. (2016). Analisis kandungan kafein dalam kopi Sumatera dan kopi Flores dengan variasi siklus menggunakan spektrofotometer UV-Vis. *Jurnal Kimia Mulawarman*, **13**(1), 28-31.
- Nascimento, M.O., Ombredane, A.S., & Oliveira, L.de.L.de (2024). Descriptive sensory tests for evaluating *Coffea arabica*: A systematic review. *Coffee Science*, **19**, e192204. <http://dx.doi.org/10.25186/v19i.2204>
- Pamungkas, M.T., Masrukan, M., & Kuntjahjawati, S.A.R. (2021). Pengaruh suhu dan lama penyangraian (*roasting*) terhadap sifat fisik dan kimia pada seduhan kopi Arabika (*Coffea arabica* L.) dari Kabupaten Gayo, Provinsi Aceh. *Agrotech: Jurnal Ilmiah Teknologi Pertanian*, **3**(2), 1–10. <http://dx.doi.org/10.37631/agrotech.v3i2.278>
- Poltronieri, P., & Rossi, F. (2016). Challenges in specialty coffee processing and quality assurance. *Challenges*, **7**(2), 19. <http://dx.doi.org/10.3390/challe7020019>
- Ramadhana, A.W.S., Aulia, A.D., & Ulum, T. (2024). Keunggulan komparatif ekspor kopi di Indonesia. *Journal of Economics, Business, Accounting and Management*, **2**(1), 110–123. <https://doi.org/10.61476/095w2813>
- Rince, A.F. (2021). Perbaikan Metode Penyangraian Untuk Meningkatkan Kualitas Kopi Arabika (*Coffea arabica* L.) Specialty Sumatera Barat. [Doctoral Thesis], Universitas Andalas.
- Rizky, T.A., Saleh, C., & Alimuddin. (2016). Analisis kafein dalam kopi Robusta (Toraja) dan kopi Arabika (Jawa) dengan variasi siklus pada sokletasi. *Jurnal Kimia Mulawarman*, **13**(1), 41-44.
- Santoso, D., & Egra, S. (2018). Pengaruh metode pengeringan terhadap karakteristik dan sifat organoleptik biji kopi Arabika (*Coffea arabica*) dan biji kopi Robusta (*Coffea canephora*). *Rona Teknik Pertanian*, **11**(2), 50–56. <https://doi.org/10.17969/rtp.v11i2.11726>
- Schenker, S., & Rothgeb, T. (2017). The roast—creating the beans’ signature. *The Craft and Science of Coffee*, 245–271. <https://doi.org/10.1016/B978-0-12-803520-7.00011-6>
- Sott, M.K., Furstenau, L.B., Kipper, L.M., Giraldo, F.D., López-Robles, J.R., & Cobo, M.J. (2020). Precision techniques and agriculture 4.0 technologies to promote sustainability in the coffee sector: state of the art, challenges and future trends. *IEEE Access*, **8**, 149854–149867. <http://dx.doi.org/10.1109/ACCESS.2020.3016325>
- Sujatmiko, T., & Ihsaniyati, H. (2018). Implication of climate change on coffee farmers’ welfare in Indonesia. *IOP Conference Series: Earth and Environmental Science*, **200**(1), 012054. <http://dx.doi.org/10.1088/1755-1315/200/1/012054>
- Sukandar, D., Abriyani, E., Pranata, F., Bintang, I., & Roma, S. (2024). Analisis kandungan asam klorogenat dalam biji kopi dengan metode HPLC: Tinjauan literatur. *Jurnal Ilmiah Wahana Pendidikan*, **10**(20), 184–196.
- Sulaiman, I., Hasni, D., Husaini, I., & Maliza, N.O. (2024). The quality and flavour effects of robusta coffee cultivated at various altitudes in aceh tengah district-gayo highlands were investigated. *IOP Conference Series: Earth and Environmental Science*, **1356**(1), 012001. <http://dx.doi.org/10.1088/1755-1315/1356/1/012001>
- Sunarharum, W.B., Williams, D.J., & Smyth, H.E. (2014). Complexity of coffee flavor: A compositional and sensory perspective. *Food Research International*, **62**, 315–325. <https://doi.org/10.1016/j.foodres.2014.02.030>
- Taveira, J.H.da.S., Borém, F.M., Rosa, S.D.V.F.da., Olivera, P.D., Giomo, G.S., Isquierdo, E.P., & Fortunato, V.A. (2015). Post-harvest effects on beverage quality and physiological performance of coffee beans. *African Journal of Agricultural Research*, **10**(12), 1457–1466. <https://doi.org/10.5897/AJAR2014.9263>
- Velásquez, S., & Banchón, C. (2023). Influence of pre-and post-harvest factors on the organoleptic and physicochemical quality of coffee: A short review. *Journal of Food Science and Technology*, **60**(10), 2526–2538. <https://doi.org/10.1007/s13197-022-05569-z>
- Wijaya, H., Wiratama, I.P.R.K.P., Putri, P.K.P.D., Ariyanthini, K.S., Angelina, E., Andina, N.K.D.P., Naripradnya, P.S., & Setyawan, E.I. (2022). Application d-optimal method on the optimization of formulation of Kintamani Arabica coffee gel (*Coffea arabica* L.). *Jurnal Farmasi Sains dan Praktis*, **8**(1), 19–27. <https://doi.org/10.31603/pharmacy.v8i1.6115>