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Various Roasting Characteristics Against Alteration of Antioxidant Activity, Amino Acids Content, and Flavor of Java Ijen-Raung Coffee Beans

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Abstract

The coffee roasting keys are temperature and time. Coffee beans have many chemical and physical reactions while the roasting is running. These reactions are characterized by a pattern in the drying and development phases during coffee roasting. This study discussed how roasting affected the characteristics of coffee beans, particularly antioxidant activity and amino acids, and also tried to define the roasting process by describing each roasting phase. The study discussed these characteristics of Java Ijen-Raung Arabica coffee, which has specialty coffee criteria. The roasting process can increase amino acids and antioxidant activity inside the coffee beans, but the excessive heat and longer duration of roasting can burn the amino acids. Based on this study, the highest antioxidant activity was found in beans that had been roasted with a total roasting time under 13 minutes, started with a temperature of 148 ^{0}C, and released at 190.5 ^{0}C. The beans that had been roasted with a total duration under 13 minutes, started with a temperature of 149 ^{0}C, and released at 184.8 ^{0}C is the best roasting degree with the highest score on the cup test.

Keywords: Amino acids, antioxidant activity, coffee flavor, Java Ijen-Raung Arabica coffee, roasting

INTRODUCTION

Coffee is one of the most commonly consumed beverages in the world. Indonesia is one of the coffee producers that have some famous specialty coffee. One of the prospected specialty coffee in Indonesia is Java Ijen-Raung Arabica coffee from Bondowoso. This Arabica coffee has a unique geographical indication. The coffee had been planted on the foothill of the Ijen mountains. The production chain had been established through the institutional apparatus at the farmer level to a cooperative processing unit before being sold to consumers (Permatasari *et al.*, 2018). The Java Ijen-Raung coffee could be developed as one of the specialty coffee in Indonesia with high quality and unique characteristics.

One thing that determines the quality and character of coffee is the roasting process. Many studies have observed the effect of roasting degree on antioxidant activity and amino acids with rigid roasting treatment. The rigid roasting treatment was expressed at constant roasting temperature for a period of time, however, in practice, the roasting temperature should be dynamic, not at constant temperatures.

This study observes the dynamics of changes in amino acids, phenolic content, antioxidant activity, and flavor caused by the roasting characteristics. The roasting characteristics are defined by the time and temperature in each roasting phase. There are two phases of roasting based on coffee beans' response to heating treatment: the drying and development phases. Each phase has some observation points to mark the bean's response to heating. The drying phase consists of charge or initial temperature, turning point, and dry end. The development phase consists of the first crack, second crack, and drop or release point (Rao, 2014).

Antioxidant activity in coffee was known to be high. Antioxidant activity detected in coffee has an advantage for nutraceuticals which is good for body metabolism. Coffee provides more significant total antioxidants than black tea and cocoa (Yashin *et al.*, 2013). Some specialty coffee from Indonesia, like beans from Wamena and Moanemani, has antioxidant activity of 61.71% and 69.07% in a solution concentration of 150 ppm (Mangiwa *et al.*, 2015).

Coffee also contains amino acids that are important for human metabolism. The digestive system absorbs the amino acids actively (Diana, 2009). Arnold *et al.* (1994) described 99.8% of the free amino acids detectable by extracting green coffee beans. Glutamic acid and aspartic acid were present in significant quantities, but alanine and serine were in lower amounts inside green coffee beans. Moreover, the amino acids in coffee beans are also key components since they are used as precursors of the Maillard reaction during roasting, in which color and aroma are formed (Murkovic & Derler, 2006). During the roasting, this reaction transformed protein, amino acids, and antioxidant properties, which ran optimally at temperatures between 140 ^{0}C and 170 ^{0}C (Del Castillo *et al.*, 2002).

The transformation of protein, amino acids, and antioxidants also generates various aroma and flavor characteristics. The transformation started after the coffee beans were immediately put into a hot drum roaster. The temperature of beans inside the drum roaster is raised, so the water content inside is decreased. The heating inside the drum roaster continued, followed by the bean's responses: first crack and second crack. In the first crack and second crack, glycosylamines and melanoidins were generated that contribute to coffee flavor (Rao, 2014). This study explores how different roasting characteristics influence and trigger those bean activities. Besides transformation in the appearance of the coffee bean, the difference in antioxidant activity, amino acids, and flavor was also observed.

MATERIALS AND METHODS

The coffee bean used in this research is Arabica coffee from Bondowoso, Indonesia, which has been processed with natural processes. Coffee sample preparation was made at the laboratory of Post Harvest Processing, Study Program of Agriculture Science, University of Jember, Jember, Indonesia. Antioxidant activity analysis of coffee beans was conducted at the Plant Analysis Laboratory, Study Program of Agronomy, University of Jember. Amino acid content analysis of coffee beans was conducted at Saraswanti Indo Genetech (SIG) Laboratory. Sensory analysis was done in Indonesian Coffee and Cocoa Research Institute, Jember, Indonesia.

Roasting and Observation Method

The drum roaster in this research was equipped with thermocouples and data loggers to measure and record the temperature and time duration of roasting. Every batch of roasting used a kilogram of beans. Six batches of roasting were done with different characteristics, as

shown in Table 1 and Table 2. The observation is focused on two roasting phases with six stages of observation points. Temperature and time of roasting at each point form a pattern, as shown in the graph of Figure 1. There are charge, turning point, dry end, first crack, second crack, and drop point. The event just before the green coffee bean was put in the roasting drum was the charge observation point, where the drum roaster temperature was maintained at high temperatures. After the green beans enter the drum, the drum temperature drops fast and rises again at the turning point.

The temperature slowly rises to a dry end observation point after dropping to the max at the turning point. This point indicates the Maillard reaction has started. The temperature of the dry end is set to 140 ^{0}C while the drying process has drastically decreased, and the Maillard reaction has started (Mulato, 2019; Pramudita *et al.*, 2017). The bean's volume has expanded during roasting and finally gets cracks called the first and second cracks. The first crack and second crack indicate the beans entered the development phase. The last observation point is the drop point, which is the time for finishing the roasting process and releasing roasted coffee beans.

Antioxidant Activities Analysis

The antioxidant activity is measured based on phenolic compounds contained in the coffee beans. Fifty grams of coffee beans from each roasting batch are ground into powdered form. The coffee powder is extracted with 70% ethanol for 48 hours. After filtration, each extract was concentrated to dryness under vacuum and washed with n-hexane. The washed MeOH extracts were used for the study. Antioxidant activity analysis was performed to determine total phenolic compounds following the method described by Gálvez *et al.* (2005). The concentration of total phenolic compounds in the MeOH extracts was determined spectrophotometrically using the ciocalteu's reagent. 100 µL of crude extracts and the standard, previously

Table 1. The characteristics of temperature and duration of some roasting method in the first comparison

Roasting degree	Roast I		Roast II		Roast III	
Observation point	Temperature (^{0}C)	Time (seconds)	Temperature (^{0}C)	Time (seconds)	Temperature (^{0}C)	Time (seconds)
Charge	153.8	0	149	0	155	0
Turning point	71	63	85	60	88	66
Dry end	140	289	140	301	140	268
First crack	-	-	185	407	178	311
Second crack	-	-	-	-	189	93
Drop	167	187	185	10	209	136
Total time (seconds)		539		778		874

Table 2. The characteristics of temperature and duration of some roasting methods in the second comparison

Roasting degree	Roast IV		Roast V		Roast VI	
Parameter	Temperature (^{0}C)	Time (seconds)	Temperature (^{0}C)	Time (seconds)	Temperature (^{0}C)	Time (seconds)
Charge	148.25	0	149	0	155	0
Turning point	78	57	85	60	87	60
Dry end	140	332	140	301	140	307
First crack	187	226	185	407	179	411
Second crack	-	-	-	-	-	-
Drop	191	12	185	10	180	137
Total time (seconds)		627		778		915

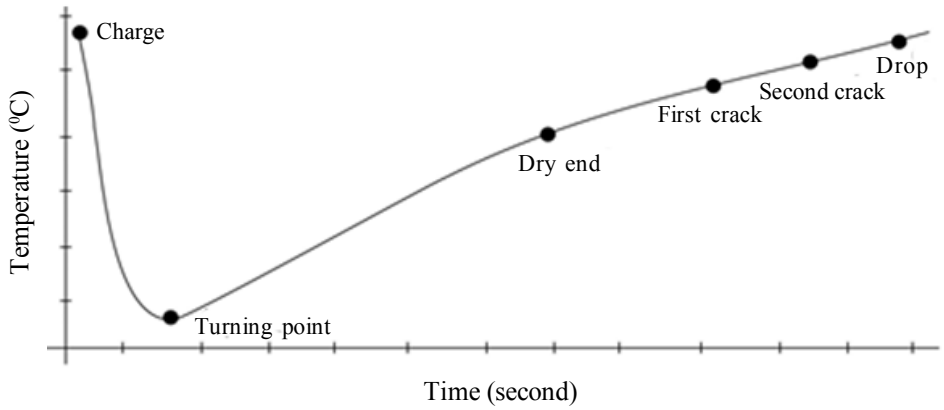

Figure 1. Observation point during roasting

dissolved in methanol, was diluted with water to 8 mL, 0.5 mL of FolinCiocalteu phenol reagent was added, and the flasks were shaken vigorously. After 8 min, 1.5 mL of 20% sodium carbonate solution was added, and the mixtures were mixed thoroughly again. The mixtures were allowed to stand for an hour protected from light. The absorbance of the blue color produced was measured with a spectrophotometer at 750 nm.

Extract of the phenolic compound is then used to determine antioxidant activity. The measurement of antioxidant activity is carried out by using DPPH (2,2-diphenyl-1-picrylhydrazyl) method to extract phenolic solutions obtained before. To measure antioxidant activity requires 10 µg GAE (gallic acid equivalent) of phenolic. The testing of antioxidant activity is conducted by measuring the scavenging of synthetic radicals in polar organic solvents. The DPPH solution with a concentration of 5 mMol dissolved in methanol. Supernatant from the sample extract was taken as much as 100 µL and then added to 100 µL of methanol and 800 µL of DPPH solution. The solution was then incubated for 20 minutes, and the absorbance was measured using a spectrophotometer. Each phenolic and antioxidant activity measurement was repeated three times to improve accuracy.

Amino Acids Analysis

Amino acids test used UPLC (ultra performance liquid chromatography) method. The instrument for doing the UPLC method is the acquity UPLC H-Class system. This instrument consists of sample injection, UPLC columns, and a detector. The stages for sample preparation until it becomes a solution ready to be analyzed can be seen in Figure 2. The measurement used UPLC C18 column, with gradient pump system, column temperature used was 49 ^{0}C, and the detection was performed using PDA detector. The calculation of amino acids used a ratio of analyte area with internal standard. The amino acid level (mg kg^{-1}) is calculated using Eq 1.

Amino acid level =

$$\frac{\frac{Rsa}{Rst} x \frac{C_{std}}{1000000} x\ BM\ x\ Va\ x\ Fp}{W_{spl}} \quad \text{..... (Eq 1)}$$

Where:

Rsa : Sample ratio
Rst : Standard ratio
C_{std} : Concentration of amino acid solution (pmol µL^{-1})
BM : Molecular weight of amino acids
Va : Final sample volume (µL)
Fp : Dilution factor
W_{spl} : Weight of sample (g)

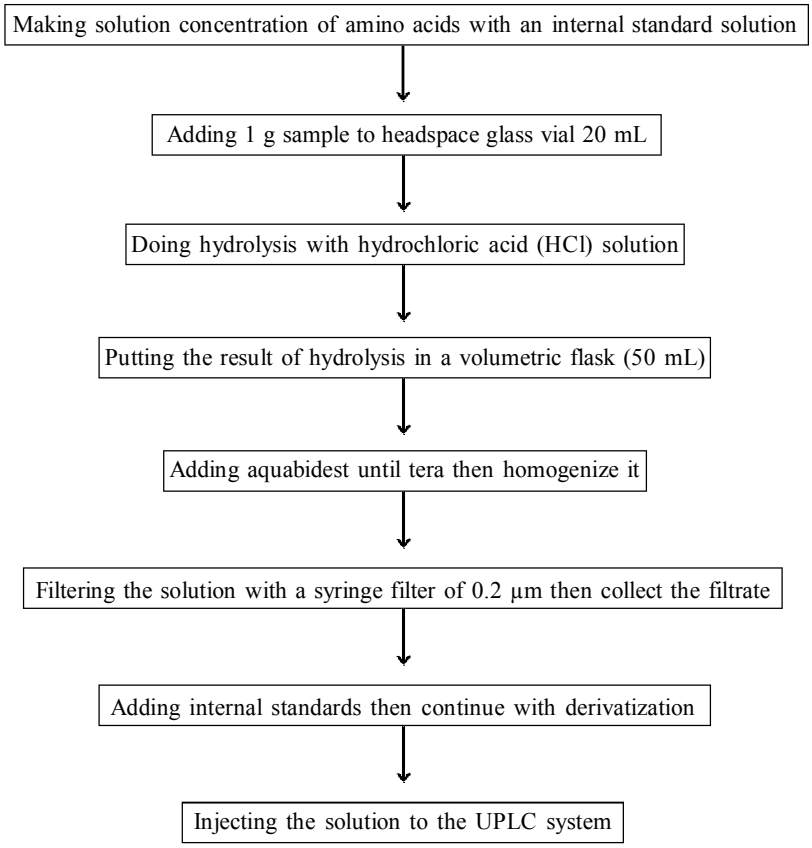

Figure 2. Working steps of amino acid analysis using the UPLC

The observation was focused on L-amino acids except for glycine since glycine is not a stereoisomer. The observation was also carried out on some essential and non-essential amino acids. The essential amino acids observed in this research are L-histidine, L-isoleucine, L-leucine, L-lysine, L-phenylalanine, L-threonine, and L-valine; thus, the non-essential amino acids are L-alanine, L-arginine, L-aspartic acid, L-glutamic acid, glycine, L-proline, L-serine, and L-tyrosine.

Cup Test Method

The organoleptic brewing assessment or cup test refers to the Specialty Coffee Association (SCA). Three trained panelists carried out the test. The parameters tested include aroma, flavor, body, acidity, aftertaste, sweetness, balance, uniformity, clean cup, overall, and final score (SCAA, 2015). The main characteristics of coffee are aroma and flavor. The aroma shows the first impression when sipping coffee. The flavor describes the dominant feeling in the middle of drinking coffee. The aftertaste represents how long the aroma and flavor last after drinking. Some coffee feels quite sour in taste, called acidity, and a little sugary, called sweetness. The body measures the viscosity or texture quality of the coffee. The harmony of flavor, aftertaste, acidity, and body is called balance. If there is no negative impression when drinking a coffee, it means the coffee has an excellent clean cup. Coffee also should have good flavor consistency, that is called

uniformity. The total value of each parameter is called the overall value.

RESULTS AND DISCUSSION

Roasting Observation

The roasting is implemented with two kinds of roasting observation. The first observation is to analyze the roasting degree at different drop temperatures. In this first comparison, there are three levels of roasting degree, namely Roast I, Roast II, and Roast III, with characteristics as shown in Table 1. The drum temperature at the drop point, the number of roasting phases was passed, and total roasting durations were set to increase from Roast I to Roast III. This difference aims to get different drop temperatures in each roasting degree. The roasting process for Roast I ended before the first crack, Roast II ended before the second crack, and Roast III ended after the second crack. The temperature of the dry end observation point is set to 140 ^{0}C based on the study of Mulato (2019), which states that the chemical reaction is started with the Maillard reaction at a temperature of about 140 ^{0}C then caramelization is started at a temperature of about 170 ^{0}C. It means the dry end is a crucial point of roasting since the flavor and aroma of coffee are started to establish at that point.

The second comparison focuses on analyzing the effect of roasting at relatively the same degree, but the roasting time completions are different. The second comparison was conducted in bean samples from Roast IV, Roast V, and Roast VI roasting treatments, with characteristics as shown in Table 2. Although Roast IV, Roast V, and Roast VI ended after the first crack and before the second crack, the total time roasting of those roasting degrees is different. Therefore the roasted beans produced from these three roasting degrees tend to have almost the same color level.

The easiest way to distinguish the roasting result is the coffee beans' color. The color of roasted beans is darker at the longer roasting time than at the shorter roasting time. The color comparison of coffee beans after roasting with various characteristics in Table 1 and Table 2 is shown in Figure 3. Roast III generates the darkest color compared to beans after roasting with Roast II and Roast III because the beans were dropped from the drum roaster after the second crack stage. Although the beans are released after the first crack, the bean's color after roasting with Roast IV, Roast V, and Roast VI have different color levels. It indicates that the roasting characteristics in each stage also influence the roasted beans besides the total roasting time.

Every phase in roasting has a specific mechanism. The heating process in the initial phase causes water and volatile content to evaporate. After that, pyrolysis occurs and causes complex chemical and physical reactions. In the next phase, evaporation is massive, and the coffee bean is darker due to caramelization. The longer the roasting time, the more the beans burn and the darker the bean's color (Rodrigues *et al.*, 2002).

Phenolic Content and Antioxidant Activity

The observation of phenolic content and antioxidant activity is divided into two parts, the first part focuses on comparing phenolic content and antioxidant activity between roasted beans from which different numbers of roasting stages have been passed, as shown in Figure 4(a) and Figure 5(a). The second part intends to compare between roasted beans from similar roasting phases and stages but have various total time completion and drop temperatures, as shown

Figure 3. Color comparison of coffee beans due to various roasting treatment

in Figure 4(b) and 5(b). The changes in the phenolic content of coffee beans are shown in the graph in Figure 4. The phenolic expressed in milligram gallic acid equivalent per gram (mg GAE g^{-1}). At the first observation, the phenolic tends to rise with higher roasting degrees but then decreases in Roast III. It means the roasting method with Roast II generates the highest phenolic content. Based on the graph in Figure 4(a), we can see growth of phenolic content in roasted beans but degraded in the darkest roasted beans. This result is similar to a study from Liao *et al.* (2022) where the amount of total phenolic contents is higher in roasted beans than in unroasted beans. However the phenolic content in those studies is not significantly correlated with roasting degree. The other study from Liu & Kitts (2011) found that the phenolic component, mostly chlorogenic acid (CGA), degrades during roasting. Based on the graph in Figure 4, we can assume the heating process can stimulate the growth of phenol in roasted beans. However, the longer duration of heating can decrease the phenol content. This phenomenon is because phenol can burn due to excessive heat (Hayat *et al.*, 2019). The most possible reason that caused phenolic content increase during roasting is because the phenolic reagent was also reactive to other reducing compounds such as ascorbic acid, thiol derivatives, cysteine, tyrosine, and tryptophan (Everette *et al.*, 2010). The phenolic content was relatively the same in Roast IV, V, and VI in the second comparison. However, the beans after roasting with Roast V have the highest phenolic content, but the difference between those three roasting degrees is not much of a gap.

The result of the antioxidant activity measurement is shown on the graph in Figure 5. At first comparison, the antioxidant activity in each phenolic content increases from green beans (no roast) to Roast II, thus decreasing again in Roast III. Interestingly, the increase in antioxidant activity is not as large as the increase in phenolic in each roasting degree. This might be because the antioxidant activity is not only influenced by the existence

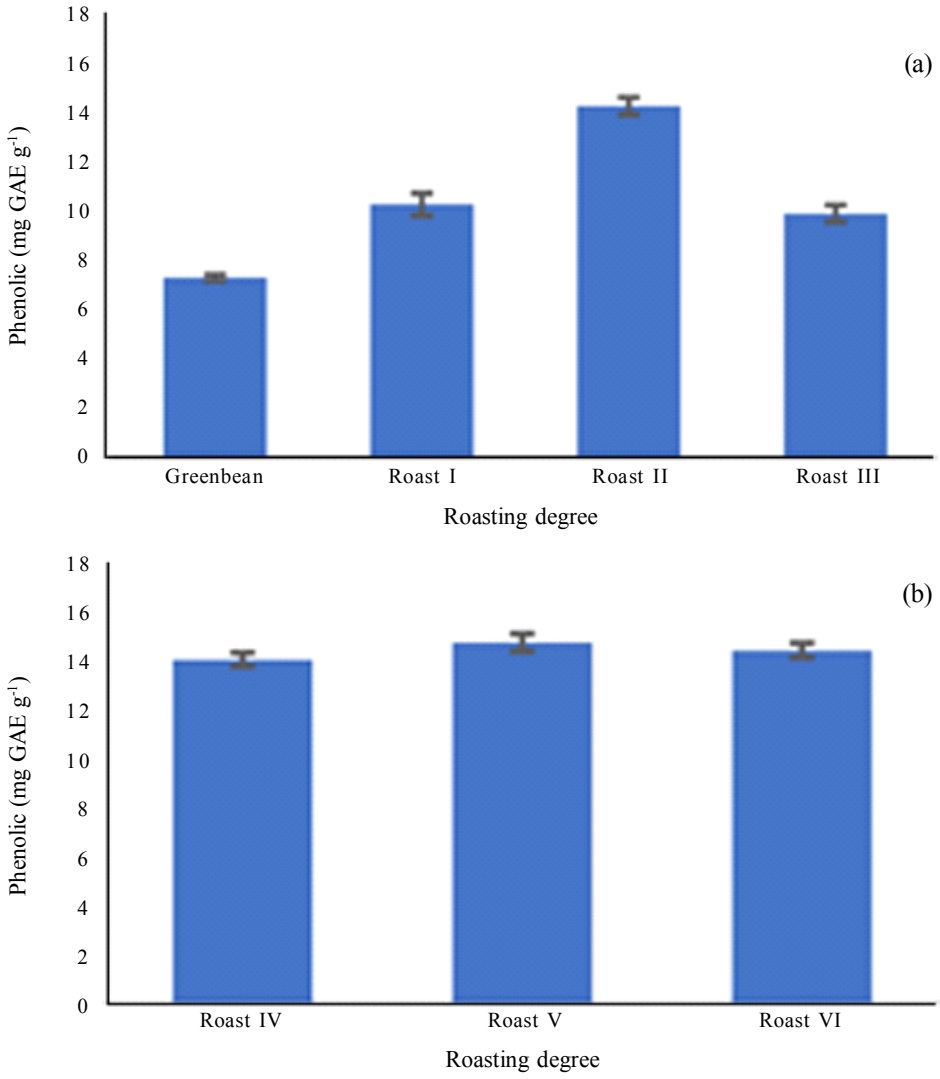

Figure 4. Phenolic content of coffee beans at (a) first comparison, (b) second comparison

of phenolic content but also by the change of other Maillard reactions products (Alves *et al.*, 2010). This result aligns with a study from Liao *et al.* (2022) indicating that roasting degree did not significantly affect radical scavenging activity. However, roasting could increase or decrease radical scavenging activity. Liu & Kitts (2011) conclude that roasted coffee beans' antioxidant activity is principally Maillard reactions products. Moreover, the Maillard reaction can exhibit peroxyl radicals scavenging activity by a transfer of hydrogen atoms to oxygen radicals. Interestingly, the increase in antioxidant activity is not as large as the increase in phenolic in each roasting degree. The percentage of antioxidant activity in Roast IV, V, and Roast VI was not significantly different in the second observation. This result is similar to the phenolic observation. However, the beans with Roast IV have the highest percentage of antioxidant activity.

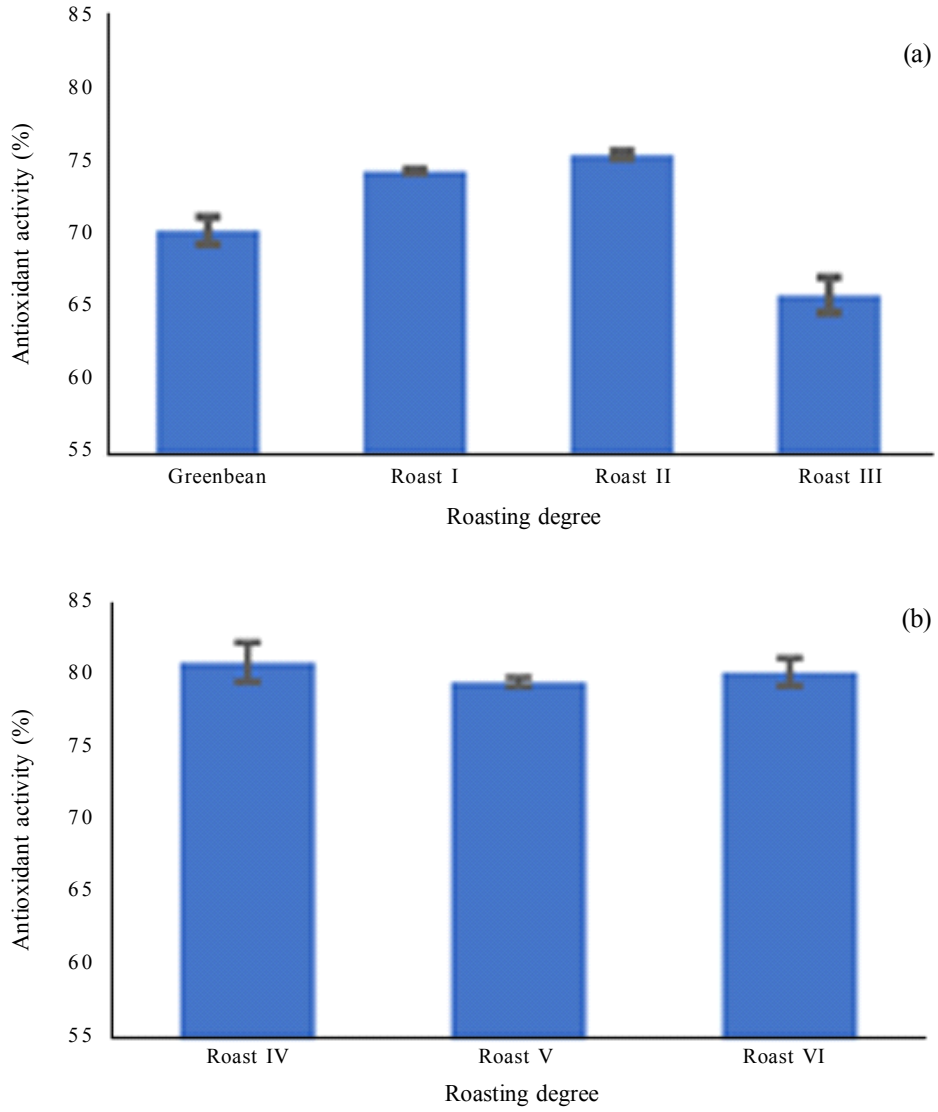

Figure 5. Antioxidant activity of coffee beans at (a) first observation, (b) second observation

This result is in line with Del Castillo *et al.* (2002), which found that the rise of antioxidant activity goes down in dark roasting conditions since partial degradation of some compounds contributing to anti-oxidant activity occurs. Protein and peptides are responsible for antioxidant activity in the green bean. The Maillard reaction during roasting has transformed protein and peptides into melanoidins, contributing to increased anti-oxidant activity in medium-roasted coffee beans. The loss of antioxidant activities can be caused by heating. Some phenolic compounds like butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), propyl gallate (PG), and tertiarybutylhydroquinone (TBHQ) had a loss of antioxidant activity during heating at 185 ^{0}C (Hamama & Nawar, 1991).

Amino Acid

Amino acids examination inside the coffee bean in this study is focused on L-isomer to explore the efficacy inside coffee beans. The observation also includes essential and non-essential amino acids. The result of amino acid analysis and examination is shown in Table 3. L-isomer is a common form of nutritional importance, while D-isomer is a common constituent of bacterial cell walls (Pundir *et al.*, 2018). Some essential amino acids are found in the highest amount in Roast I, except phenylalanine and lysine. The highest phenylalanine was found in the roasted beans with Roast III; meanwhile, the highest lysine was found in the unroasted bean. The smallest amount of phenylalanine, valine, isoleucine, and leucine was found in the unroasted bean, and the smallest amount of lysine, threonine, and histidine was found in roasted beans with Roast III. The pattern shows that roasted beans with Roast I, Roast III, and unroasted beans have a specific marker of essential amino acid amount. This pattern also occurs in several non-essential amino acids. Most of the highest amount of non-essential amino acids was found in roasted beans with Roast I except serine, tyrosine, and arginine. The highest amount of serine and arginine was found in the unroasted bean, and the highest amount of tyrosine was found in the roasted beans with Roast III. The heating process triggers amino acids to racemize and also leads to peptide linkage in the protein chain. Aspartic acid was detected as the most sensitive amino acid. However, the prolonged heating caused amino acids to decrease. The amino acids were found to start to be destroyed above 180 ^{0}C (Casal *et al.*, 2005). This might be why several amino acids tend to be higher and the others tend to be less in roasted beans than unroasted beans.

The heating process triggers amino acids to racemize and also leads to peptide linkage in the protein chain. However, the prolonged heating caused amino acids to decrease. The amino acids were found to be highly destroyed above 180 ^{0}C (Casal *et al.*, 2005). This might be the reason why several amino acids tend to rise in roasted beans compared to unroasted beans. Some amino acids dropped drastically during roasting, like lysine, which was reduced by 90% in Roast III compared with the unroasted beans. Lysine, unsaturated fatty acid and reducing sugar inside unroasted beans, is the precursor of carboxymethyl-lysine (CML), a harmful substance. The signi-ficant factors of CML presence are the prolonged time and higher temperature of roasting and lysine loss, which can indicate the emergence of CML (Liu *et al.*, 2021). However, to clarify this phenomenon, more observation is needed to analyze the transformation of CML in roasted beans. Maillard reactions are the most influential reactions that affect the alteration of amino acids and phenolic compounds. Maillard reactions are initiated by interactions between carbonyl groups and the nucleophilic amino groups of amino acids, peptides, or proteins, resulting in the sugar–amine condensation and rearrangement to Amadori or Heyns products (Oracz & Nebesny, 2019). Another amino acid that is significantly affected by the roasting degree is arginine. The significant degradation of arginine occurred till the amount was less than 46.0 mg kg^{-1} in Roast III, so it cannot be detected in the measurement.

Based on this study, leucine is the largest portion of essential amino acids in coffee beans. It can reach 30% of the total measured essential amino acids in roasted beans with Roast III. The total amount of measured non-essential amino acids is always greater than the measured essential amino acids in

Table 3. The result of amino acids measurement using UPLC

Amino Acids (%)	Green bean (Unroasted)	Roasting degree					
		Roast I	Roast II	Roast III	Roast IV	Roast V	Roast VI
Essential Amino Acids (%)							
L-Phenylalanine	4.47	5.52	4.62	6.04	6.83	4.62	4.46
L-Isoleucine	3.14	3.53	3.32	3.37	3.40	3.32	3.20
L-Valine	4.47	4.97	4.56	4.66	4.76	4.56	4.41
L-Lysine	4.72	1.10	0.83	0.48	0.65	0.83	0.70
L-Leucine	6.86	8.00	7.43	7.60	7.67	7.43	7.23
L-Threonine	3.21	3.46	2.60	1.05	2.80	2.60	2.12
L-Histidine	2.14	2.24	1.68	1.60	2.24	1.68	1.54
Non-essential Amino Acids (%)							
L-Serine	4.23	3.94	2.41	< 0.83	2.34	2.41	1.71
L-Glutamic Acid	15.84	19.39	17.76	14.78	16.62	17.76	17.29
L-Alanine	3.66	4.12	4.02	3.57	3.85	4.02	3.90
L-Arginine	4.51	1.29	0.43	ND	ND	0.43	ND
Glycine	5.39	6.07	5.35	5.55	6.10	5.35	5.22
L-Aspartic Acid	7.11	7.49	6.58	3.74	5.77	6.58	5.83
L-Tyrosine	2.40	2.79	2.25	3.12	3.42	2.25	2.19
L-Proline	4.27	5.01	4.43	4.27	4.52	4.43	4.38

Note: ND = Not detected.

each roasting degree. The total compounds of non-essential amino acids can be 1.4 times to 1.7 times more than a total compound of essential amino acids. Glutamic acid occupies the first position for the highest number of total amino acids, reaching 42% of the total amino acids in roasted beans with Roast II. This result is similar to Arnold *et al.* (1994), in which glutamic acid is the highest concentration of amino acids in the Arabica coffee bean. The glutamic acid content of Arabica green coffee is 40 times higher than the average of Arabica coffee from different countries (Murkovic & Derler, 2006). Glutamic acid is considered essential for protein repair, regeneration, and growth. The free form of glutamic acid in food enhances flavor and has no distinctive smell (Kulkarni *et al.*, 2005).

Coffee Flavor Comparison

Based on the cup test, the highest score was found in roasted beans with Roast II, with a total score of 83.6. This score is enough to qualify the coffee beans as specialty coffee. The roasted beans with Roast III characteristics have the lowest score, with a total score of 68.8. It proves that roasting stages can determine the flavor quality of coffee. The differences in temperature and roasting duration, even in similar phases and stages, can also change the coffee flavor. It is indicated by the total score of beans with Roast IV, V, and VI, which have a total score of 78.1, 83.6, and 74.1 respectively.

Temperature and time of roasting that is too high causes loss of sweetness and acidity in coffee. Acidity and sweetness drop significantly in Roast III, as shown in Figure 6. However, roasting also tends to increase the score of flavor, aftertaste, and body. The highest score of flavor, aftertaste, and body was found in Roast II but decreased in Roast III. Based on this result, the best roast for generating the best cup test is coffee beans with a roasting method of Roast II. The roasting might expand the flavor of coffee, but at a certain point, the higher temperature and the longer time of roasting can drop the flavor significantly.

The higher temperature and longer time of roasting often generate a type of dark roasted beans. The characteristic of dark roasting is the existence of a charred aroma resulting from fat degradation and high concentrations of several furans, pyridines, and thiazoles.

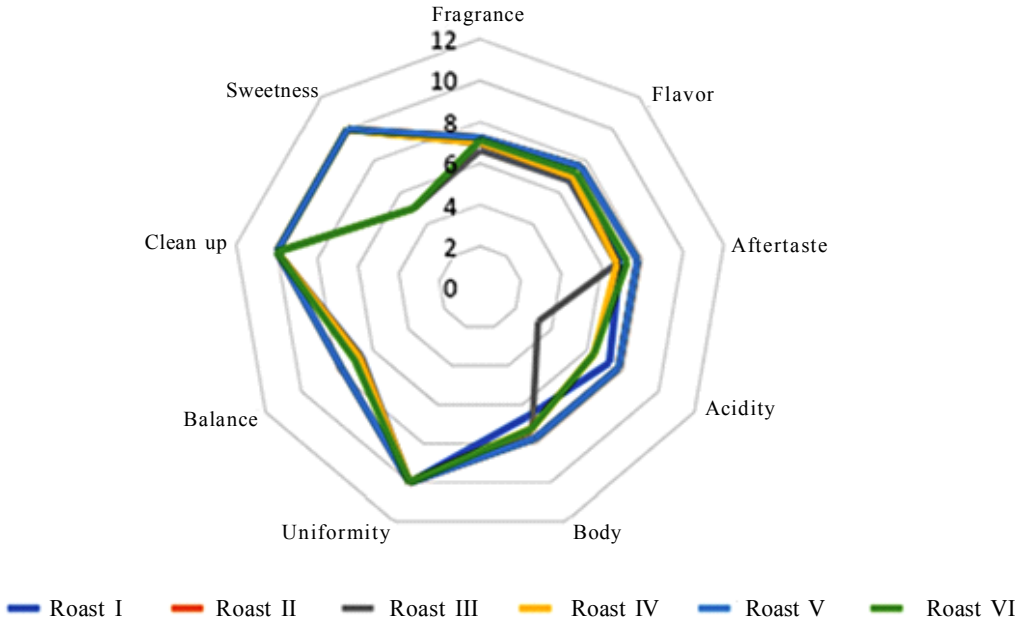

Figure 6. Score diagram of coffee cup test in each roasting degree

Lipid oxidation produces substances with an unpleasant odor (Nebesny & Budryn, 2006). The glucose inside the coffee bean is burnt during roasting and generates a burnt aroma in some coffee, especially in broken beans. Furthermore, higher temperatures and longer roasting times can burn the coffee's aromatic compound (Rini *et al.*, 2017). After evaluating various roasting characteristics and examining the roasted beans, the Roast II method is the best roasting degree for producing the best flavor with high antioxidant Activity and amino acids content. The characteristic of Roast II in this study has a total time roasting of 13 minutes and final roasting temperature not exceeding 185 ^{0}C.

CONCLUSIONS

Observing the roasting stages can analyze more detail than just monitoring fixed temperature and total roasting duration to know the roasting process's effect. The roasting process can develop the antioxidant activity, amino acids, and flavor of coffee, but a longer duration and higher roasting temperature can burn the amino acids, flavor, and aromatic compounds inside the coffee beans. Compared to other roasting characteristics in this study, Roast II is the best method to produce Java Ijen-Raung Arabica coffee with the best flavor, high antioxidant activity, and high amino acid compounds inside the beans. The beans have been roasted at different duration and temperatures, with similar stages and phases, resulting in different flavors but having almost the same trend of antioxidant activity and phenolic content.

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