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Physiochemical Properties and Cupping Quality of Gayo Espresso Coffee Based on Blending Ratio and Roasting Techniques

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***Abstract*— Espresso is considered the finest brewing technique to provide coffee's optimum sensory and physiochemical quality. The quality of the Espresso is influenced by many factors, such as bean varieties and origin, roasting process, and blending formation. This research investigated the effect of the blending ratio of two varieties (70:30; 80:20; 90:10 of Arabica and Robusta) of the coffee blend from Gayo Highland Aceh Indonesia, and roasting techniques (conventional and torrefacto) on physiochemical and cupping quality of Gayo espresso. Coffee cupping quality assesses ten coffee sensory attributes based on SCAA cupping test procedures. Physiochemical characteristics refer to pH, total dissolved solids, phenolic contents, and antioxidant activity of Espresso. The research applied a completely factorial randomized design. The research stages were roasting, blending, grinding, and brewing the Espresso. The results showed that both factors blending ratio and roasting techniques, had a significant effect (P≤0.01) on cupping quality (fragrance/aroma, flavor, aftertaste body, overall and balance attributes) and the physiochemical characteristics (pH, total dissolved solids, phenolic contents, and antioxidant activity) of Gayo espresso. The Torrefacto roasting technique, which refers to adding 11% sugar at the end of the roasting process, tends to provide Espresso with better cupping quality, higher pH, total solid particles, and antioxidant activity than the conventional roasting technique. On the other hand, Espresso, which had a blending ratio of 80:20 showed better cupping quality, whereas a blending ratio of 70:30 produced the Espresso with higher total phenol content and antioxidant activity than other ratios.**

***Keywords*—Espresso; cupping test; torrefacto; maillard reaction; sugar; Gayo Highland.**

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I. INTRODUCTION

Aceh province produces the largest Arabica coffee in Indonesia, Gayo Arabica coffee. Gayo coffee is the main contributor to Indonesian export commodities, which produced 126.289 tons in 2020, increased to 126,490 tons in 2021, and is estimated to 127,464 tons in 2022 [1]. This Gayo Arabica coffee was cultivated in three districts: Central Aceh, Gayo Luwes, and Bener Meriah [2]. Coffee has received some quality improvement activities as a pillar of the Gayo community's economy. Several Arabica coffee developments have been established since the 1970s, either through government programs by the Plantation Service or cooperation or collaboration with non-governmental institutions [3]. These programs mainly aimed to add the economic value of Gayo coffee and empower farmers' capability for diversifying coffee products. This development program covers the entire coffee production chain and improves the quality and processing of Gayo coffee. Local researchers have studied the impact of post-harvest, coffee processing, roasting and brewing, which local producers have applied locally towards the quality of Gayo coffee [4]–[6] as seen in Figure 1. Brewing could be used to diversify Gayo Arabica coffee consumption, especially Espresso [7], [8]. This coffee diversification is also an attempt to fulfill global demands as worldwide coffee consumption steadily increases over the decades [9].

Espresso coffee is a brewed beverage produced through the extraction of solid coffee grounds using high-pressure hot water [10]. It is made using 7-9 grams of ground coffee and 25-40 ml of hot water. Espresso coffee is generally used as the basis for coffee-based drinks [11]. The quality of the Espresso is mainly influenced by the coffee varieties, blending formulation, the size of grounded coffee, water temperature, and the coffee quality itself [12], [13].

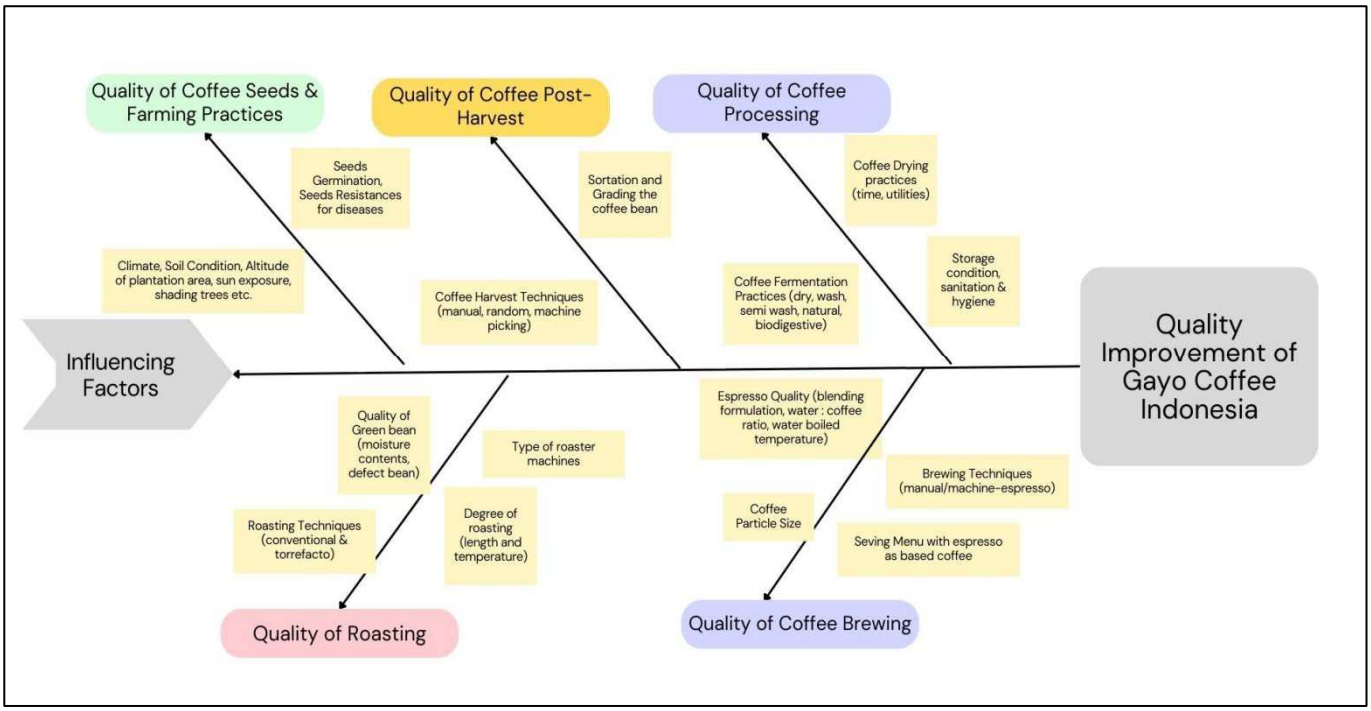

Fig. 1 Concept note of quality improvement of Gayo Coffee Indonesia

Coffee quality impacts most harvest handling and coffee processing [14], [15]. Coffee processing includes roasting, grinding, and brewing. Roasting is the thermal process of forming coffee's distinctive taste and aroma from green beans[16]. Coffee roasting is generally done using conventional roasting and torrefacto roasting. Conventional roasting is a technique commonly used with direct contact with heat and coffee beans [17].

In contrast, the torrefacto roasting technique is a roasting technique with the addition of 11% sugar carried out at the end of roasting. According to Wei and Tanukora [18], this roasting can cover the defects in coffee beans and improve the taste of its brewed. Therefore, torrefacto roasting is generally carried out on Robusta coffee, which is reported to have a lower sensory quality than Arabica coffee.

Apart from roasting and other mentioned factors, blending formulation has significant impact for espresso quality[19]. Coffee blending is required to produce a coffee with good balance of sensory properties, especially for espresso coffee which is generally used as the basic material for other coffee-based drinks such as macchiato, cappuccino, latte, and others [11], [20]. Arabica coffee is known for its distinctive flavor but has a lighter body than Robusta coffee. Robusta coffee increases the extraction value in blended coffee and filters out the sour taste. On the other hand, since Arabica coffee is slightly acidic, this variety enables to reduce the bitter taste and increase the aroma produced [21], [22]. Therefore, blending Arabica and Robusta is expected to generate more favorable and higher selling price coffee. Moreover, Espresso obtained from the blended Arabica and Robusta would produce a special cupping taste. Therefore, the material used for the coffee shop's flagship menu is espresso coffee, with Arabica coffee sizes ranging from 90% and Robusta coffee to 10% [20], [23].

Besides being a refreshing drink, coffee is also an antioxidant since it contains chlorogenic acids (CGA) [24]. Based on its varieties in the form of green beans, Robusta has higher chlorogenic acids of 7-8% of dry matter, and Arabica is commonly around 4-6 % [25]. Although Espresso is a well-known brewed coffee beverage, intensive reports related to Gayo Arabica and Robusta's blending formulation and the roasting techniques on espresso quality are not yet reported. Roasting is reported to have a huge impact on coffee quality, both its sensory and functional compounds, since CGA is heat-sensitive matter [26]. Therefore, this study explores the effects of blending formulation and roasting techniques on brewed Espresso's chemical, antioxidant, and sensory properties. These findings will be valuable information for Gayo coffee producers by obtaining the optimum treatment with favorable cupping quality and health benefits.

II. Materials and Method

A. Materials

This study used Arabica and Robusta green beans obtained from collectors in Central Aceh Regency. Cultivar of Arabica was *timtim* or *catimor* and cultivar of Robusta was *kopi geste*. Both cultivars were locally cultivated in Central Aceh Gayo Highland, Indonesia, in 1200-1300 *m.a.s.l*. The chemicals used include DPPH reagent, methanol, Na_2CO_3, Folin *Ciocalteau* solution, gallic acid, and distilled water. The green bean is roasted for sensory analysis based on SCAA cupping protocols.

B. Experimental Design

This study applied a completely factorial randomized design with two factors as experimental work. The first factor is the roasting technique, which consists of 2 levels: conventional roasting (P1) and torrefacto (P2). The second factor is the blending ratio of Arabica and Robusta coffee grounds which consists of 3 (three) levels, namely the ratio of

Arabica and Robusta, 70:30 (B1), 80:20 (B2), 90:10 (B3), as the treatments combined and replicated three times so that 18 experimental units were obtained.

1) Coffee Roasting Procedure: The green beans were previously sorted and cleaned from foreign materials and defects based on SNI 2907-2008. Then both Arabica and Robusta are weighed ± 3kg and roasted separately. The roasting process was carried out using an Italian *Didacta* TA143D roaster machine, referring to the Wei and Tanukora [18] procedures with minor modifications. The process begins with starting the engine, and the temperature is set to 190ºC for roasting at medium degrees. When the temperature reached 125º C, each green bean (Arabica and Robusta) entered the roaster chambers separately. The roasting was done for 20 minutes, with different steps for each technique. Conventional roasting took 20 minutes on the roaster. Then, the roasted beans were cooled by airing them for 5 minutes until the bean temperature was down to 45^0C. The following step was storing the beans in an airtight container before grinding. For torrefacto roasting, the beans were out after 10 minutes in the roaster machine. Next, half-roasted beans were moved to a large wide aluminum pan and manually roasted on medium heat. During roasting, the 11% sugar was added (based on the weight of ingredients after roasting) continuously while stirring well for 10 minutes. Then the roasted beans were cooled by airing the bean for 5 minutes until the bean temperature was down to 45^0C and stored in an airtight conditioner. The research procedure sequences can be seen in Figure 2.

2) Coffee Grinding and Blending Procedure: The grinding and blending process was carried out 30-60 minutes before brewing, referring to SCAA with slight modification[27]. First, each coffee variety is weighed and placed onto a similar jar based on experimental design (70:30%, 80:20%, 90:10%). Next, the mix-roasted coffee bean is ground. Both varieties were grounded using a 60 mesh (fine grounds) *Didacta* Italian grinder type TA417D to blend the coffee powder. Then it is stored in airtight containers at room temperature and ready to be brewed.

3) Espresso Brewing Procedure: The brewing process was carried out using the Italian *Didacta* Espresso Maker machine type TA421D, referring to the Angeloni et al. [20] procedures with minor modifications. First, the process starts with starting the engine. The engine was left on until the pressure reached 18-20 atm and the brewing water temperature reached 90ºC. Furthermore, 8 g of coffee powder was filled into the filter holder and compacted with a portafilter. Then the filter holder was inserted into the coffee brewing section. Next, put a glass to hold the espresso coffee. Then the hand lever is pulled to press the espresso coffee powder with a pressure of 8-9 atm. The procedure was repeated for each treatment.

C. Physicochemical characterization

The physiochemical analyses carried out were the analysis of the acidity level of Espresso (pH) using a pH meter, analysis of total dissolved solids using a hand refractometer [24], analysis of total phenol using the *Folin-Cioucalteau* method, and antioxidant activity using the DPPH method [28], [29].

D. Sensory Evaluation

The cupping quality of Espresso referred to Arabica cupping test protocols [27]. This assumption is made since the Arabica percentage is higher in blending ratio than Robusta. Three certified professional Q-graders from Gayo Cupper Team – Indonesia carried out the description test. The sensory analysis carried out was a descriptive analysis of fragrance/aroma, flavor, aftertaste, acidity, body, balance, sweetness, uniformity, clean cup, and overall Espresso. The analysis used a 6 to 10 descriptive scale with 0.25 intervals with descriptions 6.00- 6.75 (good), 7.00-7.75 (very good), 8.00-8.75 (excellent), and 9.00-9.75 (outstanding). All attribute scores were summats a cupping test score [27], [30]. The cupping test score is classified as mentioned in Table 1.

TABLE I
SCAA TOTAL SCORE QUALITY CLASSIFICATION

Range of Score	Description	Quality Classification
90-100	Outstanding	Specialty
85.0 – 98.99	Excellent	
80 – 84.99	Very Good	
< 80.0	Below Specialty Quality	Not Specialty

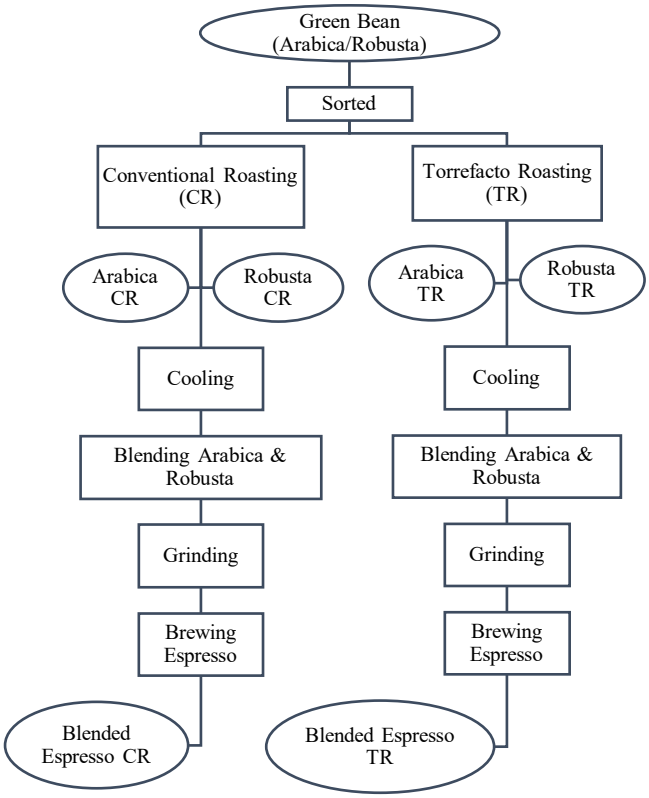

Fig. 2 Research procedure

E. Statistical Analysis

The obtained data were statistically analyzed with ANOVA. Further analysis is done with Least Significant Differences chemical characteristics and Duncan Multiple Range Test (DMRT) if any significant influence is reported. The statistical methods were done with SPSS 20 and Microsoft Excel.

III. Results and Discussions

A. pH of Espresso

Based on the measurement, the pH of Gayo espresso was between 5.82-5.88, with an average value of 5.85. ANOVA of pH value of espresso coffee showed that both the roasting technique (P) and blending ratio of Arabica and Robusta has a very significant effect (P≤0.01) on the pH of Gayo espresso. However, the interaction between the independent factors (BP) had no significant effect (P>0.05) on the pH of Espresso. The effect of the roasting technique (P) and ground powder (B) blending ratio on the pH value of Espresso can be seen in Figures 3 and 4.

Figure 3 shows that the pH value of Espresso from beans roasted with conventional roasting techniques was significantly different from Espresso of torrefacto. Torrefacto produced espresso coffee with the lowest or more acid pH value of 5.83 than conventional roasting, with a higher pH of 5.88. Roasting techniques are considered one of the influencing factors of acidity in the coffee brew.

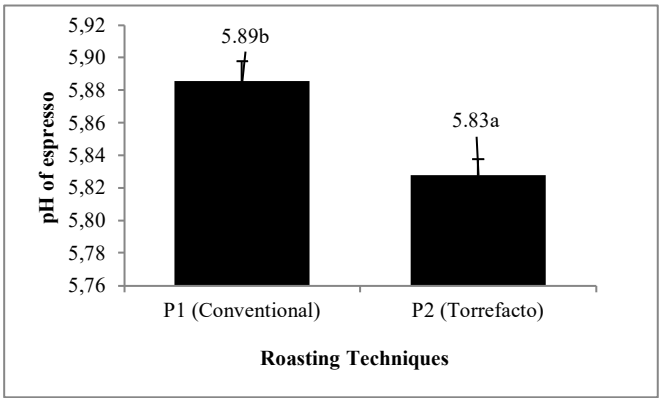

Fig. 3 Effect of roasting techniques on pH espresso (KK = 0.08%, LSD0.05 = 0.029). Value followed by a similar alphabet shows any significant differences. An error bar represents the standard deviation (n= 18)

Previous studies have reported higher pH values of the brew as the roasting degree and temperature increase [24], [31]. In torrefacto roasting, the added sugar during the last minute of roasting increases mono-saccharide compounds that are decomposed during the roasting process, resulting in more aroma compounds and aliphatic acids such as formic acid, acetic acid, gallic acid, and glycolic acid than conventional [18]. These acids will decompose at a roasting temperature of 160°C-175°C, and the pH tends to increase toward a neutral pH value as the roasting process finishes [32]. The addition of sucrose might influence the higher number of acid compounds produced during roasting and lower the acidity degree of Espresso brewed from the bean of torrefacto roasting [33].

Figure 4 shows that the pH value of Espresso brewed from blended bean 70:30 Arabica Robusta (B1) is higher and significantly different from Espresso from 2 other treatments, which a pH of 5.89. Moreover, the blending ratio of Arabica and Robusta 80:20 (B2) and 90:10 (B3) produced Espresso, which is insignificantly different, where both treatments have pH values of 5.85 and 5.82, respectively. Blended coffee, which has a higher ratio of Arabica, tends to have an espresso with lower pH. This might be caused by Arabica's condition, which has an average pH of 5.47 while pH Robusta is 5.01 [34].

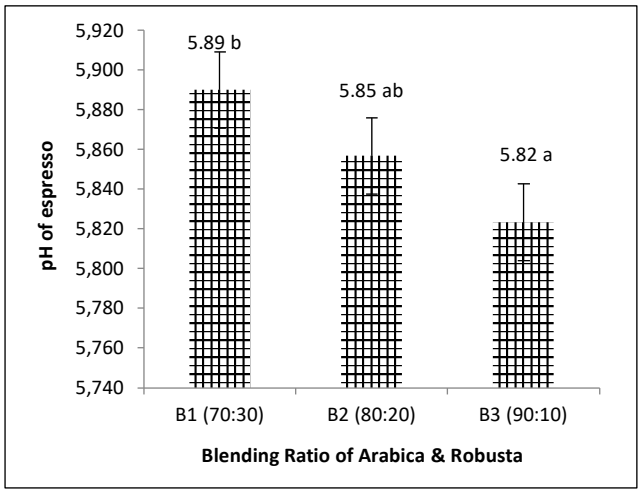

Fig. 4 Effect of Arabica & Robusta blending ratio on pH espresso (KK 0.08%, LSD0.05 = 0.04). Value followed by a similar alphabet shows any significant differences. An error bar represents the standard deviation (n = 18)

The lower pH of Arabica is the result of growing conditions as well as the coffee processing. Arabica grows well in highlands, around 1.000 -1.500 *m.a.s.l* [35]. Higher altitude plantation area is reported to lead to a lower pH of brewed coffee [36]. Moreover, Gayo arabica coffee has gone through semi-wash processing. The microbial activity during 10-12 hours of semi-wash coffee fermentation contributes to the accumulation numbers of lactic acid and acetic acid [37]. Brewed *gayo* Arabica coffee planted at.000-1.500 *m.a.s.l* has an average pH of 5.02 [38]. Coffee beans grown in the highlands contain higher acid compounds than coffee beans grown in the lowlands [39]. In addition, semi-wet processing has a higher acid content due to aliphatic acid residues produced during fermentation [4], [40]. Therefore, brewing espresso coffee with a blending ratio of 90:10 has the lowest pH content because the acid content in Arabica coffee is higher.

B. Total Dissolved Solids

Gayo espresso's total dissolved solids (TDS) range from 4.20°Brix to 7.40°Brix with an average TDS of 5.74°Brix. ANOVA shows that both factors of roasting techniques (P) and blending ratio of Arabica and Robusta (B) and their interaction (BP) have a very significant effect (P≤0.01) on the TDS of Gayo espresso, as can be seen in Figure 5.

Figure 5 shows that Espresso from beans from conventional roasting has lower TDS than other treatments for all three blending ratio treatments, respectively B1P1, B2P1, and B3P1. These three treatments are insignificantly different. Meanwhile, the highest Espresso TDS is obtained in Espresso of conventional roasting with a blending ratio of 90:10 (B3P2), which is 7.27°Brix. Compared to other treatments, B3P2 is very significantly different. As can be seen in Figure 3, torrefacto roasting produced Espresso with higher TSD. This might result from adding 11% sugar at the end of the roasting process. Generally, sucrose is reported to disintegrate rapidly in the early stages of roasting and is degraded to various aliphatic acids. However, since sucrose is intentionally added in

torrefacto, sugar decomposition also occurs in the final stage of roasting [33]. This decomposition increased the water-soluble polysaccharides, making SD in Espresso of torrefacto roasted bean higher than conventional [18].

Moreover, Espresso is from a coffee blend with a higher percentage of Robusta, especially treatment B1 with 30% of Robusta have higher TSD and is statistically different from other blending ratio treatments in torrefacto roasting (B2P2 and B2P3). This is presumably because Robusta coffee contains soluble solids. Robusta coffee contains higher amounts of dissolved solids than Arabica coffee [31]. Therefore, Robusta coffee is preferable to be used in a higher percentage as the raw material of the instant coffee blending formation [35]. Therefore, Espresso brewed from blended beans with a higher percentage of Robusta and roasted in torrefacto techniques has a higher TDS value.

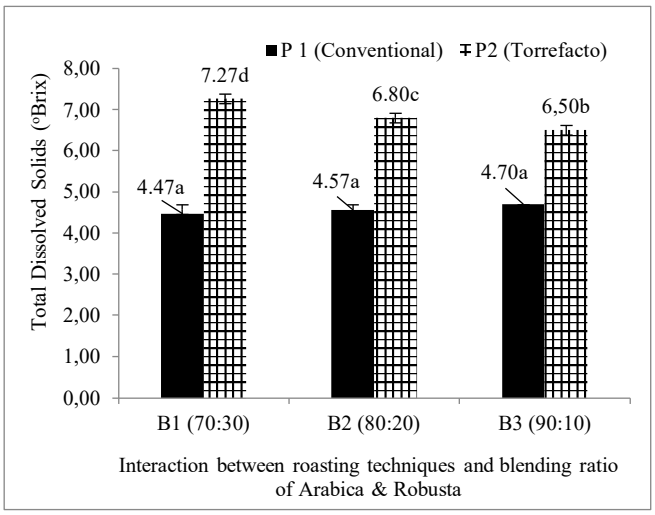

Fig. 5 Effect of interaction of the roasting techniques and blending ratio of Arabica and Robusta on total dissolved solids (KK = 2.78%), LSD0.05 = 0.28). Value followed by a similar alphabet shows any significant differences. An error bar represents the standard deviation (n = 18)

C. Total Phenol

Gayo espresso's total phenol varied from 99.00-124.00 mg GAE/ml, with an average score of 111,03 GAE/ml. ANOVA shows that only the factor of blending ratio of Arabica and Robusta has a significant effect (P≤0.01) on the total phenol of Espresso. On the other hand, roasting techniques and interaction between factors have statistical differences. In this study, torrefacto and conventional roasting processes showed any influence on the total phenol of produced Espresso. These findings agree with previous studies [41], [29], [42], where all studies do not find any contribution of torrefacto techniques on the phenolic compound of commercial or laboratory coffee blends. The total phenol of Espresso seems to be affected by other factors such as roasting degree, coffee varieties, and brewing methods [29], [43]. Therefore, the result of LSD on the effect of Arabica and Robusta blending ratio on total phenol is presented in Figure 6.

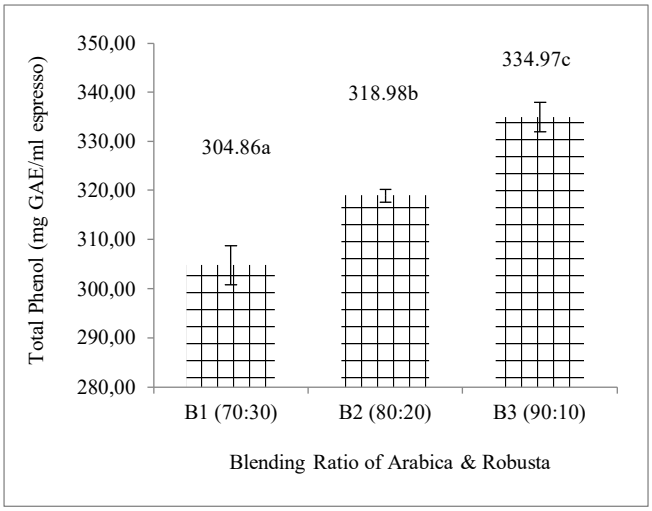

Fig. 6 Effect of blending ratio of Arabica & Robusta on total phenol of Espresso (KK = 0.30%, LSD0.05 = 7.46). Value followed by a similar alphabet shows any significant differences. An error bar represents the standard deviation (n = 18)

Figure 6 shows that the blending ratio of 70:30 (B1) Arabica and Robusta has a total phenol of 304.86 mg GAE/ml, lower than other treatment levels. However, the Espresso blending ratio of 90:10 Arabica and Robusta (B3) has the highest total phenols. Total phenols in coffee are commonly classified as chlorogenic and *quinic* acids [42], [44], [45]. CGA contents are reported lower after roasting in medium degrees since the bean has direct contact with heat. The C. Arabica has CGA around 1.7 to 3.5 g/100g, and for Robusta vary from 1.0 to 4.3 g/100g (dm) [26]. As beverage, a cup of has CGA around 1.3-3.8%, and Arabica has only 1.0-2.5% [46]. But since the total amount of phenol in brewed coffee depends on many factors, especially the brewing method, water temperature, and the size of the coffee grounds, it will affect the rate of substrate extraction in brewed liquids such as espresso [43], [47].

In this present study, the coffee was machine-made into Espresso. This study's total phenolic contained in Espresso is aligned with the previous result. Coffee infused by coffee machine has a range of 340-360 mg GAE/100 g coffee infusion of total phenol content. This range is lower than the total phenol of coffee infusion brewed by a percolator but higher than that of coffee brewed with filtered or unfiltered water at temperatures 90-100°C [43]. The phenolic content in this study is higher than the total phenol of commercial *gayo* coffee (Arabica and Robusta), which has an average of 129.06 mg GAE/100 g of coffee infusion. Even though previous study used torrefacto and conventional techniques for roasting, this commercial coffee was not blended, and the brewing methods were different [29]. Thus, it could be named the source of different values of total phenols.

Moreover, grounded Robusta coffee brewed by coffee machine has total phenol of 342.1 ± 13 mg GAE/100 g. This value is lower than the total phenol of 100% arabica brewed by a similar method, respectively 363± 28 mg GAE/100 g of infusion [43], [48]. Thus, it can be said that in coffee blends, where the portion of Arabica is higher, the total phenol may be higher, as presented in this study in the levels of B2 and B3.

D. Antioxidant Activity

The antioxidant activity of Espresso was evaluated by measurement of chain-breaking activity by DPPH. This analysis is sensitive and rapid and utilizes a small UV-Vis spectrophotometry sample [49]. DPPH (2,2-diphenyl-1-pikrilhidrazil) is a purple radical liquid solved in ethanol as polar organic solvents at room temperature. When DPPH interacts with anti-radical compounds, the color will turn yellow, and the inhibition process is counted as a percentage of inhibition or antioxidant activity. This percentage calculates how strongly active an antioxidant in the sample inhibits the free radicals, as a high percentage is noted as strong antioxidant activity [50]. The antioxidant activity of Espresso obtained from this present study varied between 33.71-78.37%, with an average value of 59.31%. The ANOVA shows that both independent factors and their interaction have a very significant effect ($P \leq 0.01$) on antioxidant activity. Figure 7 shows the effect of interaction on the antioxidant activity of Espresso.

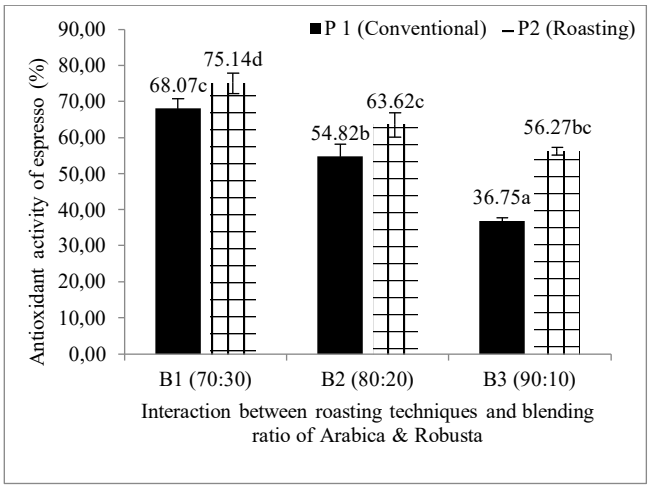

Fig. 7 Effect of interaction of the roasting techniques and blending ratio of Arabica & Robusta on the antioxidant activity of Espresso (KK = 0.80%, LSD0.05 = 5.11). Value followed by a similar alphabet shows any significant differences. An error bar represents the standard deviation (n = 18)

Figure 7 shows that B1P2, Espresso, which undergoes the torrefacto roasting and 70:30 blending ratio has the highest percentage of antioxidant activity and is significantly different from other treatments. Figure 5 also shows that the torrefacto roasting process produces Espresso with higher antioxidant activity than conventional roasting, similar torevios research [51]. This trend is aligned with the increased portion of Robusta in coffee blend formulation. Blending ratio B1 (70:30), which has a larger percentage of Robusta, tends to have higher antioxidant activity in Espresso than B2 and B3, which have less portion of Robusta. Even Arabica is reported to have higher total phenol, but the antioxidant activity of Espresso with a greater portion of Arabica tends to be lower [48], [52].

This finding is similar to the previous studies [42], [53]. The studies reported that torrefacto roasting and Robusta varieties produce brewed coffee with higher antioxidant activity measured by DPPH. This tendency is influenced by adding 11% sugar during the roasting process. The addition of sugar in torrefacto roasting mainly affects the Maillard reaction and the caramelization during roasting, which might contribute to the higher DPPH quenching activity, and leads to higher antioxidant activity in Espresso from torrefacto roasting [54]. Several authors mentioned that in antioxidant activity using DPPH, nonphenolic compounds such as melanoidin's, protein, and thiols produced during the Maillard reaction are also evaluated [25]. The maillard reaction produces brown compounds, such as melanoidin that show antioxidant activity [55], [56]. This condition makes torrefacto have higher antioxidant activity than conventional since phenolic compounds are susceptible to heat treatment such as roasting. On the other hand, adding sugar tends to support the maillard reaction and this condition tends to produce more acids compounds [57].

E. Cupping Quality

The sensory profile of Espresso is evaluated by following SCAA cupping procedure for arabica coffee with slight modification in the preparation stages. Instead of manual brewing, the drink was made by an espresso machine and blended coffee. Therefore, none of the obtained espressos is valued as specialty coffee since the cup-test scores are below 80. The cup-test scores of Espressos in this present study varied from 52.83 to 68.67 (described as below specialty quality). But researchers obtained the sensory profile of each treatment. The cup-test score in Table 2 shows that torrefacto roasting produced Espresso with better sensory properties than conventional since the cupping scores of espressos torrefacto roasted for all levels of blending ratio are higher. A coffee roaster in Italia introduced torrefacto roastings, the solution to cover the defects and mask the negative flavor of Robusta [58].

TABLE II
CUPPING TEST SCORES AND CUPPING NOTES FOR THE AROMA OF ESPRESSO

Treatments	Cup test score	Cupping notes for the aroma of Espresso
B1P1	55.33	bread, hay-like, roasted peanut, pipe tobacco, metalic, ashy, bitter, smoky, ruberry, low acidity, grassy and burn
B1P2	68.42	ruberry, salty, low acidity, sweet, dark caramel, harsh, toasted, bread, brun and astrigency like
B2P1	66.00	nutty, straw-like, astringency, dusty, harsh, low acidity, sweet, bright nutty, sugar cane, ashy and sweet potato
B2P2	68.67	astrygency, tasty, tobacco, bitter, low acidity, sweet, bright nutty, sugar cane, ashy and sweet potato
B3P1	52.83	astringency, medicine, ruberry, dusty, low acidity, soybean like, pipe-tobacco, metallic, hars, ashy, phenol, hay-like
B3P2	65.33	ruberry, bitter, sugar cane, malty, low acidity, tarty, sweet, metalic, strawy, and dusty

Then, Table 2 also shows that Espresso from torrefacto roasting is noted as sweet, dark caramel, toasted bread, sugar cane, malty and burnt. These aromas result from Maillard reactions and caramelization and are noticed as the distinctive sensory characteristics of torrefacto [15]. When sugar is added during roasting, the Maillard reaction produces more pyrazines, pyridines, and furans than conventional roasting. Torrefacto enables to keep coffee's essential oil and delays coffee staling [18], [55].

The other findings are the presence of nutty or bright nutty aroma in Espresso of blended ratio Arabica and Robusta

80:20 and 90:10. Nutty is a specific characteristic of coffee that undergo semi-wet processing and is roasted at a medium degree, such as Gayo coffee [59]. However, the remarks such as rubber, metallic, and low acidity also showed that Robusta in this present study has slightly low quality. These remarks were identified in Espresso from a blended ratio of 70:30, which has a greater percentage of Robusta than other treatments. Succinic acid is reported as responsible for formation of bitter, sour, and odorless brewed coffee [60]. Moreover, Batali et al. [61], Espresso as a hot brewed coffee tend to have less significant aroma and more bitter than cold brew.

Table 3 shows that torrefacto produces Espresso with better cupping quality. Roasting is formed and built-up specific coffee aroma, as well as coffee physical and chemical changes. When sugar is added during torrefacto roasting, it produces more volatile compounds such as pyrazines, pyridines, and more furans than in conventional roasting, forming a thin sugar film on the surface to provide oxidation [62]. Especially for Robusta, the addition of sugar is reported to reform different volatile compounds and superior cupping quality, such as flavour [58]. Sugar, as primary carbohydrate source is responsible for the formation of bitterness as part of the aftertaste in brewed coffee [32]. Therefore, fragrance, flavor, aftertaste, and overall scores of Espressos from torrefacto roasting are higher. Torrefacto produces coffee with a stronger aroma and flavor and tends to be more bitter, similar to this finding [18]. Overall, it is defined as the score given by the coffee grader as the overall opinion of the coffee judged based on his experience in cupping [30].

TABLE III
EFFECT OF ROASTING TECHNIQUES ON FRAGRANCE, FLAVOR, AFTERTASTE, OVERALL ESPRESSO BASED ON CUPPING TEST (N = 18)

Roasting techniques	Fragrance	Flavor	Aftertaste	Overall
P1 -Conventional	6.78±0.11	6.78±0.11	6.14±0.08	6.13±0.04
P2 - Torrefacto	7.03±0.15	7.03±0.15	6.72±0.08	6.56±0.06

6,00 – 6,75 (good); 7,00 – 7,75 (very good); 8,00 – 8,75 (excellent); 9,00 – 9,75 (outstanding)

In SCAA cupping protocols, ten sensory attributes of coffee are evaluated [27], [30]. Based on ANOVA, the factor of roasting techniques significantly influences ($P \leq 0.01$) fragrance, flavor, aftertaste, and overall, as seen in Table 3. The factor of blending ratio of Arabica and Robusta has a significant influence ($P \leq 0.01$) on five sensory attributes, as seen in Table 4. The interaction of both factors significantly influences ($P \leq 0.05$) the balance of obtained Espresso, as presented in Figure 7.

TABLE IV
EFFECT OF BLENDING RATIO ON THE ESPRESSO'S SENSORY ATTRIBUTES (N = 18)

Ratio Arabica & Robusta	Frag.	Flavor	Aftertaste	Body	Overall
B1 (70:30)	7.04±0.15	7.04±0.15	6,33±0,23	7.75±0.00	6.42±0.12
B2 (80:20)	7.21±0.09	7.21±0.09	6,71±0,21	7.25±0.00	6.38±0.15
B3 (90:10)	6.46±0.02	6.46±0.03	6,25±0,18	6.46±0.30	6.25±0.18

6,00 – 6,75 (good); 7,00 – 7,75 (very good); 8,00 – 8,75 (excellent); 9,00 – 9,75 (outstanding)

Espresso is commonly used as a based coffee-based beverage. Each barista is passionate about creating a distinguished espresso with a thicker body and less acidity but a high fragrance and flavor [63]. Espresso from this present study tends to have a higher score of fragrance, flavor, aftertaste, body, and overall if the portion of Robusta in the blending ratio is higher than 10%. Robusta coffee is reported to have a thicker body and distinguished bitterness. Therefore, B1 and B2 levels of ratio blending produce espresso with higher scores and a very good description. Blending Arabica and Robusta was reported to be produced. However, the presence of Arabica is crucial since Arabica mainly contributes to the fragrance and flavour of Espresso. The post-harvest techniques of Gayo arabica coffee, which is semi-wash, plays a crucial role in forming the sensory properties of the brew [24], [64].

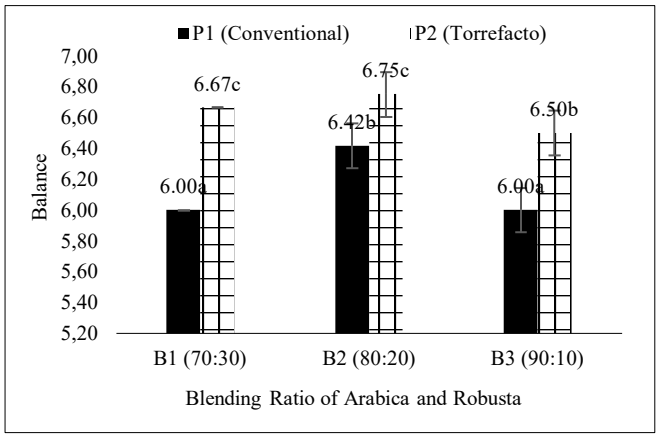

Fig. 8 Effect of interaction of the roasting techniques and blending ratio of Arabica & Robusta on the balance score of Espresso (KK = 0,22%, DMRT0,05 =0,0164). Value followed by a similar alphabet shows any significant differences. An error bar represents the standard deviation (n = 18).

Figure 8 shows that Espresso that undergoes torrefacto roasting has a higher score of balance, especially Espresso from blending ratio B1 and B2 levels, which have a larger percentage of Robusta than B3. Furthermore, as torrefacto can mask the negative flavor of Robusta, it increases its sensory quality. It produces a dark-brown color high in crema and has a better flavor than its brewed coffee. Therefore, as the balance is defined as an equilibrium of flavor, acidity, and aftertaste of coffee, torrefacto roasting seems to enable it to cover all the negative points and provide Espresso with better balance than conventional roasting [27], [30]. Furthermore, adding 20% robusta as a minimum percentage seems to produce Espresso with better balance attributes since, in coffee blending, Robusta is a source of the body and less acid for the coffee brew.

IV. CONCLUSION

Gayo espresso has the potential to be developed as a base for coffee-drink beverages. Both factors, ratio blending and roasting techniques, independently have a significant effect ($P \leq 0.01$) on sensory attributes (fragrance/aroma, flavor, aftertaste body, overall and balance attributes) as well as the physiochemical characteristics (pH, total dissolved solids, phenolic contents, and antioxidant activity) of Gayo espresso. Torrefacto is a roasting technique with sugar addition at the end of the process that tends to provide Espresso with better cupping quality, higher pH, total solid particle, and antioxidant activity than the conventional roasting technique.

On the other hand, Espresso with a blending ratio of 80:20 is stated to have better cupping quality. In contrast, a ratio of 70:30 considers Espresso with higher total phenol and antioxidant activity than different ratios. Therefore, a blending ratio of 80:20 of torrefacto roasted Arabica and Robusta should be an option to produce excellent quality Espresso.

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