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Original Paper

Quality Analysis of Natural Processed Coffee Using Different Roasting Levels

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***Abstract*— Coffee is one of the leading plantation commodities in Indonesia. High-quality coffee has a higher price than low-quality coffee. The quality of coffee is determined by the method of selecting planting materials, handling during harvest, and processing. Coffee that is processed naturally, will be dried in the form of fruit/cherry so that coffee will decrease in quality. The quality of coffee beans can be improved if the roasting process is carried out using the right roasting temperature and time. With a variety of treatments in post-harvest processing methods and roasting levels will produce different coffee quality so that appropriate treatment is needed to determine the final result of coffee with the best quality. This study used the Complete Randomized Design (CRD) method with 2 factors, namely differences in coffee types (robusta coffee and arabica coffee) and roasting levels (light roast, medium roast, and dark roast). The research variables observed were seed weight, camba density, water content, and caffeine content. The data obtained will be analyzed using analysis of variance. If there is a significant difference between treatments, then further tests will be carried out using the Duncan Multiple Range Test (DMRT) at the 5% failure level.**

Keywords*— Arabica coffee, Robusta coffee, quality, roasting level, natural process

I. INTRODUCTION

Coffee is a key plantation commodity in Indonesia, giving it significant market potential both domestically and internationally [1]–[3]. The price of coffee is determined by its quality [4]. Coffee with high quality commands a higher price compared to low-quality coffee [5]. The quality of coffee beans is influenced by harvesting activities, processing, drying, and storage conditions [6]. The coffee processing process generally consists of three types: natural processing (dry process), fullwash, and semi-wet processing [7]. Coffee processed naturally is dried in the form of cherries, allowing it to undergo natural fermentation without the addition of water [8]. Farmers use natural coffee processing because it is easier and less expensive [9].

The roasting process is one of the criteria that determines the quality of coffee. The quality of coffee beans can be improved if the roasting process is done with the correct temperature and roasting time. This aims to achieve the quality standard as per SNI 01-3542-2004 [10]. Roasting is divided into three types: light roast, medium roast, and dark roast [11].

The different treatments in post-harvest processing methods and roasting levels lead to varying coffee qualities, requiring the appropriate treatments to determine the final coffee product with the best quality [12]. Coffee bean quality is evaluated based on its physical and chemical characteristics [13]. To date, there has been limited discussion on the analysis of the quality of naturally processed Arabica and Robusta coffee from the Argopuro mountains at different roasting levels. Therefore, the aim of this study is to obtain information about the quality of these two types of coffee, which are well-known in Indonesia, namely Robusta and Arabica, roasted at different levels

II. MATERIALS AND METHODS

A. Time and Location

The research was conducted at Rangkum Café, Jl. Danau Toba No. 08, Tegalgede, Sumbersari District, Jember Regency, for the roasting process. The analysis of the physical-chemical characteristics was carried out in the Biochemistry Laboratory of the Faculty of Agricultural Technology, University of Jember. The research was conducted from March-April 2024.

B. Tools and Materials

The materials used in this research include green beans of Robusta and Arabica coffee, distilled water (aquadest), standard caffeine, filter paper, chloroform ($CHCl_3$), alcohol, calcium carbonate ($CaCO_3$), aluminum foil, and white paper.

The equipment used includes roasting machines, crucibles, set of glassware, analytical balances, hot plates, UV-Vis spectrophotometers, ovens, desiccators, pipettes, scale, watch glass, erlenmeyer flasks, beakers.

C. Experimentl Design

The research method used is a factorial experimental design with a Completely Randomized Design involving 4 replications. This design includes two factors, the first factor is the type of coffee with two levels, and the second factor is the different roasting levels with three levels. Therefore, the study has 24 experimental units.

I. The first factor is the the difference in coffee types with natural processing, consisting of 2 levels:
   A_1: Robusta Coffee
   A_2: Arabika Coffee

II. The second factor is the roasting levels of the coffee, consisting of 3 levels:
T_1: Light roast (180° C, 8 minutes)
T_2: Medium roast (190° C, 10 minutes)
T_3: Dark roast (200° C, 12 minutes)

D. Variables

The research variables include the observation of physical and chemical characteristics as follows:

1. Moisture content, the moisture content test was conducted using the gravimetric method [4].
2. Caffeine content, the caffeine content test was conducted based on the UV-Vis Spectrophotometry method [5].
3. Bean weight, the procedure involves weighing 100 g of green beans before and after roasting. Then, the number of beans in 100 g is counted, and their weight is measured, followed by calculating the average [6]. The determination of the weight per coffee bean can be calculated using the formula:

$$Bean\ weight\ \left(\frac{gram}{bean}\right) = \frac{100\ gr\ coffe\ beans}{amount\ of\ coffe\ 100\ gr} \quad \text{.....(1)}$$

4. Bulk density, this is done by weighing the coffee bean sample and then placing it into a 250 ml graduated cylinder [7]. It is then calculated using the following equation:

$$Bulk\ density = \frac{M}{V} \quad \text{.....(2)}$$

M = the weight of the sample used (g)
V = the volume of the sample observed (ml)

III. Results And Discussion

The coffee roasting process is the most important process for transforming green coffee beans into roasted beans with distinctive aroma and flavor [14]. This process requires heating the coffee beans, which triggers various chemical and physical reactions [15]. At the beginning of the roasting process, there is a temperature decrease because the coffee beans, which are at room temperature, are added to the preheated drum, causing them to absorb heat from the drum and thus leading to a drop in temperature [16]. Afterwards, this will cause the coffee beans to change color to yellow due to Maillard reaction, enzymatic changes, and caramelization [17], [18].

The first crack phase occurs due to the accumulation of carbon dioxide gas and water vapor inside the coffee beans, leading to internal pressure until it reaches the highest pressure point and the beans start to crack, commonly referred to as the first crack [19]. The image shows that the dark roast level (dark roast) experiences the first crack process more quickly. This is because the higher temperature causes the coffee beans to absorb heat more rapidly, accelerating the chemical and physical reactions (water evaporation and gas release) within the beans, which leads to the first crack occurring more quickly [20].

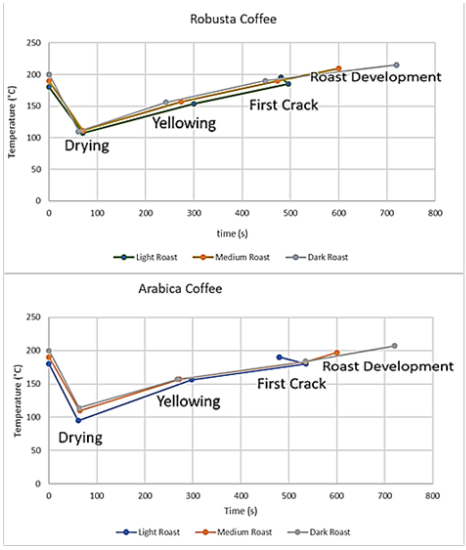

Fig. 1. Roasting curve

At the roast development stage, the final roasting results can be determined in terms of the desired color and degree of roasting. At the light roast level, both coffee types (arabica and robusta) tend to undergo the roast development phase more quickly, whereas at the medium roast level, and even more so at the dark roast level, the roast development phase takes longer [21]. During the roasting process, the coffee beans go through various stages that cause color changes. The color changes in the coffee beans are due to the heating during roasting, which leads to the breakdown of chemical compounds such as sugars, amino acids, and chlorogenic acids. This process triggers the Maillard reaction, which produces Melanoidins that give coffee its brown color [18], [22].

A. Water Content

The results of the analysis in Table I. showed that the combination of Robusta coffee and medium roasting (A1T2), as well as the combination of Arabica coffee and light roasting (A2T1), tend to produce the best moisture content at each simple effect of coffee type on the roasting level or the simple effect of roasting on the same coffee type. The combination of Robusta coffee and medium roasting (A1T2) shows an average value of 3.346%. Meanwhile, the combination of Arabica coffee and light roasting (A2T1) shows an average value of 4.487%.

TABLE I. The Results Of The Analysis On The Effect Of Coffee Type And Roasting Level On Moisture Content (%)

Coffee Type	Roasting Level		
	Light Roast (T1)	*Medium Roast (T2)*	*Dark Roast (T3)*
Robusta coffee (A1)	7,280 (a)	3,346 (a)	3,729 (b)
	A	C	B
Arabica coffee (A2)	4,487 (b)	3,796 (a)	3,883 (a)
	A	A	A

Note: Numbers followed by the same letter show a significant difference in Duncan's test at the 5% level. Numbers followed by the same lowercase letters (in vertical alignment) indicate the simple effect of the coffee type factor at the same roasting level. Numbers followed by the same uppercase letters (horizontal) indicate the simple effect of the roasting level factor at the same coffee type level.

In this study, both Robusta and Arabica coffee experienced a decrease in moisture content as the roasting time increased. During the roasting process, heat is transferred from the roasting medium to the beans, and water mass transfer occurs, causing the moisture content to decrease. The lower the moisture content, the longer it takes for the product to absorb moisture from the air. This helps preserve the beans from microbial damage during storage [23].

B. Caffeine Content

The analysis results in Table II. show that the lowest caffeine content was observed in the combination of Robusta coffee and medium roast (A1T2), with an average value of 104.22 µg/g. Conversely, the lowest caffeine content for Arabica coffee was found with light roast (A2T1), with an average value of 97.57 µg/g. The study results indicate that as the roasting time increases, the caffeine content in coffee beans decreases.

TABLE II. THE RESULTS OF THE ANALYSIS ON THE EFFECT OF COFFEE TYPE AND ROASTING LEVEL ON CAFFEINE CONTENT (µG/G)

COFFEE TYPE	Roasting Level		
	Light Roast (T1)	*Medium Roast (T2)*	*Dark Roast (T3)*
Robusta coffee (A1)	110,6 (a)	104,22 (a)	103,99 (a)
	A	B	B
Arabica coffee (A2)	97,57 (b)	99,39 (a)	97,59 (b)
	A	A	A

Note: Numbers followed by the same letter show a significant difference in Duncan's test at the 5% level. Numbers followed by the same lowercase letters (in vertical alignment) indicate the simple effect of the coffee type factor at the same roasting level. Numbers followed by the same uppercase letters (horizontal) indicate the simple effect of the roasting level factor at the same coffee type level.

The higher the temperature, the greater the decrease in caffeine content. This is because the internal cavities of the coffee beans expand, causing the caffeine crystals to separate from the beans during grinding and roasting [24]. Caffeine reduction also occurs as the beans reach higher levels of maturity due to the sublimation process of caffeine compounds. As the cavities in the coffee beans open, the caffeine is exposed to heat and begins to sublimate, meaning the longer the roasting time, the more caffeine sublimates in a linear relationship.

C. Bulk Density

The analysis results are in Table III. for the bulk density variable show that the combination of Robusta and Arabica coffee with light roast (A1T1, A2T1) tends to produce the best bulk density across the simple effects of coffee type at the same roasting level, as well as the simple effects of roasting level at the same coffee type level. The combination of Robusta and Arabica coffee with light roast yields the best average bulk density, at 0.373 g/ml (A1T1) and 0.360 g/ml (A2T1), respectively.

TABLE III. THE RESULTS OF THE ANALYSIS ON THE EFFECT OF COFFEE TYPE AND ROASTING LEVEL ON BULK DENSITY (G/ML)

COFFEE TYPE	Roasting Level		
	Light Roast (T1)	*Medium Roast (T2)*	*Dark Roast (T3)*
Robusta coffee (A1)	0,373 (a)	0,325 (b)	0,331 (b)
	A	B	B
Arabica coffee (A2)	0,360 (a)	0,351 (a)	0,327 (a)
	A	A	B

Note: Numbers followed by the same letter show a significant difference in Duncan's test at the 5% level. Numbers followed by the same lowercase letters (in vertical alignment) indicate the simple effect of the coffee type factor at the same roasting level. Numbers followed by the same uppercase letters (horizontal) indicate the simple effect of the roasting level factor at the same coffee type level.

Bulk density is a variable used to determine the ratio of a material to the volume it occupies. Longer roasting times result in a decrease in bulk density. This reduction occurs because, during roasting, the coffee beans expand in volume, and water evaporation, along with other volatile compounds, reduces the weight of the roasted coffee [25].

D. Weight Beans

The analysis results on the main effect of coffee type show that Robusta coffee (A1) and Arabica coffee (A2) tend to have the greatest influence on the bean weight variable. The coffee types exhibit different bean weights, with Robusta (A1) producing an average bean weight of 0.172 g, while Arabica (A2) yields an average bean weight of 0.158 g.

The roasting process causes the compounds within the coffee beans to evaporate, which leads to changes in the yield. This evaporation of water and volatile compounds reduces the overall weight of the beans, affecting the final yield of roasted coffee [26]. Additionally, in terms of morphology, Robusta coffee beans (A1) are larger, which contributes to their greater bean weight. The choice of coffee type can be determined based on the growing environment and should align with the specific growing conditions required for each type of coffee.

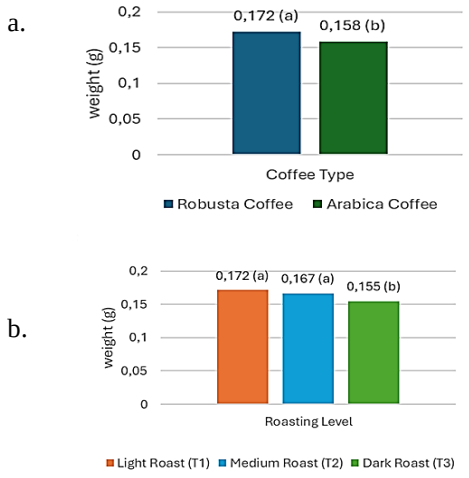

Fig. 2. The average values of the main effects on the observed variable of bean weight a) the use of naturally processed coffee, b) the use of different roasting levels.

The analysis of the main effect of roasting type shows that the light roast (T1) and medium roast (T2) treatments tend to have the best influence on the bean weight variable. The light roast (T1) yields an average bean weight of 0.172 g, while the medium roast (T2) produces an average bean weight of 0.167 g. As roasting time and temperature increase, the mass of the coffee beans decreases due to the evaporation of organic compounds. The temperature and roasting duration also affect the density of the coffee beans, which contributes to the reduction in bean mass.

The roasting temperature and duration also influence the change in coffee bean weight, leading to a decrease in weight. During the roasting process, moisture content decreases as water evaporates due to the heat from the roaster walls. This evaporation process is known as hydrolysis. Thus, it can be concluded that the higher the roasting temperature, the more the coffee bean weight decreases, as water evaporates, and more volatile compounds are formed and released.

IV. CONCLUSIONS

Based on the research results, the conclusions are as follows: (1) The interaction between coffee type and roasting level has a very significant effect on caffeine content and bulk density, a significant effect on moisture content, but no significant effect on bean weight. The best treatments are Robusta coffee with medium roast and Arabica coffee with light roast; (2) The main effect of coffee type has a very significant effect on caffeine content and a significant effect on bean weight, but no significant effect on moisture content and bulk density. Both Robusta and Arabica coffee can be used as the best treatment; (3) The main effect of roasting level has a very significant effect on moisture content, caffeine content, and bulk density, and a significant effect on bean weight. The best treatments are light roast or medium roast.

REFERENCES

[1] C. P. Herliani, D. A. Savitri, H. M. Suud, and M. G. Rosyady, "Characterization of Robusta Coffee Powder with Addition of Palm Sugar and Vanilla Powder to Improve The Quality of Robusta Coffee (Coffea canephora," vol. 05, no. 03, pp. 38–45, 2024.

[2] D. A. Savitri, Setiyono, S. B. P. S. Meliala, A. P. Arum, N. Novijanto, and C. P. Herliani, "Chemical and Microbiological Characteristics of Kombucha Beverage Produced from Robusta and Arabica Coffee with Varied Roasting Profiles," *J. Appl. Agric. Sci. Technol.*, vol. 8, no. 3, pp. 290–302, 2024.

[3] D. A. Savitri, S. Setiyono, N. Novijanto, and R. M. Fajriati, "Defect Analysis and Development Strategy for Robusta Coffee of Tanahwulan Village, Indonesia," *J. La Lifesci*, vol. 03, no. 01, pp. 14–25, 2022, doi: 10.37899/journallalifesci.v3i1.548.

[4] Setiyono *et al.*, "Pelatihan pengolahan limbah kopi sebagai kombucha cascara," vol. 8, pp. 629–636, 2024.

[5] A. Santoso, S. Slameto, D. A. Savitri, D. E. Kusbianto, and H. M. Suud, "The Effect of Using Fast Roast and Slow Roast Roasting Techniques on the Chemical and Organoleptic Characteristics of Robusta Coffee Beans (Coffea robusta L.)," *Int. J. Food, Agric. Nat. Resour.*, vol. 5, no. 1, pp. 95–99, 2024, doi: 10.46676/ij-fanres.v5i1.261.

[6] S. B. P. S. Meliala, S. Setiyono, D. A. Savitri, A. P. Arum, S. N. H. Hidayah, and S. Noviana, "Physical and Chemical Characteristics of Chosen Genotype of Robusta Coffee from Curahpoh Village Bondowoso East Java," *J. La Lifesci*, vol. 5, no. 4, pp. 353–368, 2024, doi: 10.37899/journallalifesci.v5i4.1338.

[7] N. F. Soraya, B. Kusmanadhi, S. B. Patricia SM, and D. A. Savitri, "Pengaruh Jenis Wadah Penyimpanan dan Ukuran Biji Dalam Penyimpanan Pasca Panen Terhadap Karakteristik Fisik Biji Kopi Robusta (Coffea robusta L.)," *Technologica*, vol. 2, no. 1, pp. 14–20, 2023, doi: 10.55043/technologica.v2i1.50.

[8] H. M. Suud *et al.*, "Various roasting characteristics against alteration of antioxidant activity, amino acids content, and flavor of Java Ijen-Raung coffee beans," *Pelita Perkeb. (a Coffee Cocoa Res. Journal)*, vol. 39, no. 3, pp. 216–229, 2023, doi: 10.22302/iccri.jur.pelitaperkebunan.v39i3.563.

[9] H. M. Suud, N. Novijanto, R. Nadzirah, and D. A. Savitri, "Study of Coffee Bean Displacement Inside Drum Roaster Using Force Balance Analysis," *J. Tek. Pertan. Lampung (Journal Agric. Eng.*, vol. 12, no. 4, p. 909, 2023, doi: 10.23960/jtep-l.v12i4.909-920.

[10] [BSN] National Standardization Agency of Indonesia, "SNI 01-2907-2008: Biji Kopi," *Badan Standarisasi Nas.*, pp. 4–5, 2008.

[11] D. A. Savitri *et al.*, "Caffeine Content of Bondowoso Arabica Ground Coffee with Variation of Roasting Profile and Type of Packages," *Pelita Perkeb. (a Coffee Cocoa Res. Journal)*, vol. 38, no. 2, pp. 128–137, 2022, doi: 10.22302/iccri.jur.pelitaperkebunan.v38i2.511.

[12] and O. C. Thomas Dippon, Monica Dan , Melinda Haydee Kovacs, Emoke Dalma Kovacs, Erika Andrea Levei, "Analysis of Volatile Compounds , Composition , and Thermal Roasting Intensity," *Foods*, vol. 11, pp. 2–15, 2022.

[13] M. Banti and E. Abraham, "Coffee Processing Methods, Coffee Quality and Related Environmental Issues," *J. Food Nutr. Sci.*, vol. 9, no. 6, p. 144, 2021, doi: 10.11648/j.jfns.20210906.12.

[14] A. Sualeh, K. Tolessa, and A. Mohammed, "Biochemical composition of green and roasted coffee beans and their association with coffee quality from different districts of southwest Ethiopia," *Heliyon*, vol. 6, no. 12, p. e05812, Dec. 2020, doi: 10.1016/j.heliyon.2020.e05812.

[15] V. Gottstein *et al.*, "Monitoring of Chemical Changes in Coffee Beans during the Roasting Process Using Different Roasting Technologies with Nuclear Magnetic Resonance Spectroscopy," *Beverages*, vol. 9, no. 87, pp. 1–15, 2023, Accessed: Dec. 16, 2024. [Online]. Available: moz-extension://ee3b368e-f719-4896-92d4-623af5b58d8e/enhanced-reader.html?pdf=https%3A%2F%2Fbrxt.mendeley.com%2Fdocument%2Fcontent%2F2819f970-d8f2-3251-b453-95aa2628459e.

[16] D. P. Putri, R. C. E. Andriansyah, F. Setiyoningrum, L. E. Yulianti, and D. D. Hidayat, "Physicochemical Properties of Robusta Coffee at Various Roasting Levels Using Different Roaster Types," *BIO Web Conf.*, vol. 69, pp. 1–9, 2023, doi: 10.1051/bioconf/20236903016.

[17] S. Ratanasanya, N. Chindapan, J. Polvichai, B. Sirinaovakul, and S. Devahastin, "Model-based optimization of coffee roasting process: Model development, prediction, optimization and application to upgrading of Robusta coffee beans," *J. Food Eng.*, vol. 318, p. 110888, Apr. 2022, doi: 10.1016/j.jfoodeng.2021.110888.

[18] D. S. da Costa, T. G. Albuquerque, H. S. Costa, and A. P. A. Bragotto, "Thermal Contaminants in Coffee Induced by Roasting: A Review," *Int. J. Environ. Res. Public Health*, vol. 20, no. 8, 2023, doi: 10.3390/ijerph20085586.

[19] E. B. Tarigan, E. Wardiana, Y. S. Hilmi, and N. A. Komarudin, "The changes in chemical properties of coffee during roasting: A review," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 974, no. 1, 2022, doi: 10.1088/1755-1315/974/1/012115.

[20] J. Vosloo, "Heat and mass transfer model for a coffee roasting process," North-West University, South Africa, 2017.

[21] P. C. Ayu, M. R. Machrizailani, A. Rohanah, K. N. Sinamo, and N. U. W. Sebayang, "Design of coffee roaster with controlled temperature system to maintain the sustainability of coffee roasting process," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 1302, no. 1, 2024, doi: 10.1088/1755-1315/1302/1/012116.

[22] E. A. Mutovkina and S. A. Bredikhin, "Analysis of coffee thermophysical changes during roasting using differential scanning colorimetry," *Food Sci. Technol.*, vol. 43, pp. 1–5, 2023, doi: 10.1590/fst.119722.

[23] Hasriani and S. Arwati, "Karakteristik Kimia Kopi Arabika Bubuk dari Varietas Linie-S dan Sigararutan Chemical," *Agroindustri Halal*, vol. 10, no. 2023, pp. 90–100, 2024.

[24] N. M. Suaniti, A. A. S. D. Saraswati, and A. A. B. Putra, “Analisis Kafein Dalam Kopi Arabika (Coffea Arabica L.) Pada Berbagai Suhu Penyangraian Dengan Metode Spektrofotometer UV-Vis Dan GC-MS,” *J. Kim.*, vol. 16, no. 1, p. 115, 2022, doi: 10.24843/jchem.2022.v16.i01.p15.

[25] S. S. Mardjan, E. Heri Purwanto, and G. Yoga Pratama, “Pengaruh Suhu Awal Dan Derajat Penyangraian Terhadap Sifat Fisikokimia Dan Citarasa Kopi Arabika Solok,” *J. Keteknikan Pertan.*, vol. 10, no. 2, pp. 108–122, 2022, doi: 10.19028/jtep.010.2.108-122.

[26] A. Kinasih, S. Winarsih, and E. A. Saati, “Karakteristik Sensori Kopi Arabica Dan Robusta Menggunakan Teknik Brewing Berbeda,” *J. Teknol. Pangan dan Has. Pertan.*, vol. 16, no. 2, p. 12, 2021, doi: 10.26623/jtphp.v16i2.4545.