PHYSICAL, CHEMICAL, AND SENSORY CHARACTERISTICS OF COFFEE BEANS PROCESSED BY HONEY SOSOH WITH DIFFERENT FERMENTATION TIMES

KAMILA TUSSYADIYAH[1, ♥♥], ANALIANASARI[2], KURNIA RIMADHANTI N[3], TAUFIK NUGRAHA A[4]

[1,2,3,4]Politeknik Negeri Lampung. Jl. Soekarno Hatta No 10 Raja Basa Bandar Lampung, ♥email: analianasari@polinela.ac.id

Manuscript received: 10 Mei 2025. Revision accepted: 15 Juni 2025.

Abstract. Honey sosoh processing is a traditional method used to produce honey-processed coffee. This study aimed to analyze Arabica and Robusta coffee's physical, chemical, and sensory characteristics. The research design employed a completely randomized design (CRD) with three replications. The collected data were analyzed using ANOVA and a Least Significant Difference (LSD) test at the 5% significance level. Based on the evaluation results, the best treatment for defect value testing was obtained from Arabica coffee fermented for 36 hours and Robusta coffee fermented for 48 hours. In the sieve analysis, Arabica (36 hours) and Robusta (48 hours) were the best treatments. For the moisture content of green beans, the best results were found in Arabica and Robusta, both at 48 hours of fermentation. The best moisture content in ground coffee was also observed in Arabica and Robusta at 48 hours. The best ash content results were obtained from Arabica and Robusta at 0 hours of fermentation. Sensory evaluation showed that Arabica fermented for 36 hours scored 81.83, while Robusta fermented for 48 hours scored 82.42. According to the Indonesian National Standard (SNI), all treatments met the quality standards for coffee.

Key words: Fermentation, Honey Sosoh Arabica and Robusta Coffee

INTRODUCTION

Coffee is a major agricultural commodity widely traded in international markets. According to data from the United States Department of Agriculture (USDA), global coffee production reached 170 million bags or 10 million tons in 2022/2023. Indonesia is one of the world's largest coffee producers and exporters, ranking fourth after Brazil, Vietnam, and Colombia. In 2022/2023, Indonesia's coffee production reached 11.85 million bags or 665,100 tons. Arabica coffee production amounted to 1.3 million bags, while Robusta coffee production totaled 10.5 million. Coffee plantations in Indonesia covered an area of 1.29 million hectares (ha) in 2022 (USDA).

Lampung Province has suitable land for coffee cultivation due to its vast area. West Lampung Regency has an area of 54,106 ha, or 34.5% of Lampung's total coffee plantation area, followed by Tanggamus Regency with 41,510 ha, and Way Kanan Regency with 21,656 ha. The coffee plantations are located at altitudes ≤ 1,000 meters above sea level (BPS Lampung, 2020). Robusta coffee is a significant commodity in Lampung Province (Sinaga et al., 2022). Robusta coffee production in Lampung reached 118,139 tons in 2022 (BPS Lampung, 2022). Recently, Arabica coffee has also started to be cultivated by Lampung coffee farmers. Arabica coffee grows in highland areas, at altitudes ≥ 1,000 meters above sea level (asl), while Robusta coffee can grow at altitudes ≤ 1,000 meters (Rahardjo, 2012 and Ditjenbun, 2016).

Harvesting and post-harvest are significant parts of the agricultural supply chain that determine production quality, especially in coffee plantations. Coffee cherries should be picked correctly once they are ripe, when the coffee fruit changes to red (Najiyati & Danarti, 2012). The ripeness of coffee cherries can be assessed by their firmness and sugar content. Ripe coffee cherries have soft flesh, a slimy texture, and relatively sweet components (Reta et al., 2021). Post-harvest processing can be done using wet and dry methods (Analianasari et al., 2021). Wet processing involves a complete washing, while dry processing includes natural and honey methods (Analianasari et al., 2021).

Honey processing is a method developed from the natural process (Asni et al., 2015). The purpose of honey processing is to retain the mucilage layer on the coffee fruit. The mucilage layer remains because it stores sugar and acids, which concentrate as the coffee dries, giving the coffee a fruity flavor. The honey process creates a variety of aromas and sweet flavors in coffee while preserving its acidity (Asni et al., 2015). There are three types of honey processing: yellow honey, red honey, and black honey. In the yellow honey process, 25% of the mucilage layer is retained by drying it for 8 days in a moderately hot climate. Red honey retains 50% of the mucilage layer by drying it for 12 days in semi-shady weather. The black honey procedure retains 100% of the mucilage, or removes none, except for washing and drying it under a drying canopy for 30 days. Black honey is sweeter than yellow honey or red honey (Lia & Perdana, 2017).

In honey processing, pulping is typically done using a pulper machine; however, pulper machines are still tricky for farmers to access, especially in Lampung. Fruit skin peeling can be done using a mortar, as PT Inti Gravfarm Indonesia practices. This method is known as the sosoh method. Honey processing using the sosoh method involves several stages, such as picking the coffee cherries, sorting the fruit and removing defects, pulping, fermentation, drying, resting, hulling, sorting green beans, and determining coffee defects.

Honey processing results in unique flavor and aroma characteristics. The flavor produced is more complex, yielding various fruity and sweet tastes, and the honey-like aroma is very pronounced, with a slight hint of cascara aroma. The coffee is processed with the mucilage layer, followed by fermentation and direct drying with the fruit skin that has been peeled—the coffee ferments using the mucilage on the coffee beans. Resting refers to the period when the coffee rests after the drying process. The purpose of resting coffee is to develop its flavor and aroma. Applying the sosoh method is based on observations at PT Inti Gravfarm Indonesia.

Post-harvest coffee processing can influence the quality, flavor, and aroma produced. Based on this description, applying post-harvest coffee processing using the sosoh method is essential. This research aims to provide an alternative coffee processing method that coffee farmers, particularly in Lampung, can implement to improve coffee quality and achieve higher selling prices. The honey sosoh process is a relatively simple and easy-to-practice post-harvest coffee handling method. It can be done without a pulper machine, which helps reduce processing costs.

MATERIALS AND METHODS

Tools and Materials

The tools used in this study include a bucket, mortar, pestle, drying trays, explicit plastic clips, label paper, markers, winnowing tray, digital scale, analytical scale, porcelain dish, beaker glass, pestle, stopwatch, oven, furnace, conical burr grinder, sizing tool, cupping cups, cupping spoons, cupping forms, pens, and kettle. The materials used in this study are ripe red coffee cherries of the Arabica and Robusta varieties.

Research Location

The research titled "Physical, Chemical, and Sensory Characteristics of Coffee Beans Processed by Honey Sosoh Fermentation Method" was conducted at the coffee plantation in Tribudisyukur Village, West Lampung Regency, the Analytical Laboratory of Lampung State Polytechnic, and the Indonesian Coffee and Cocoa Research Center, from June to August 2024.

Procedures

The post-harvest processing of coffee cherries using the honey sosoh method involves several stages, from picking the coffee cherries to obtaining green beans. Coffee cherries are hand-picked using honey in the first stage of post-harvest coffee processing. 96 kg of coffee cherries and 48 kg of Arabica and Robusta were harvested. The harvested cherries are then sorted by separating the green, yellow, and red cherries. The red cherries from the sorting process are then floated in water to separate defective cherries. The cherries that float are considered defective, having only one seed or being empty, while the cherries that sink are used as raw material for the research. In addition to separating ripe and defective cherries, the floating process also cleans the cherries from twigs and dirt. The sorted and floated red cherries are then pulped. Pulping is done using the sosoh method by pounding the cherries with a mortar and pestle, which separates the skin from the fruit flesh. After pulping, the coffee cherries undergo fermentation for 0 hours, 24 hours, 36 hours, and 48 hours.

The coffee beans are dried after the fermentation period is complete. The coffee is dried under direct sunlight using drying trays or racks. The drying process is conducted for 7 hours per day. After drying, the coffee is rested in plastic bags to allow for resting time. The resting treatment is done by placing the coffee and the separated skin into a plastic bag, which is then sealed to allow the coffee to undergo natural fermentation. Once the coffee beans are dry, they are hulled to remove the parchment skin. Hulling is performed to separate the coffee beans from the parchment or husk. Hulling is done using a mortar and pestle, just like in the pulping stage, to produce green coffee beans. The resulting green beans are then observed at the Coffee and Analytical Laboratory at Lampung State Polytechnic. The observations include physical tests such as yield, defects, and moisture content, chemical tests to measure ash content in the coffee, and sensory evaluation conducted by the SCAA at the Indonesian Coffee and Cocoa Research Center.

Data analysis

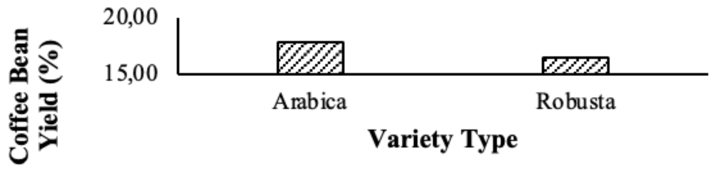
This research was conducted using a Factorial Completely Randomized Design (CRD) with two factors, 2x4 (2 types of coffee varieties: Arabica and Robusta, and four fermentation treatments), with three replications, resulting in a total of 24 experimental units. The first factor is the effect of fermentation in honey processing, and the second factor is the type of coffee, Arabica and Robusta.

The research used 96 kg of raw coffee and 48 kg of each coffee type, Arabica and Robusta. In each experimental unit, 5 kg of ripe red coffee cherries produced 700-1000 grams of green coffee beans. Observations were made by conducting physical tests, chemical tests, and sensory evaluation (SCAA). The data obtained from physical and chemical tests were analyzed using ANOVA and the BNT post hoc test. For the best quality treatments, sensory evaluation (SCAA) was conducted by the Indonesian Coffee and Cocoa Research Center.

RESULTS AND DISCUSSION

Coffee Bean Yield

Yield is the percentage comparison between wet coffee cherries and the dry weight of the coffee. The higher the yield, the fewer coffee beans are lost during processing. The yield of ground coffee is determined by several factors, such as the size of the beans, the floating process of the coffee cherries, the separation of the skin from the wet husk, the presence of coffee beans left behind during drying, and the loss of beans during hulling (Budiyanto et al., 2021). The average yield values for Arabica and Robusta ground coffee can be seen in Figure 1.



Picture 1. Average Yield of Arabica and Robusta Coffee Beans, Honey Sosoh Processing

Figure 1. Shows that the highest yield was obtained from Arabica coffee (17.83%), while the lowest was from Robusta coffee (16.50%). This is in line with the research by Lia (2017), which reported a coffee yield range of 13% to 16%. The yield values were obtained by peeling the fruit skin, drying, hulling the parchment skin, and then roasting to produce ground coffee.

Physical Characteristics of Coffee Beans

Physical testing of coffee beans is a test used to assess the quality of coffee beans based on their physical appearance, either using tools or seen with human senses, by SNI 01-2907-2008 (Gayo Cuppers Team, 2017). Raw materials and post-harvest influence the physical quality of coffee beans. Testing the physical characteristics of coffee beans is a determinant in evaluating and classifying premium coffee beans from low-quality coffee beans.

Coffee Bean Quality Defects

The quality of coffee beans is determined based on the defects in the tested bean samples (Budiyanto et al., 2021; Analiansari et al., 2024). The types of defects found are then summed to determine the overall quality of the coffee beans. Determining the quality of coffee beans requires a sorting process to ensure that the defect rate is not too high, thus producing quality that meets the Indonesian National Standard (SNI). The grading classification for coffee beans is based on SNI 01-2907-2008. This test is conducted according to SNI using 300 g of coffee bean samples, which are then categorized according to the types of defects and grouped by quality. The average defect values for Arabica and Robusta coffee can be seen in Figure 2.

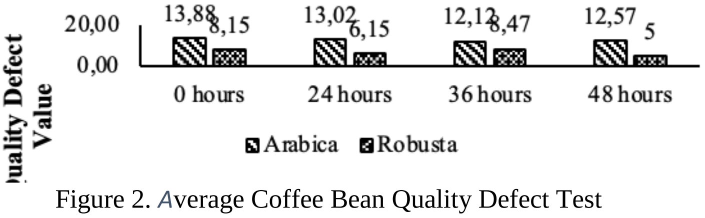


Figure 2. Average Coffee Bean Quality Defect Test

Figure 2. Explains that the defect values for Arabica and Robusta coffee differ, with Arabica coffee showing a higher defect value than Robusta coffee. The best treatment for defect evaluation in Arabica coffee occurred with 36 hours of fermentation, resulting in a defect value of 12.12, while the best treatment for defect evaluation in Robusta coffee occurred with 48 hours of fermentation, resulting in a defect value of 5. For Robusta coffee, the 48-hour and 24-hour fermentation

treatments fall into the premium coffee bean category, as the defect values produced are less than 8. A low defect value results in better coffee bean quality. The quality classification for Arabica coffee beans is grade 2, with defect values ranging from 12 to 25, while Robusta coffee beans fall into grade 1, with a maximum defect value of 11. The grade classification follows SNI 01-2907-2008. The defect values for Arabica and Robusta coffee beans processed using the honey sosoh method can be seen in Tables 1 and 2.

Table 1. Quality Defects of Arabica Coffee

Types Of Quality Defects		0 hours	24 hours	36 hours	48 hours
	Value	Defective value	Defective value	Defective value	Defective value
Black seeds	1	1.0	1.0	1.3	1.0
Partly black	1/2	12	1.0	0.8	1.0
Brown seeds	1/4	0.4	0.6	0.4	0.3
Cracked seeds	1/5	3.7	3.1	2.8	3.2
Young seeds	1/10	0.3	0.4	0.3	0.3
Seed hole1	1/5	1.3	1.3	1.1	1.3
Seed hole >1	1/5	4.7	4.5	4.2	4.2
Nuts and seeds	1/10	1.2	1.1	1.1	1.2
Amount		13.88	13.02	12.12	12.57
Quality		2	2	2	2

Based on Table 9, the most common defects in Arabica coffee beans are wrinkled beans, cracked beans, and hollow beans. Wrinkled beans in Arabica coffee are caused by the fruit skin and parchment (wet husk) being removed before drying. Cracked beans in coffee occur during processing, where the beans are cut or cracked during the peeling of the fruit skin and parchment due to excessive pounding. Cracked beans have an incomplete shape, with less than ¾ of the bean remaining intact. Hollow beans in coffee are caused by pest or disease attacks (Aklimawati et al., 2014).

Table 2. Quality defects of Robusta coffee

Types Of Quality Defects		0 hours	24 hours	36 hours	48 hours
	Value	Defective value	Defective value	Defective value	Defective value
Black seeds	1	0.0	0.0	0.3	0.0
Partly black	1/2	0.8	0.7	0.7	0.5
Brown seeds	1/4	0.4	0.4	0.5	0.3
Cracked seeds	1/5	3.3	2.3	3.3	2.1
Young seeds	1/10	0.6	0.5	0.6	0.5
Seed hole1	1/5	0.3	0.2	0.3	0.1
Seed hole >1	1/5	1.7	1.3	1.8	0.9
Nuts and seeds	1/10	1.0	0.7	0.9	0.6
Amount		8.15	6.15	8.47	5.0
Quality		1	1	1	1

Based on Table 2, the most common defects in Arabica coffee are cracked beans and hollow beans, while in Robusta coffee, the most common defect is cracked beans. Cracked beans in coffee are caused by processing, where the beans are cut or cracked during the peeling of the fruit skin and parchment due to excessive pounding. Hollow beans in coffee are caused by pest or disease attacks (Aklimawati et al., 2014). The types of quality defects in Arabica and Robusta coffee processed using the honey sosoh method include eight characteristics: black beans, partially black beans, brown beans, cracked beans, beans with one hole, beans with more than one hole, and wrinkled beans.

The defect value of coffee beans is one of the characteristics that affects the flavor of coffee. The defect value can be addressed by sorting the beans (Budiyanto et al., 2021). Black beans determine the defect value (Aklimawati et al., 2014). Black coffee beans have a wrinkled outer skin and are black. Black beans occur due to several factors from the coffee farm, such as poor plant growth and poorly controlled processing, such as overfermentation. Black beans can also occur if less than half of the outer part of the coffee bean is black or has a small bluish spot without a hole larger than the spot. Black beans often occur when coffee cherries are harvested too late during the harvest. Black beans can create a different sensation on the tongue that might not be very pleasant (Setyani et al., 2018).

Chocolate beans in coffee are caused by improper and uneven drying, resulting in different moisture content and causing the beans to turn brown, which is not uniform with the usual color of coffee beans (Wulandari et al., 2024). Poor drying processes also cause beans to have a wrinkled appearance, as during drying, the husk may peel off, leading to spots on the beans. Immature beans are caused by harvesting cherries that are still unripe and by insufficient attention during the sorting process of the coffee cherries. Immature beans are half the size of a whole bean (Aklimawati et al., 2015).

Cracked beans are not whole, with a size of ¾ of a full coffee bean. Cracked beans are caused during the peeling of the fruit skin and husk, where the beans are struck during the process, leading to cracks, as stated in the research by Budiyanto et al. (2021). One-hole and multi-hole beans have holes due to an attack by the coffee borer beetle (Hypothenemus hampei) (Novita et al., 2010). Beans with holes usually come from cherries that dry on the tree and fall to the ground. The chemical quality damage in coffee is caused by the beans with holes (Winarno et al., 2020).

The results of the defect quality values of the coffee beans obtained were subjected to an ANOVA statistical test. The ANOVA test determines significant differences between the studied samples using variance. The analysis of variance test for defect quality in Arabica and Robusta coffee beans yielded an F calculated value of 343.14 and an F table value of 4.49. The analysis of variance test for defect quality in the beans at different fermentation times obtained an F calculated value of 8.86 and an F table value of 3.24. The analysis of variance test for defect quality in the beans with interactions obtained an F calculated value of 7.09 and an F table value of 3.24. Since the F calculated value is greater than the F table value, it can be concluded that the Arabica and Robusta coffee beans processed using the honey sosoh method with different fermentation times show significant differences in the number of defects produced.

Fermentation performed on coffee beans significantly affects the defect quality values. The genetic composition differences between Arabica and Robusta coffee affect the physical resilience of the beans. Robusta and Arabica coffee have different textures. Robusta coffee has a more complex texture than Arabica coffee and a higher caffeine content (Herlinawati, 2020). The high caffeine content makes Robusta coffee plants known to be resistant to disease attacks (Hakim & Septian, 2011). The caffeine content in Arabica and Robusta coffee affects the number of beans with holes, which causes Robusta coffee to have fewer beans with holes than Arabica coffee. The high number of defects in Arabica coffee is caused by the suboptimal altitude at which the coffee is grown. The Arabica coffee studied was grown at an altitude of 850 meters above sea level (MDPL). In contrast, Arabica coffee is typically grown at altitudes above 1000 MDPL and is more susceptible to diseases when grown below 1000 MDPL (Budihardjono, 2020). The attack of the coffee borer beetle is heavier on coffee cherries at lower altitudes than on higher altitudes (Asfaw et al., 2019). Meanwhile, according to Hifnalisa and Karim (2008), coffee plants grown at lower altitudes are more vulnerable to pest and disease attacks, resulting in more defective beans.

The processing steps cause different defect quality values in each fermentation duration treatment. Suboptimal post-harvest handling leads to defects in the coffee beans (Winarno et al., 2021). The processing steps affecting the defect value of coffee beans include harvesting the coffee cherries, improper peeling of the fruit skin, suboptimal drying, and hulling. The defects in the beans influenced by the processing are black beans, brown beans, underdeveloped beans, beans with scars, and cracked beans.

Bean Size

Sieve passing coffee separates coffee beans based on sieve sizes—large, medium, and small (SNI 01-2907-2008). Coffee that passes through the sieve is one way to obtain uniform-sized coffee beans, an important requirement for international consumers (Analianasari et al., 2023). In Arabica coffee, dry processing has specific sieve passing size requirements: large size (does not pass through a 6.5 mm sieve), medium size (passes through a 6.5 mm sieve), and small size (passes through a 5.5 mm sieve). For Robusta coffee with dry processing, the specific sieve passing size requirements are: large size (does not pass through a 6.5 mm sieve) and small size (passes through a 6.5 mm sieve). The percentage of beans passing the sieve is expressed as a percentage (%). In this study, sieve passing tests for Arabica and Robusta coffee beans were performed using a 6.5 mm diameter sieve. The results of the sieve passing can be seen in Figure 3.

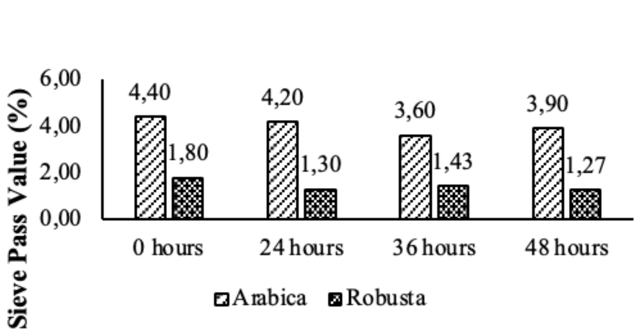


Figure 3. Average Test Pass Size Sieve 6,5 mm

Figure 3 explains that the sieve passing values for Arabica and Robusta coffee are different. Arabica coffee produced higher sieve passing values compared to Robusta coffee. The best treatment for the sieve passing test on Arabica coffee was the 36-hour fermentation, with a sieve passing value of 3.60. In contrast, the best treatment for the sieve passing test on Robusta coffee was the 48-hour fermentation, with a sieve passing value of 1.27. A lower sieve passing value results in better quality coffee beans.

The sieve passing value requirement for coffee beans is a maximum of 5%. The average sieve passing values for Arabica and Robusta coffee processed with the honey sosoh fermentation method are by SNI 01-2907-2008, as the sieve passing values are below 5%. The sieve passing values obtained were then subjected to an ANOVA statistical test to determine significant differences between the samples studied using variance analysis. The ANOVA test for sieve passing values of Arabica and Robusta coffee beans obtained an F calculated value of 1240.01 and an F table value of 4.49. The ANOVA test for sieve passing values at different fermentation times obtained an F calculated value of 12.72 and an F table value of 3.24. The ANOVA test for the interaction effect obtained an F calculated value of 4.31 and an F table value of 3.24. Since the F calculated values are greater than the F table values, it can be concluded that the sieve passing values for Arabica and Robusta coffee processed with the honey sosoh method and different fermentation times are significantly different.

Moisture Content of Coffee Beans

Moisture content refers to the amount of water contained in a material. It is the percentage of water content expressed based on the wet or dry weight. Moisture content affects the quality and grade of coffee beans. This study conducted a moisture content test to determine the percentage of water still contained in the coffee beans. A moisture content that meets the standards (SNI) will allow for adequate storage over an extended period. High moisture content can lead to faster fungal growth, damaging the coffee's physical characteristics and flavor profile (Saleh et al., 2021). The moisture content data for Arabica and Robusta coffee beans can be seen in Figure 4.

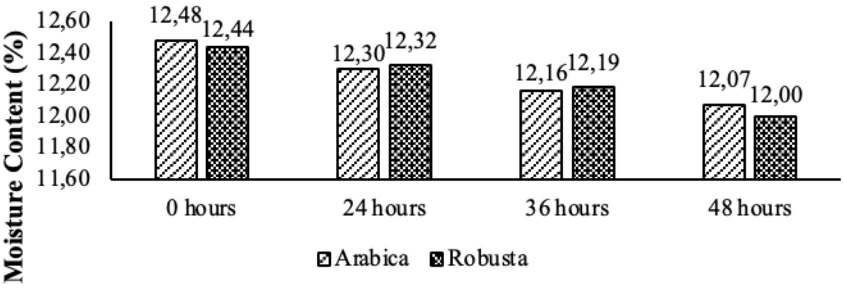


Figure 4. Average Moisture Content of Coffee Beans

Figure 4 shows the average moisture content of Arabica and Robusta coffee beans. The average moisture content results indicate that the longer the fermentation time, the better the moisture content of the coffee beans. The best treatment for moisture content in Arabica and Robusta coffee was achieved with 48 hours of fermentation, with moisture content values of 12.07% and 12.00%, respectively. At 0 hours of fermentation (control), the highest moisture content was observed, with moisture content values of 12.48% for Arabica and 12.44% for Robusta. The moisture content at 0 hours of fermentation is close to the SNI standard but still meets the requirement, as it is below 12.5%.

The general requirement for moisture content in coffee beans, according to SNI 01-2907-2008, is a maximum of 12.5%. Moisture content that meets the SNI standard is safe from mold and fungus odors and is safe for long-term storage. Moisture content below 10% or overly dried (over-drying) will affect the coffee's taste, color, aroma, and overall quality (Novita et al., 2010).

The moisture content values of the coffee beans that were obtained were tested using an ANOVA statistical test. The ANOVA test uses variance analysis to determine significant differences between the studied samples. The analysis of variance for the moisture content of Arabica and Robusta coffee beans at different fermentation times yielded an F value of 37.41 and a table value of 3.24. Since the F calculated is greater than the F table, it can be concluded that the fermentation time significantly affects the moisture content produced. This is in line with the study by Thalia et al. (2020), which showed that the longer the fermentation time, the lower the moisture content of the coffee beans. At 5 hours of fermentation, the moisture content was 12.4%, at 10 hours it was 11.97%, and at 15 hours it was 11.84%. Similarly, Pratiwi et al. (2023) found that the moisture content of coffee beans decreases during fermentation at 24 hours and 48 hours. At 0 hours of fermentation, the moisture content was 10.97%, at 24 hours it was 10.62%, and at 48 hours it was 10.47%. During fermentation, the decrease is due to the increased activity of microorganisms, which activate enzymes that help dilute the pulp. This process opens the pores in the coffee beans, allowing water to exit more easily during drying (Tobing, 2009).

Chemical Characteristics of Ground Coffee

The chemical characteristics of ground coffee come from the coffee beans that have been roasted to a medium level and then ground using a medium-coarse grind size. The quality of ground coffee can be determined by the moisture content and ash content, which are measured according to SNI 01-2907-2008 standards.

Moisture Content of Ground Coffee

The moisture content of ground coffee is the percentage of water content expressed on a dry basis. In this test, the calculation is done in percentage (%) according to SNI 01-2907-2008 standards. Moisture content tests were carried out on Arabica and Robusta ground coffee to determine the quality and grade of the produced ground coffee. Moisture content in ground coffee has a significant impact on its shelf life. High moisture content causes ground coffee to oxidize, leading to a rancid aroma and a shorter shelf life. The optimal drying process uses sunlight for 20 days until the moisture content reaches 12%, followed by further processing, including roasting and grinding, to produce ground coffee. These stages influence the decrease in moisture content of the coffee beans by about 20%. The data on the moisture content of ground coffee can be seen in Figure 5.

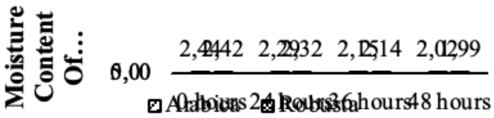


Figure 5. Average Moisture Content of Ground Coffee

Figure 5 shows that the longer the fermentation time, the better the moisture content produced. This is indicated by the results, where the moisture content at zero fermentation was higher than at 24, 36, and 48 hours of fermentation. The best treatment for the moisture content of ground coffee for both Arabica and Robusta occurred at 48 hours of fermentation, with moisture content values of 2.02% and 1.99%, respectively.

The general requirement for the moisture content of ground coffee according to SNI 01-3542-2004 is a maximum of 7%. The study results show that the moisture content of both Arabica and Robusta coffee is below 7%, so all treatments meet the SNI standards. Ground coffee with moisture content that complies with the SNI can increase resistance to damage caused by microorganisms and preserve its flavor (Pastiniasih, 2012). This is related to the process of water release and absorption from the surface of the coffee.

The moisture content data of ground coffee obtained were statistically analyzed using ANOVA. The ANOVA test aimed to determine whether there were significant differences among the samples by applying variance analysis. The analysis of variance on the moisture content of Arabica and Robusta ground coffee at different fermentation times yielded an F-calculated value of 78.89 and an F-table value of 3.24. Since the F-calculated value is greater than the F-table value, it can be concluded that fermentation time had a statistically significant effect on the moisture content of the coffee.

The fermentation treatment resulted in significantly different moisture contents due to variations in fermentation durations. The 48-hour fermentation period produced the lowest moisture content, indicating that this duration was the most effective treatment for reducing the moisture content of coffee beans. This finding is consistent with the study by Aslani et al. (2023), which reported that differences in fermentation duration significantly affected the moisture content of ground coffee. The highest moisture content was found in the control sample at 3.90%, while the lowest was observed in the 6-day fermentation treatment at 1.75%. Similarly, Mulyono et al. (2016) noted that the longer the resting period of the coffee beans, the lower the resulting moisture content in the ground coffee. According to Barus (2019), the reduction in moisture content occurs because prolonged fermentation increases temperature, producing heat that dissolves the mucilage on the beans, opening the pores and allowing the moisture to evaporate.

Ash Content

Ash content is the inorganic component that remains after combustion at high temperatures. In-ground coffee ash is derived from mineral elements and may contain foreign substances introduced as contaminants during processing (Gafar, 2018). A lower ash content indicates higher quality coffee. The average ash content results are shown in Figure 6.

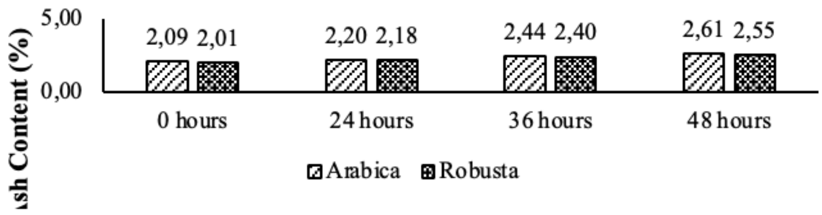


Figure 6. Average Ash Content Of Ground Coffee

Figure 6 shows that fermentation treatment can increase the ash content of ground coffee. This is evidenced by the lower ash content observed at 0 hours of fermentation than at 24, 36, and 48 hours of resting time. The highest average ash content was recorded at 48 hours of fermentation, while the lowest was at 0 hours. The best treatment for Arabica and Robusta coffee was found at 0 hours of fermentation (control), with ash contents of 2.09% and 2.01%, respectively. After 48 hours of fermentation, the ash content increased, reaching 2.61% for Arabica and 2.55% for Robusta coffee.

According to the Indonesian National Standard (SNI) 01-2907-2008, ground coffee's maximum allowable ash content is 5%. Ground coffee that meets this standard is considered clean and free from contaminants. This parameter is closely related to the coffee processing method, as in addition to mineral content, impurities such as dirt and silver skin can also contribute to higher ash levels (Winarno et al., 2021).

The obtained ash content data of ground coffee were analyzed statistically using ANOVA. The ANOVA test aimed to determine whether there were significant differences among the samples through variance analysis. The analysis of variance for the ash content of Arabica and Robusta coffee at different fermentation times resulted in an F-calculated value of 11.28 and an F-table value of 3.24. Since the F-calculated value is greater than the F-table value, it can be concluded that fermentation time had a statistically significant effect on the ash content produced.

The fermentation treatment resulted in significantly different ash contents due to variations in fermentation time. The 0-hour fermentation (control) produced the lowest ash content, indicating that it was the most effective treatment in minimizing the ash content of coffee beans. This finding aligns with the study by Barus (2019), which reported the highest ash content at 48 hours of fermentation (4.150%) and the lowest at 12 hours (3.225%), with all treatments showing statistically significant differences from one another. Longer fermentation times tend to increase ash content. This is attributed to the decreasing moisture content of ground coffee over time, leading to a relative increase in mineral concentration (Barus, 2019).

Ash content is the portion that remains unburned when a substance is subjected to high temperatures. In-ground coffee ash content is influenced by the natural mineral composition of the beans (Gafar, 2018). A higher ash content often results from a practical and optimal fermentation process. The better the fermentation, the higher the resulting ash content. The reduction in moisture due to fermentation can increase mineral concentration, thereby elevating the ash content (Mulyono & Vandalisna, 2016). Coffee bean fermentation must be followed by a drying process to reduce moisture; during drying, water evaporates, but organic matter and minerals remain in the ground coffee and are later converted into ash. Fermentation contributes to increased ash content in ground coffee as organic matter degrades. The more organic matter broken down during fermentation, the higher the ash content (Izzati et al., 2022).

Flavor Profile

According to the Specialty Coffee Association of America (SCAA), the flavor characteristics were determined using the cupping test method performed by the Indonesian Coffee and Cocoa Research Center (PUSLITKOKA). The cupping test was conducted on the best treatments, specifically Arabica coffee (36 hours) and Robusta coffee (48 hours). The best treatments were selected based on the results of physical and chemical analyses. The most critical parameter for flavor testing is the defect count of the beans, as defects can significantly affect the coffee's flavor. Several quality attributes were evaluated to understand the flavor characteristics, including Fragrance (dry aroma), Flavor (aroma), Body (mouthfeel), Acidity (sourness), Aftertaste (lingering taste), Sweetness, Balance, Clean Cup (clarity), Uniformity, Overall Quality (general perception), and Defects (pleasant or unpleasant flavors). The results of the cupping test are presented in Table 3 and Figure 7.

Table 3. Cupping Test Results

	Taste Score

Characteristics	Arabica (36)	Category	Robusta (48)	Category
Fragrance/Aroma	7.58	Very Good	8.00	Excellent
Flavor	7.67	Very Good	7.92	-
Aftertaste	7.50	Very Good	7.83	-
Acidity	7.25	Very Good	7.83	-
Body	7.33	Very Good	7.75	Very Good
Uniformity	10.00	-	10.00	-
Balance	7.25	Very Good	7.67	Very Good
Clean cup	10.00	-	10.00	-
Sweetness	10.00	-	7.58	Very Good
Overall	7.25	Very Good	7.83	-
Final Score	**81.83**		**82.42**	
Comments:	Sweet Potato, Lactic Acid Aroma, Nutty, Sugar Cane, Black Tea, Fruity, Flowery-Honeyed, Low Body		Brown Sugar, Cereally, Chocolaty, Acidy, Black Tea	

Based on the flavor test results, Table 3 shows the cupping test results for the honey sosoh processing method in Arabica coffee, which achieved a final score of 81.83, classified as Excellent. The flavor profile included notes of Sweet Potato and Lactic Acid *Aroma, Nutty, Sugar Cane, Black Tea, Fruity, Flowery-Honeyed, and Low Body.* Arabica coffee exhibits a complex flavor profile with a variety of taste notes. Robusta coffee received a final score of 82.42, classified as Excellent, and displayed flavors of Brown Sugar, Cereal, Chocolaty, Acidity, and Black Tea. The Black Tea flavor in Arabica and Robusta coffees results from the fermentation process caused by the oxidation of catechin enzymes, also known as polyphenols (Asfar, 2017). The cupping test results for the honey sosoh processing method in Arabica and Robusta coffees are presented in the spider chart in Figure 7.

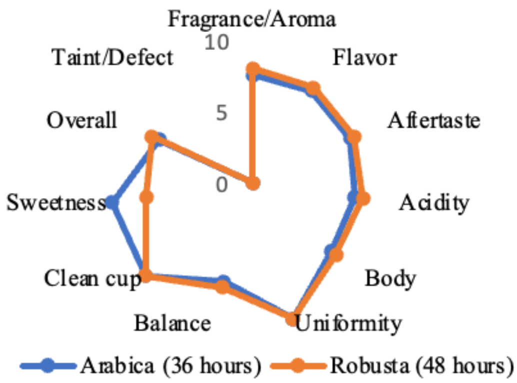


Figure 7. Arabica and Robusta coffee flavor profiles

Based on Figure 7, the flavor profile of both Arabica and Robusta coffees reveals that aroma plays a crucial role in the overall coffee experience, representing the comfort of the coffee's aromatic qualities both before brewing (dry aroma) and after brewing (wet aroma) (Widyasari et al., 2023). The aroma of Arabica coffee scored 7.58, while Robusta coffee scored 8.00, indicating that Robusta coffee produces a better aroma than Arabica coffee. Following cupping standards, the roasting process was conducted at a medium roast level, which helps develop aromatic components such as chocolaty notes found in Robusta coffee (Rini, 2017). A pleasing aroma significantly influences the overall quality of coffee (Setyani & Grace, 2018; Andani et. al., 2025).

Flavor represents the taste's intensity, quality, and complexity, significantly influencing consumer demand. The flavor of Arabica coffee scored 7.67, while Robusta coffee scored 7.92. Arabica coffee developed a nutty flavor, whereas Robusta coffee displayed brown sugar and cereal flavors. The nutty flavor in Arabica beans is typically formed when the roasting process is underdone. Chemically, the nutty aroma is produced during the caramelization of sugars, which is associated with compounds such as furfural and pyrazine (Hasni et al., 2021).

Aftertaste refers to the impression left after drinking coffee, following its consumption (SCAA, 2015). Aftertaste contributes to the quality of the lingering flavor and aroma, leaving a lasting impression even after the coffee is swallowed

(Saleh et al., 2020). Arabica coffee received an aftertaste score of 7.50, while Robusta coffee scored 7.83, indicating that the aftertaste of both Arabica and Robusta coffees is quite favorable.

Acidity refers to the sensation of sourness with a balanced complexity, providing a pleasurable experience on the palate. The acidity of Arabica coffee scored 7.25, while Robusta coffee received a score of 7.83. The acidity levels of Arabica and Robusta coffees fall into the "good" category, meaning the acidity or sourness of the coffee is still enjoyable.

Clean cup refers to the level of cleanliness in the flavor profile of the coffee, from the moment it is swallowed to the aftertaste. A clean cup indicates that the coffee flavor is free from defects and contamination, such as over-fermented fruit, earthy or rotten aromas typically associated with defective beans (Novita et al., 2010). Arabica and Robusta coffees scored 10, meaning no unpleasant flavors or aromas were detected in the tested coffees. Sweetness in Arabica coffee scored a perfect 10, while Robusta received a score of 7.58, indicating that Arabica coffee has a sweeter profile than Robusta. This difference is due to Arabica coffee's higher sugar content than Robusta (Sabarni & Nurhayati, 2019).

Overall quality reflects the complexity and appeal of the coffee's flavor when consumed. Based on the overall score, Arabica coffee scored 7.25, while Robusta scored 7.83. Coffees with higher overall flavor ratings are considered to have a more complex and enjoyable flavor profile (Rini et al., 2017). The overall rating is the evaluation the panelists give or the one they prefer (Widyasari et al., 2023). Defect refers to defective coffee beans that may impart undesirable flavors when brewed. In the cupping test, Arabica and Robusta coffees showed minimal or no defects, meaning they were free from unpleasant flavors. Defective coffee refers to beans that are considered substandard and do not meet quality control standards. These defects are usually detected during the sorting process, and such coffees typically exhibit reduced flavor quality, such as excessive acidity, bitterness, or grassy aromas, which are generally disliked by coffee enthusiasts (Edy, 2018).

REFERENCES

A Gafar, P. A. G. 2018. Proses Penginstanan Aglomerasi Kering Dan Pengaruhnya Terhadap Sifat Fisiko Kimia Kopi Bubuk Robusta (*Coffea robusta Lindl. Ex De Will*). *Jurnal Dinamika Penelitian Industri*, *29*(2), 163. https://doi.org/10.28959/jdpi.v29i2.3745

Aklimawati, L., Sumarno, D., dan Mawardi, S. 2015. Effect of Service Quality on Coffee-Based Economic Cluster Development on Farmers' and Other Stakeholders' Satisfaction in Bondowoso District. *Pelita Perkebunan (a Coffee and Cocoa Research Journal)*, *31*(1), 59–72. https://doi.org/10.22302/iccri.jur.pelitaperkebunan.v31i1.68

Aklimawati, L., Yusianto, dan Mawardi, S. 2014. Karakteristik Mutu dan Agribisnis Kopi Robusta di Lereng Gunung Tambora , Sumbawa. *Pelita Perkebunan*, *30*(2), 159–180.

Andani, T.R., Analianasari, A. & Agassi, T.N. 2025. Karakteristik Fisiko Kimia Dan Cita Rasa Kopi Robusta (*Coffea canephora*) Pengolahan Black Honey Pada Ketinggian Dan Tingkatan Penyangraian Berbeda. *Jurnal Pengembangan Agroindustri Terapan*, 3(2): 1–16.

Analianasari, A., Kenali, E. W., Berliana, D., Yulia, M., dan Shintawati. 2021. Penguatan Kapasitas Produksi Kopi Robusta Premium Gapoktan Triguna 4.5. *Qardhul Hasan*, *7*(1), 126–132. https://api.semanticscholar.org/CorpusID: 244966353

Analianasari, A., Berliana, D., & Shintawati, S. (2024). Defects of Coffee Beans with Different Postharvest Processes and Roasting Temperatures on Volatile Compounds of Coffee Beans from Coffee Small-Scale Industries of West Lampung, Indonesia. TRENDS IN SCIENCES, 21(7), 1–12. https://doi.org /10.48048/tis.2024.7695

Aslani, E., Angraeni, L., dan Angraeni, L. 2023. Pengaruh Lama Fermentasi Terhadap Karakteristik Kimia dan Organoleptik Kopi Arabika (Coffea arabica L) Di KBQ Baburrayyan Aceh. *Jurnal Pertanian Agros*, *25*(1), 313–322.

Barus, W. B. J. 2019. Pengaruh lama fermentasi dan lama pengeringan terhadap mutu mubuk kopi. *Wahana Inovasi*, *8*(2), 111–115. file:///C:/Users/Asus/Downloads/2137-5223-1-SM (1).pdf

Budiyanto, B., Uker, D., dan Izahar, T. 2021. Karakteristik Fisik Kualitas Biji Kopi Dan Kualitas Kopi Bubuk Sintaro 2 Dan Sintaro 3 Dengan Berbagai Tingkat Sangrai. *Jurnal Agroindustri*, *11*(1), 54–71. https://doi.org/10.31186/j.agroindustri.11.1.54-71

Pratiwi, P., Yanto, S., dan Sukainah, A. 2023. The Effect Of Natural Fermentation Time On The Quality Of Robusta Coffee From Bantaeng. *Jurnal Pendidikan Teknologi Pertanian*, *9*, 263–272.

Lia, F., dan Perdana, D. T. 2017. Sistem Produksi Agroindustri Kopi Arabika (Studi Kasus Pt Sinar Mayang Lestari, Kecamatan Pangalengan, Kabupaten Bandung). *Agrisep*, *16*(2), 123–132.

Novita, E., Syarief, R., Noor, E., dan Mulato, D. S. 2010. Peningkatan Mutu Biji Kopi Rakyat Dengan Pengolahan Semi

Basah Berbasis Produksi Bersih (Smallholder Coffee Bean Quality Improvement with Semi Wet Processing Based On Clean Production). *Agrotek*, *4*(1), 76–90.

Reta, Dahlia, Sumule, O., dan Larekeng, H. 2021. Penerapan Teknik Panen dan Pascapanen Kopi Arabika Kalosi Produk Unggulan Kabupatan Enrekang. *Jurnal Dinamika Pengabdian*, *6*(2), 341–348.

Retmono Agung Winarno. 2021. Karakteristik Sifat Kimia Biji Kopi Arabika Dengan Beberapa Metoda Pengolahan Di Kabupaten Simalungun Provinsi Sumatera Utara. *Agrivet : Jurnal Ilmu-Ilmu Pertanian Dan Peternakan (Journal of Agricultural Sciences and Veteriner)*, *9*(2), 237–243. https://doi.org/10.31949/agrivet.v9i2.1701

Rini, A.I.P., Wiranatha, A.A.P.A.S., Yoga, I. W. G. 2017. Pengaruh Kadar Biji Pecah dalam Penyangraian terhadap Citarasa Kopi Robusta Desa Pucak Sari, Buleleng, Bali. *Jurnal Rekayasa Agroindustri, Manajemen*, *5*(3), 74–84.

Sabarni, S., dan Nurhayati, N. 2019. Analisis Kadar Kafein Dalam Minuman Kopi Khop Aceh Dengan Metode Spektroskopik. *Lantanida Journal*, *6*(2), 141. https://doi.org/10.22373/lj.v6i2.3624

Saleh, S. (2021). Identifikasi Kadar Air, Tingkat Kecerahan Dan Citarasa Kopi Robusta Dengan Variasi Lama Perendaman. *Jurnal Teknologi Pangan Dan Ilmu Pertanian (Jipang)*, *2*(1), 41–48. https://doi.org/10.36526/jipang.v2i1.1215

Setyani, S., dan Grace, H. A. 2018. Nilai Cacat dan Cita Rasa Kopi Robusta Nilai Cacat dan Cita Rasa Kopi Robusta. *Teknologi dan Industri Hasil Pertanian*, *23*(2), 103–114.

Setyani, S., Subeki, S., dan Grace, H. A. 2018. Evaluasi Nilai Cacat Dan Cita Rasa Kopi Robusta (Coffea Canephora L.) Yang Diproduksi Ikm Kopi Di Kabupaten Tanggamus [Evaluation of Defect Value and Flavour Robusta Coffee (Coffea canephora L.) Produced by the Small and Medium Industrial Sector of Coffee in Ta. *Jurnal Teknologi & Industri Hasil Pertanian*, *23*(2), 103. https://doi.org/10.23960/jtihp.v23i2.103-114

Sinaga, A. S. R. M., Putra, R. E., dan Girsang, A. S. 2022. Prediction measuring local coffee production and marketing relationships with big data analysis support. *Bulletin of Electrical Engineering and Informatics*, *11*(5), 2764–2772. https://doi.org/10.11591/eei.v11i5.4082

Tari, W., Safrizal, S., dan Fadhil, R. 2022. Evaluasi Sensori Kopi Arabika Gayo Berbagai Varietas berdasarkan Proses Pengolahan Basah dan Semi Basah menggunakan Metode AHP (Analytical Hierarchy Process). *Jurnal Ilmiah Mahasiswa Pertanian*, *7*(2), 601–611. https://doi.org/10.17969/jimfp.v7i2.20115

Thalia, TT., Ersan., Delvitasari, F., M. 2020. Pengaruh Fermentasi S. cerevisiae Terhadap Mutu Kopi Robusta (Fermentation Effect of S. cerevisiaeon Robusta Coffee Quality). *Journal of Agricultural Science*, *18*(1), 60–77. http://jurnal.unmuhjember.ac.id/in

Widyasari, A., Warkoyo, W., dan Mujianto, M. 2023. Pengaruh Ukuran Biji Kopi Robusta pada Kualitas Citarasa Kopi. *Jurnal Agro Industri Perkebunan*, *11*(1), 1–14. https://doi.org/10.25181/jaip.v11i1.2602

Winarno, R. A., dan Indah Br PA, M. 2020. Karakteristik mutu dan fisik biji kopi arabika dengan beberapa metoda pengolahan di Kabupaten Simalungun Propinsi Sumatera Utara. *Jurnal Agrica Ekstensia*, *14*(1), 86–93.