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Optimizing Coffee Flavor Through Roasting and Manual Brewing Using Chemical and Sensory Approach

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Abstract

The global popularity of coffee has led to growing attention on how processing and brewing techniques influence its sensory attributes. This study analyzed the chemical content of coffee and assessed the combination of roasting and manual brewing methods on coffee flavor. The coffee types used were Arabica coffee and Robusta coffee. The roasts used were light, medium, and dark roast with AeroPress, Siphon, and V60 manual brewing methods. The experiment was arranged in a factorial arrangement within a Randomized Complete Block Design (RCBD), where coffee varieties served as blocks, and the treatment combinations of roasting and brewing methods were randomly assigned within each block. Data analysis includes two-way analysis of variance, biplot analysis, and the compromise programming method. The results showed that the selection of roast level and brewing method had a significant influence on the coffee's chemical analysis and sensory profile. Light roasting and complex flavors were more acceptable than dark roasting, which tends to be heavy. Based on the panelists' preference analysis using the compromise programming method, RLS (Robusta-Light roast-Siphon) emerged as the optimal choice, indicating that this combination balances all coffee taste criteria. The combinations ALV (Arabica-Light roast-V60), ALA (Arabica-Light roast-Aeropress), and AMA (Arabica-Medium roast-Aeropress) which tends to similar and provide a balanced, complex flavor profile, including aroma, acidity, and high overall quality. Arabica coffee combination ADS (Arabica-Dark roast-Siphon), ADA (Arabica-Dark roast-Aeropress), and ADV (Arabica-Dark roast-V60) which have less optimal visual and balance because dark roasting reduces the sensory criteria of coffee.

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1. Introduction

Coffee is one of the leading plantation commodities with significant potential and importance for foreign exchange earnings in Indonesia. According to data from the United States Department of Agriculture (USDA 2024), global coffee production reached 174.9 million tons in the 2024/2025 period.

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Indonesia ranked fourth, with a total output of 10.9 million tons, after Brazil, Vietnam, and Colombia. Arabica (Coffea arabica) and Robusta (Coffea canephora) are the most widely grown coffee types in Indonesia. The characteristics of coffee differ based on its type. Even at a not-too-far planting radius, the same coffee plant can produce different coffee flavors according to the characteristics of the soil, pH, and vegetation found in the surrounding environment (Hamdan and Sontani 2018).

Coffee quality can be assessed through several parameters, such as aroma, flavor, and taste. Factors such as post-harvest processing, roasting, and coffee brewing methods can affect these three parameters (Fadri et al. 2019). Roasting is a thermal process that induces both physical and chemical transformations in coffee beans, ultimately contributing to the distinctive sensory properties of the brewed coffee (Sunarharum et al. 2019). The three roasting levels of coffee beans (light, medium, and dark) offer different flavor impressions. For example, light and medium roast levels tend to provide a sweeter and lighter flavor (Sasangko et al. 2018). Roasting time affects the water content of ground coffee (Alzidan et al. 2023).

Aziza et al. (2024) investigated whether the brewing method influences the coffee characteristics and sensory profile. This study used two types of coffee, Arabica and Liberica, with a medium roast level. The results showed that different manual brewing techniques significantly affected the physicochemical and sensory characteristics of the brewed coffee. Interestingly, the effect of the brewing method was more pronounced in Arabica coffee than in Liberica coffee. However, the selection of roasting level variations for coffee brewing has not been widely developed. Therefore, this study aimed to analyze the chemical content of coffee and assess the combination of roasting and manual brewing methods on coffee flavor.

2. Material and Methods

2.1 Materials and Equipment

Arabica Gayo and Robusta Gayo green coffee beans were used in this study. The coffee was roasted using a coffee roasting machine of type KEMS1. The coffee grinding process was performed using a coffee grinding machine (EK 43), while brewing was conducted using three manual methods (coffee brewing methods type V60, French press, and siphon).

2.2 Coffe Roasting

Coffee roasting was carried out using a coffee roasting machine type KEMS 1 (Figure 1), applying three roast levels: light, medium, and dark at temperatures of 190 ^{0}C, 200 ^{0}C, and 220 ^{0}C with times of 5 min, 6 min, and 8 min, respectively.

2.3 Coffee Grinding

This method is considered practical and has been widely adopted because of its accessibility and straightforward implementation. Roasted coffee beans were ground using a Mahlkonig EK43 grinder

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(Figure 2) to achieve a consistent particle size. Before grinding, the beans were placed into the hopper, and the desired grind level was adjusted using the control panel of the machine. A medium-fine grind size was selected for this study.

Figure 1. Coffee Roasting Machine

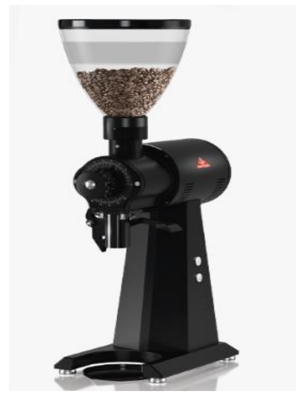

Figure 2. Coffee Grinding Machine

2.4 Coffee Brewing

Three manual brewing methods (AeroPress, Siphon, and V60) were undertaken by using the appliances shown in Figure 3.

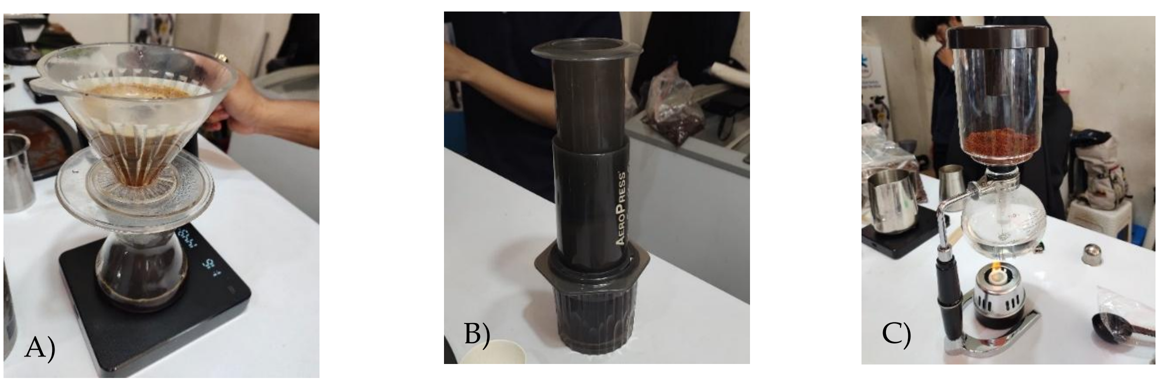

Figure 3. Manual Brewing Methods A) V60, B) Siphon, C) Aeropress.

The V60 method was performed through the dripping method, where the brewed water drips into the provided server. For the serving process, ingredients such as 15 g of medium fine coffee, one sheet of V60 filter paper, and 270 ml of water at a temperature of 95°C were prepared. The first step involved grinding 15 g of coffee, followed by heating the water to 95 °C. Next, the filter paper was moistened with hot water (flushing), and the flushed water was discarded. Next, the coffee powder is placed on the filter paper, flattened in the dripper, and hot water is poured slowly in a clockwise motion, avoiding the side of the dripper.

The siphon brewing method was performed by ensuring that the top and bottom tubes and the filter were clean. Furthermore, the siphon device is arranged properly, and the rubber seal between the two tubes must be ensured to be in good condition. Coffee was prepared with 15 grams of coffee and 270 ml of water, and the water was heated to a temperature of 95°C. The ground coffee powder was placed in the top tube of the siphon device with a medium fine grind size. The siphon device is then placed above the heat source, so that the hot water can rise to the top tube and mix with the coffee powder. After the brewing process was complete, the heat source was turned off, and the coffee was stirred using a wooden spoon to mix well before filtering. A paper filter was placed in the upper tube to separate the coffee grounds from the water, and gentle pressure was applied to enhance the filtration process.

The Aeropress method begins by placing a paper filter (Aeropress® Micro Filter) into the device, followed by the addition of 15 grams of medium-fine ground coffee and 270 ml of water. The water was heated to 95°C and then poured into the Aeropress tube to allow the blooming process to occur for a few seconds. Subsequently, the coffee was stirred using a spatula to ensure even extraction. Once the brewing process is complete, the top of the Aeropress is attached, and the coffee is allowed to infuse for a few moments before being gently pressed down, allowing the coffee to flow into the serving glass.

2.5 Total Dissolved Solids

Total Dissolved Solids (TDS) in coffee refer to the number of solids dissolved in water during the extraction process. The total dissolved solids (TDS) in coffee were measured using an Atago PAL-Coffee refractometer.

2.6 Caffeine

The caffeine content in coffee refers to the amount of caffeine ($C_8H_{10}N_4O_2$) present in coffee beans or brewed coffee per unit volume or weight. The iodometric back titration method (AOAC 960.25) was used for testing.

2.7 Acidity

Coffee acidity refers to the total amount of acidic compounds in coffee beans, both organic and inorganic. The acidity test method used in this study was the acidity method (SNI 3719:2014).

$$Acidity\ (\%) = \frac{V \times P \times M \times 100\%}{w} \tag{1}$$

Where: V: Volume of NaOH 0,1 M (mL), P: Conversion factor, M: Molarity of NaOH (M), w: Sample weight (g).

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2.8 Analysis of Coffee Sensory

In this study, five expert panelists, according to the Specialty Coffee Association (SCA) protocol, rated the coffee samples using a structured hedonic scale, focusing on key sensory attributes, including aroma, flavor, sweetness, body, aftertaste, acidity, and overall impression. The criteria for expert panelists were in-depth knowledge of coffee, practical experience in cupping, trained sensory skills, consistency in assessment, and good oral and nasal health. Each panelist was a certified Q-grader accredited by the Specialty Coffee Association (SCA), indicating verified competence in evaluating coffee quality.

2.9 Data Processing and Analysis Methods

The experiment was conducted using a factorial arrangement within a Randomized Complete Block Design (RCBD), involving two treatment factors. The first factor was the roasting level (light, medium, and dark), and the second was the manual brewing method (Aeropress, siphon, and V60). The blocking factor was the coffee variety (Arabica and Robusta), which was used to control the variation due to the inherent differences between the two types. A two-way analysis of variance (ANOVA) was performed using R software based on the factorial RCBD structure to determine the significance of the main effects (roasting and brewing methods) and their interaction on each measured parameter. The blocking effect of coffee variety was considered in the model but not tested as a treatment factor. Biplot analysis was performed using Minitab 17 software. In the biplot graph, each mixture attribute has a vector direction that is in the same direction as or not in the same direction as the object of research. The direction of the attribute vector in the direction of the object indicates that the attribute is a variable that is close to the object under study (proximity). Objects whose positions are close together show the same or similar characteristics. Biplot analysis was conducted using data that included sensory and chemical content variables. Because these variables have different units and scales, all data were first standardized using Z-score normalization to ensure comparability and avoid scale bias in the principal component analysis. This transformation converts all variables to a common scale with a mean of zero and a standard deviation of one.

The Compromise Programming (CP) method was used as a decision-making method by minimizing deviations from the ideal point. The criteria used to determine the optimum coffee taste were aroma, flavor, acidity, body, sweetness, aftertaste, and overall impression. All of these data were ensured to have the same scale by normalizing using the min-max normalization method.

3. Results and Discussion

3.1 The Effect of Roasting and Brewing Methods on Chemical Properties of Brewed Coffee

Table 1 shows the chemical test results of the brewed coffee based on variations in the coffee type, roast level, and brewing method.

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Table 1. Descriptive table of TDS, caffeine, and acidity values

Group	Treatment		Code	Mean ± SD		
	Roasting	Brewing		TDS (%)	Caffeine (mg/ml)	Acidity (%)
Arabica	Light Roast	V60	ALV	2,40 ± 0,00	1,29 ± 0,01	0,21 ± 0,01
	Medium Roast	V60	AMV	1,95 ± 0,07	1,24 ± 0,00	0,17 ± 0,01
	Dark Roast	V60	ADV	2,60 ± 0,00	1,22 ± 0,01	0,18 ± 0,01
	Light Roast	Aeropress	ALA	1,85 ± 0,07	1,29 ± 0,01	0,13 ± 0,01
	Medium Roast	Aeropress	AMA	1,90 ± 0,00	1,24 ± 0,00	0,14 ± 0,01
	Dark Roast	Aeropress	ADA	2,00 ± 0,00	1,22 ± 0,01	0,12 ± 0,01
	Light Roast	Siphon	ALS	1,90 ± 0,00	1,29 ± 0,01	0,16 ± 0,01
	Medium Roast	Siphon	AMS	1,70 ± 0,14	1,24 ± 0,00	0,16 ± 0,01
	Dark Roast	Siphon	ADS	1,90 ± 0,00	1,22 ± 0,01	0,14 ± 0,01
Robusta	Light Roast	V60	RLV	2,50 ± 0,00	1,41 ± 0,01	0,18 ± 0,01
	Medium Roast	V60	RMV	2,40 ± 0,14	1,38 ± 0,01	0,19 ± 0,01
	Dark Roast	V60	RDV	2,85 ± 0,07	1,32 ± 0,01	0,18 ± 0,01
	Light Roast	Aeropress	RLA	1,95 ± 0,07	1,41 ± 0,01	0,13 ± 0,01
	Medium Roast	Aeropress	RMA	1,80 ± 0,00	1,38 ± 0,01	0,14 ± 0,01
	Dark Roast	Aeropress	RDA	2,10 ± 0,00	1,32 ± 0,01	0,13 ± 0,01
	Light Roast	Siphon	RLS	1,70 ± 0,00	1,41 ± 0,01	0,12 ± 0,01
	Medium Roast	Siphon	RMS	1,70 ± 0,00	1,38 ± 0,01	0,13 ± 0,01
	Dark Roast	Siphon	RDS	1,80 ± 0,00	1,32 ± 0,01	0,15 ± 0,01

The chemical parameters analyzed included total dissolved solids (TDS), caffeine, and acidity in coffee. The data aims to provide an overview of the effect of each treatment combination on the chemical characteristics of coffee from both roasting and brewing perspectives.

The highest TDS level was found in RLV coffee (2.50 ± 0.00), while AMS coffee had the lowest TDS level (1.70 ± 0.14). The results of the analysis of caffeine content in the RLV, RLA, and RLS coffee treatments (1.41 ± 0.01) showed the same mean value and standard deviation in all treatments, whereas the lowest caffeine content was in ADV, ADA, and ADS (1.22 ± 0.01). According to Bicho et al. (2013), robusta coffee has a higher caffeine content than arabica coffee. In addition, based on research conducted by Elfariyanti et al. (2020), the caffeine content in brewed Gayo coffee ranges from 1.09 mg/ml to 1.97 mg/ml.

The highest acidity was found in ALV coffee (0.21 ± 0.01). Simultaneously, the lowest acidity content was found in ADA and RLS coffee (0.12 ± 0.01). In the Siphon method, which uses high temperatures, the extraction of acid compounds can increase in both Arabica and Robusta coffee. The

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results of this study indicate that the effects of roasting and brewing methods can balance or even equalize the acid content between coffee types under certain conditions.

3.2 Total Dissolved Solids (TDS)

Total Dissolved Solids (TDS) in brewed coffee refer to the amount of solids dissolved in water during the extraction process. The mean and standard deviation of the total dissolved solids for the different roasting and brewing methods can be seen in Table 2.

Table 2. Tukey further tests results on TDS content in coffee (%).

Factor	Level	Mean
Roasting*Brewing	Dark Roast V60	2,73 ± 0,15[a]
	Light Roast V60	2,45 ± 0,58[ab]
	Medium Roast V60	2,18 ± 0,28[bc]
	Dark Roast Aeropress	2,05 ± 0,58[cd]
	Light Roast Aeropress	1,90 ± 0,08[cde]
	Medium Roast Aeropress	1,85 ± 0,58[de]
	Dark Roast Siphon	1,85 ± 0,58[de]
	Light Roast Siphon	1,80 ± 0,12[de]
	Medium Roast Siphon	1,70 ± 0,08[e]

Notes: Different letters in the Mean column indicate significant differences based on Tukey's further test at the 5% level ($p < 0.05$).

Statistical tests showed that roasting methods, brewing methods, and the interaction between roasting and brewing methods had a significant effect ($p<0.05$) on the total dissolved solids in coffee. The total dissolved solids of dark roast (2.21%) were higher than those of light roast (2.05%) and medium roast (1.91%). Dark roasting can cause more complex compounds (such as chlorogenic acid, which breaks down into simpler compounds) to dissolve in water during the brewing process, increasing the total dissolved solids value. The TDS content increases with increasing roasting temperature for both hot and cold brewed coffee, indicating that dark roasted coffee produces a higher TDS content (Rao et al., 2020).

In addition, the effect of the brewing method on the total dissolved solids of the V60 was 2.45% higher than that of the Aeropress (1.93%) and siphon (1.78%). This is consistent with the findings of Aziza et al. (2024), who showed that the V60 manual brewing method produces higher TDS values. This is due to the blooming process, in which all coffee grounds are submerged in hot water, contributing to an increase in the TDS values. The V60 method allows water to flow slowly through the coffee grounds for a longer time than the Aeropress and Siphon methods. The Aeropress method extracts coffee through rapid immersion, resulting in shorter extraction times; therefore, the total dissolved solids tend to be lower. The Siphon method has a long contact time, but often uses a cloth

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filter that filters out more particles; therefore, it tends to produce cleaner coffee with lower total dissolved solids.

3.3 Caffeine

Coffee is well known for its caffeine content, which contains xanthine alkaloid compounds and has a stimulant effect on the central nervous system. The mean and standard deviation of caffeine content for different roasting and brewing methods are shown in Table 3.

Table 3. Follow-up Tukey test results on caffeine content in coffee (mg/ml)

Roasting Factors	Mean ± SD
Light Roast	1,35 ± 0,06[a]
Medium Roast	1,31 ± 0,07[b]
Dark Roast	1,27 ± 0,05[c]

Notes: Different letters in the Mean column indicate significant differences based on Tukey's further test at the 5% level ($p < 0.05$).

Statistical tests showed that the roasting method had a significant effect ($p<0.05$) on the caffeine content. However, the brewing method and interaction between treatments had no significant effect ($p>0.05$) on caffeine content. Further analysis showed that light roast was significantly different from medium roast and dark roast, and medium roast was significantly different from dark roast. Light roast roasting still has a denser cell structure; therefore, it takes longer to extract optimally. This is in accordance with the study by Edvan et al. (2016), who found that light roast tends to produce higher caffeine values than medium and dark roasts.

This indicates that the roasting process at different temperatures affects the caffeine content (Zwicker et al., 2023). This is in accordance with research conducted by Lindsey et al. (2024), who showed that caffeine levels decrease as the roasting temperature increases. This occurs because of the sublimation process during roasting. This result is similar to that of Budiyanto et al. (2021), who showed that the caffeine content level decreased as the roasting temperature increased and due to the sublimation process during roasting.

3.4 Acidity

Statistical tests showed that the acidity of V60 was 0.18% higher than that of Siphon and Aeropress at 0.14% and 0.13%, respectively ($p<0.05$). Roasting and interaction between treatments had no effect ($p>0.05$). The mean and standard deviation of acidity for different roasting and brewing methods are shown in Table 4.

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Table 4. Tukey further test results on acidity content in coffee (%)

Brewing Factors	Mean ± SD
V60	0,18 ± 0,01[a]
Siphon	0,14 ± 0,02[b]
Aeropress	0,13 ± 0,01[b]

Notes: Different letters in the Mean column indicate significant differences based on Tukey's further test at the 5% level ($p < 0.05$).

The acidity of coffee is closely related to the organic acid compounds extracted during brewing. The higher the water temperature or the longer the brewing process, the greater the ability of water to extract the chemical content in coffee (Gloess et al., 2013; Zarwinda et al., 2018). The V60 method produces a higher acidity because it has the highest extraction rate, allowing the coffee grounds to be poured evenly at a certain temperature (Herawati et al., 2024).

The Aeropress and Siphon methods produced the same acidity as the V60 brewing method. Organic acids dissolve in water over a longer extraction time, while the Siphon and Aeropress have shorter contact times, resulting in lower acidity. In addition, several factors that affect the brewing process, such as grind size, extraction temperature, and extraction time, significantly affect the chemical characteristics of the resulting coffee brew (Cordoba et al., 2020; Stanek et al., 2021).

3.5 Biplot Analysis

Biplot analysis is a multivariate method that simultaneously presents plots of observations and variables in two dimensions (Leleury et al., 2015). The use of this analysis function to determine the proximity between the variables and the research object can provide better information about the relationship between variables and observations. In addition, biplot analysis can describe the results of the principal components with asymmetry because they represent the samples and independent variables in the study (Kuswardono, 2024).

Biplot analysis was conducted using data from 18 coffee brews, which included seven sensory variables: aroma, flavor, body, sweetness, acidity, aftertaste, and overall impression, and three chemical content variables: caffeine, acidity, and total dissolved solids (TDS). The resulting standardized data were used to perform principal component analysis (PCA), and the biplot is presented in Figure 4.

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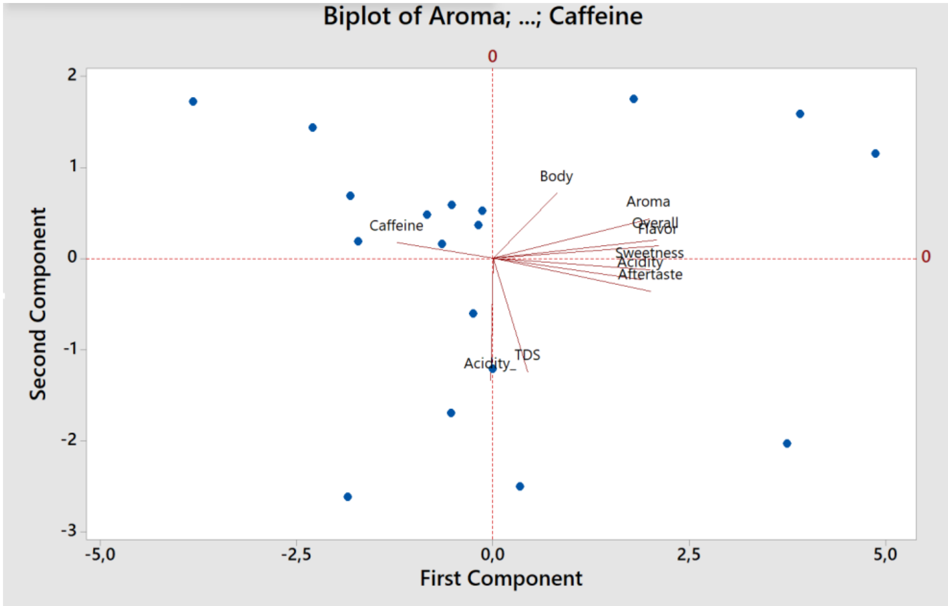

Figure 4. Biplot Analysis of Sensory and Chemical Variables of Coffee.

Figure 4 shows the closeness or similarity of the characteristics of the variables studied when viewed from the roasting and brewing methods. The first principal component (x-axis) on the horizontal axis explains the largest proportion of variation in the data, with a dominant contribution from sensory attributes such as body, aroma, overall, flavor, sweetness, acidity, and aftertaste in the positive direction, whereas caffeine is more associated with the negative direction. The second principal component (y-axis) on the vertical axis represents the second largest variation, where caffeine tends to be dominant in the positive direction, whereas chemical acidity and total dissolved solids (TDS) are more prominent in the negative direction.

Variables in the same quadrant can be said to have fairly close quality characteristics when compared with variables in different quadrants. Quadrant I includes the body, aroma, overall, and flavor. The relationships between body, aroma, overall, and flavor in coffee are interrelated in determining the coffee flavor profile.

Quadrant II contains caffeine, which is closely related to the flavor, texture, and quality of brewed coffee. Quadrant III components are acidity, whose content in coffee affects the taste of coffee when brewed. The components in quadrant IV, namely total dissolved solids, aftertaste, acidity, and sweetness, are interrelated in creating the overall taste of coffee. These four variables are important indicators of the coffee flavor.

Variables with a large diversity value are depicted as long vectors, whereas variables with a small diversity value are depicted as short vectors. The loading plot graph is shown in Figure 4. The graph shows diversity among the ten variables. Flavor and overall variables had the highest diversity among

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the other variables. This means that the criteria for flavor and overall in the 18 coffees varied. The aroma, sweetness, acidity, and aftertaste variables tend to have similar diversity because the vector length is almost the same as that of acidity and TDS. Meanwhile, the body had the lowest diversity among the other variables.

Objects located in the direction of the variable vector are said to have values above the average; otherwise, if the object is located opposite to the direction of the variable vector, then the object has a value below the average. An object that is almost in the middle means that the object has a value that is close to the average. The results of the Score Plot analysis between the variables and objects are presented in Figure 5.

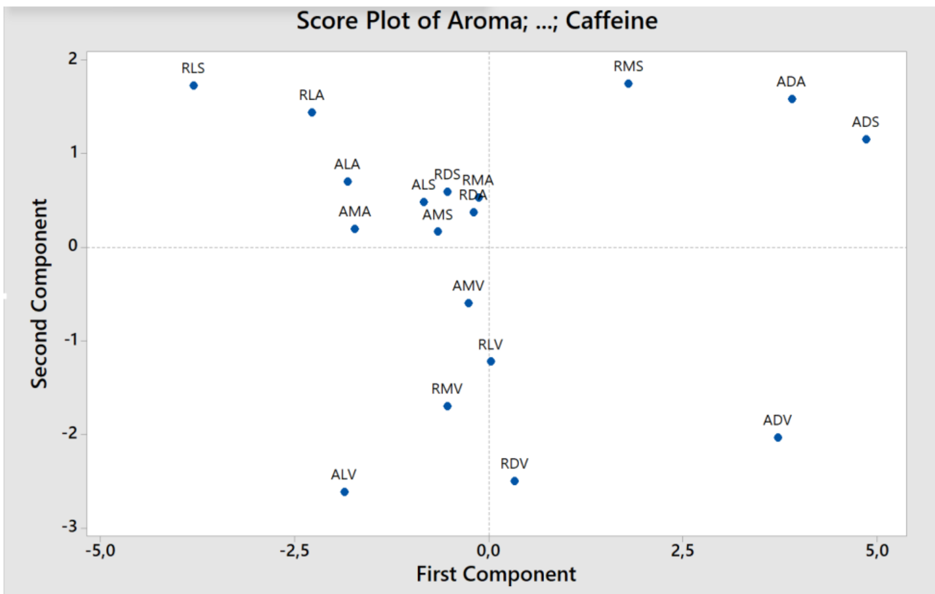

Figure 5. Results of score plot analysis between variables and objects

In the score plot, the first component (PC1) displayed on the horizontal axis explains the greatest variation. The second component (PC2) on the vertical axis represents additional variation. The Score Plot analysis showed that RLS and RLA had the highest caffeine values (above the mean), whereas RDV, RLV, and ADV in the opposite direction had lower values (below the mean). ADA, ADS, and RMS exhibited higher body, aroma, overall, and flavor values (above the mean).

3.6 Coffee Flavor Criteria Analysis

In this study, sensory evaluation was conducted to assess the overall flavor quality of coffee samples using the Compromise Programming (CP) method, which involves seven sensory attributes as the criteria. The weighting of the criteria was performed by a panel of trained assessors through pairwise comparisons. Each panelist compared the relative importance of the seven sensory attributes: flavor, aroma, sweetness, acidity, body, aftertaste, and overall impression. These pairwise

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comparisons were aggregated to produce the final weights for each criterion as follows: flavor (0.23), aroma (0.20), sweetness (0.15), acidity (0.14), body (0.14), aftertaste (0.08), and overall impression (0.06). These weights reflect the panelists' collective perception of the relative importance of each attribute in determining the overall coffee quality. The dominant weight assigned to flavor aligns with the findings of Fadhil et al. (2021), who emphasized that flavor is the most influential factor in consumer acceptance of brewed coffee.

The CP method ranks alternative treatments based on their Euclidean distance from an ideal solution. A smaller distance indicates that a particular treatment is closer to the ideal flavor profile as perceived by the panel and is thus considered more optimal. Conversely, a larger distance reflects a greater deviation from the ideal and is interpreted as less favorable. The final ranking of the treatments using this method is shown in Table 5.

Table 5. Comparison Using the Compromise Programming Method.

No	Treatment	Distance from the ideal point
1	RLS	0,06
2	ALV	0,11
3	ALA	0,11
4	AMA	0,11
5	AMS	0,15
6	AMV	0,16
7	RLA	0,16
8	ALS	0,16
9	RDS	0,18
10	RMV	0,19
11	RMA	0,19
12	RDA	0,19
13	RLV	0,20
14	RDV	0,20
15	RMS	0,29
16	ADV	0,32
17	ADA	0,37
18	ADS	0,39

Based on the compromise programming analysis, the RLS (Robusta-Light Roast-Siphon) treatment was identified as the most optimal, having the smallest Euclidean distance (0.06) to the ideal flavor profile. The distribution of sensory scores for each treatment is illustrated in Figure 6 using a radar chart.

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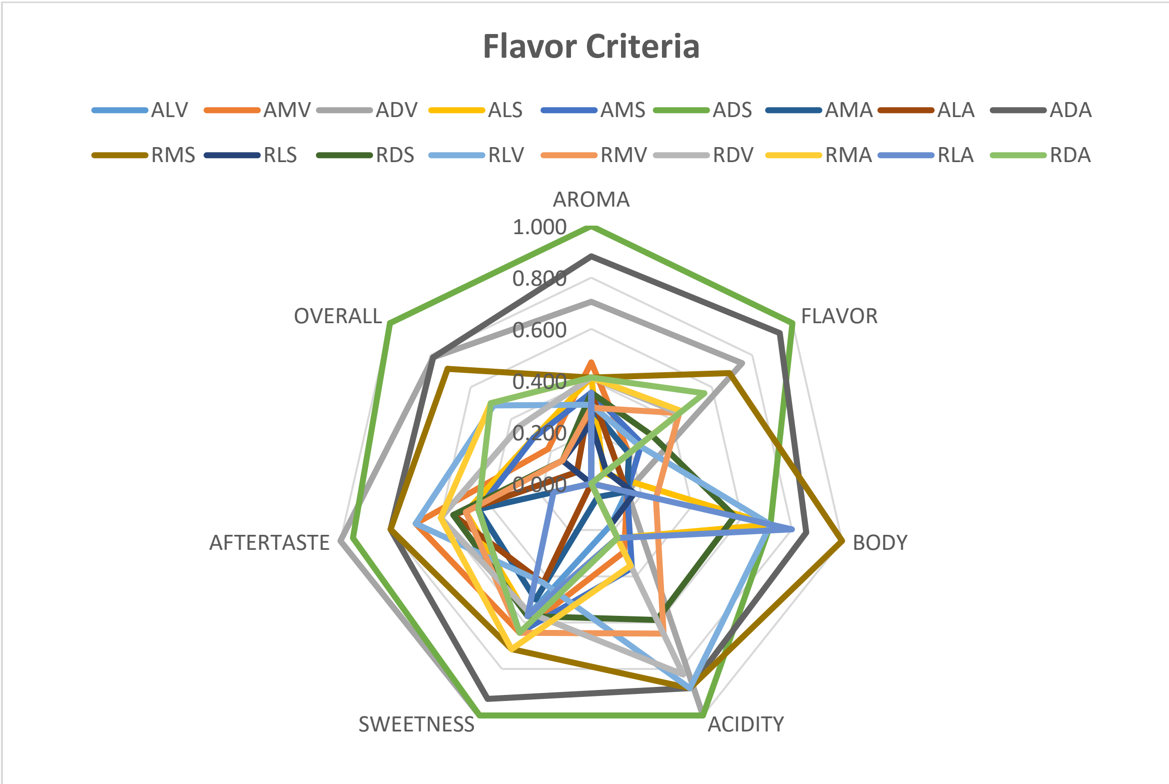

Figure 6. Flavor profile of robusta and arabica coffee in combination with the roasting and brewing methods.

The area of the radar chart visually reflects the cumulative performance of all sensory attributes. RLS exhibited the largest surface area among the treatments, indicating a balanced and high-rated flavor profile across multiple criteria. This result suggests that the combination of light roast Robusta and siphon brewing offers superior clarity and flavor balance, which is consistent with Simbolon (2024), who reported that siphon brewing enhances flavor clarity in brewed coffee.

Based on the results of the panelist preferences in Figure 6, each object can be compared based on the surface area of the radar chart. According to the panelists' preferences, RLS (Robusta-Light Roast-Siphon) ranked first, indicating that RLS was the most optimal overall. This indicates that this combination provides an excellent balance of taste (aroma, flavor, acidity, body, sweetness, aftertaste, and overall), which correlates with the clean, clear, and attractive visual appearance of the coffee. This is in accordance with Simbolon (2024), who found that the siphon method tends to produce coffee with better clarity. The same was also revealed by Febrianto et al. (2018) for the sour aftertaste attribute, where the Siphon method had the highest intensity. This is because the siphon method uses the principle of water vapor pressure, so chlorogenic acid gives a sour, bitter, and acidic taste to the coffee brew.

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Some categories of coffee with complex flavors are ALV (Arabica, Light Roast, V60), ALA (Arabica-Light roast-Aeropress), and AMA (Arabica-Medium roast-Aeropress) with respective Euclidean distance values to the ideal point of 0.11, which means that these methods provide a balance of complex flavors, such as aroma, acidity, and overall quite high. This is in accordance with Manurung (2025), who showed that the Aeropress brewing method is very suitable for Arabica coffee.

Meanwhile, coffees with suboptimal sensory balance are ADS (Arabica-Dark Roast-Siphon), ADA (Arabica-Dark Roast-Aeropress), and ADV (Arabica-Dark Roast-V60), with Euclidean values of 0.39, 0.37, and 0.32, respectively, which are ranked last. This combination shows suboptimal results because overly dark roasting reduces the flavor, aroma, and sweetness, resulting in a flat taste that is not suitable for combining with these three manual brewing methods. Arabica coffee with a light or medium roast tends to be more flexible when combined with manual brewing methods. However, dark roasting tends to produce suboptimal sensory performance and is not recommended for combination with these three manual brewing methods. Different manual coffee brewing methods affect the sensory profile of brewed coffee (Sunarharum et al., 2020). The three brewing methods have their own extractions, which affect the quality of the resulting brew. This is consistent with the findings of Lapčíková et al. (2023), which indicate that the choice of extraction method influences the antioxidant activity and aroma profile of the final coffee brew.

4. Conclusion

The dark roast roasting method significantly increased the TDS, whereas the light roast roasting method significantly increased the caffeine content. The V60 brewing method produced significantly higher coffee acidity than the Aeropress and Siphon brewing methods. The results of the compromise programming analysis show that, based on Robusta coffee consumer (RLS) preferences, light roast and the siphon brewing method produce the best coffee flavor. This combination balances the flavors (aroma, flavor, acidity, body, sweetness, aftertaste, and overall). Arabica (ALV, ALA, AMA) has greater flexibility with light or medium roasts and Aeropress and V60 brewing methods. However, Arabica (ADS, ADA, ADV) is not recommended for dark roasting and the three brewing methods because it produces less than optimal sensory performance in terms of coffee flavor.

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