The effects of temperature and roasting time on the quality of ground Robusta coffee (*Coffea rabusta*) using *Gene Café* roaster

Cite as: AIP Conference Proceedings **2199**, 060001 (2019); https://doi.org/10.1063/1.5141310
Published Online: 23 December 2019

Satrijo Saloko, Yeni Sulastri, Murad, and Mira Amalia Rinjani

The Effects of Temperature and Roasting Time on The Quality of Ground Robusta Coffee (*Coffea rabusta*) using *Gene Café* Roaster

Satrijo Saloko[1,a)], Yeni Sulastri[1,b)], Murad[1,c)] and Mira Amalia Rinjani[1,d)]

[1]*Faculty of Food Technology and Agroindustry, Mataram University*
Jl. Majapahit No. 62 Mataram, Indonesia 83126

[a)]Corresponding author: s_saloko@unram.ac.id
[b)]yenisulastri@unram.ac.id
[c)]muradfatepa@gmail.com
[d)]mira.amalia27@gmail.com

Abstract. This research aimed to determine the effect of temperature and time of roasting by using the *Gene Café* roaster on the quality of Robusta coffee and determine the appropriate treatment to obtain the best ground coffee. The method used in this research was the experimental Completely Randomized Block (CRB) using 2 factors, which were roasting temperature (225°C and 250°C) and roasting times (10 minutes; 15 minutes and 20 minutes). The parameters observed were chemical quality characteristics (moisture content, ash content, caffeine content), physical characteristics (moisture content, ash content, caffeine content and antioxidant activity), physical quality characteristics (yield, colour and browning index) and organoleptic quality(aroma and taste). Data were analyzed with analysis of variance (ANOVA) at 5%significance level by using software Co-Stat and a significant difference data were tested further by real difference test with Honestly Significant Difference (HSD) test. The results showed that the interaction between temperature and roasting time give significant effect on all parameters, such as moisture content, ash content, caffeine content, antioxidant activity, yield, L* value and °Hue of colour value, browning index, aroma (hedonic and scoring) and taste (hedonic and scoring).The treatment of roasting temperature at 225°C and roasting time for 20 minutes was the best treatment to produce ground Robusta coffee with moisture content 2.63%; ash content 4.66%; caffeine content 2.17%; antioxidant activity 50.93%; yield 73.33%; brown ground Robusta coffee (°Hue value = 16.75 and L* value = 13.93), browning index value 232.89; aroma (strong and slightly like) and taste (bitter and slightly like).

INTRODUCTION

Robusta coffee is one of the types of coffee that is widely cultivated in Indonesia, supported by the wider coverage of Robusta coffee growing areas and higher resistance to the environment and pests compared to Arabica coffee. Robusta coffee is a second-class coffee after Arabica coffee due to the taste of Robusta coffee, which is bitter, less acidic and has higher caffeine content compared to Arabica coffee. According to [1], coffee could have specific flavors not only based on the type, but also based on the location of growth, the climate of the harvest and post-harvest process, the grinding process and the way of steeping that determines the flavor of the coffee produced.

Coffee has a very good content and is useful for the body as an antioxidant. It is reported that coffee ranks first as a source of antioxidant intake (64%) followed by fruits and vegetables [2]. More than 300 chemical compounds in coffee have antioxidants, chlorogenic acid is the main antioxidant compound with a content of 4-11% [1]. In terms of health, [3] said that some positive effects and benefits of consuming coffee are reducing the chance of Alzheimer's disease, Parkinson's disease, type 2 diabetes mellitus and liver cirrhosis.

One of the processes that determine the quality of coffee is the roasting process because it is a process of forming the taste and aroma of coffee beans. The roasting process will be relatively easier to control when the coffee beans have uniformity in size, texture, moisture content and chemical structure [4]. Before the roasting process, coffee beans do not have the flavor and distinctive character of coffee yet, and only contain the precursor compounds to form the flavor, where the flavor characteristics of the coffee will be formed when the roasting process is carried out. The comparison of coffee flavor determinants is 30% through the roasting process, 60% through the cultivation and harvest in the garden and 10% is determined by the barista at the time of presentation [5].

There are two Coffee roasting techniques, roasting done conventionally, and roasting done using equipment. Conventional roasting using a frying pan as the roasting medium is considered in effective, it can be caused by uneven heat of the pan. Furthermore, it can cause the degree of ripeness and colour uniformity of roasted coffee

Proceedings of the 2nd International Conference on Bioscience, Biotechnology, and Biometrics 2019
AIP Conf. Proc. 2199, 060001-1–060001-14; https://doi.org/10.1063/1.5141310
Published by AIP Publishing. 978-0-7354-1950-6/$30.00

difficult to obtain if the coffee beans are not continuously stirred during the roasting process. Roasting temperatures that are not controlled in conventional coffee processing can cause the distribution of excess heat in the coffee beans and make the coffee beans blacken faster. Thus, the final quality will be difficult to maintain for every roasting process [6]. The use of tools in the roasting process can save energy and ease the control of temperature and roasting time, so that the final quality of the coffee product produced can be maintained. One roaster machine that can be used to roast coffee is Gene Café.

Gene Café is one type of roasting machine that can be used in the coffee roasting process. The roasting process using Gene Café utilizes hot air as a source of heat during the process. The temperature and roasting time can be adjusted as desired, so that the quality of the coffee can be controlled properly. Changes in coffee colour during the roasting process can be monitored directly, since its chamber uses clear glass.

Temperature and roasting time are one of the factors that influence the final quality in the processing of ground coffee. According to [7], the temperature needed in roasting coffee is around 60-250°C. Meanwhile, the roasting time takes about 15-30 minutes which aims to maintain the quality of coffee in terms of colour and most importantly in terms of the desired coffee flavor.

Different temperatures and roasting times in the production process results in different quality of the coffee produced. [8] research results show that roasting Robusta coffee at a temperature of 190°C for 10 minutes using the oven is the best treatment with 6.71% ash content and 1.54% caffeine content. [4] reported that roasting Robusta coffee at 200°C for 12 minutes using Teflon and electric stoves was the best treatment with water content of 2.72%. Other research results obtained the best treatment of roasting Arabica coffee at a temperature of 235°C for 14 minutes using the Gene Café machine with a yield of 82.5%, a moisture content of 1.08% wb, acidity of 5.84 and a good scoring of aromas, flavors and colours [5]. Based on the description above, further studies have been carried out on the effect of temperature and roasting time of coffee using a Gene Café roaster machine to produce ground coffee that can be accepted by consumers and in accordance with SNI 01-3542-2004.

MATERIALS AND METHODS

The tools used in this research are oven, High Performance Liquid Chromatography (HPLC) type Waters 2489 UV/Visible Detector, UV-Vis spectrophotometer, desiccators, Gene Café roast machine model CBR-101, colourimeter (MSEZ User Manual), furnace, analytical scales, beaker cups, volume pipettes, measuring flasks, erlenmeyers, porcelain cups, 60 mesh sieves, plates, plastic cups, test tubes, test tube racks, bottles, micron filters, spoons, container plates, stirrers, trays, paper trays, paper labels, blenders, wipes and aluminum type packaging with clips.

Method used in this study is an experimental method that is carried out in a laboratory. The experimental design used in this study was a Randomized Completely Block Design (RCBD) with two factors: the roasting temperature (S) consisting of 2 levels (225°C and 250°C) and the time of Roasting (L) consists of 3 levels (10 minutes, 15 minutes and 20 minutes) on Robusta coffee. Each level of the factors is combined so that 6 treatment combinations are obtained. Each combination was repeated three times, so that 18 experimental units were obtained. Observation data were analyzed for diversity (Analysis of Variance) at 5% using Co-stat software. If there are real differences, then further tests are conducted using the Honestly Significant Difference Test (HSD) at a 5% level of significance.

The parameters observed included yield, water content, ash content, colour test, browning index, caffeine content and antioxidant activity. It will also be tested for the aroma and taste of ground coffee brewing.

Coffee Bean Processing

Firstly, the sorting activity is a stage selection or separation of coffee beans from dirt or foreign objects, black coffee beans and to separate broken coffee with whole coffee so it will be easier to uniform the quality of roasted coffee produced. Second, coffee beans are weighed with a digital scale as much as 4,500 g for all treatments, where each treatment uses a sample of 250 g of coffee bean samples. Third, the process of roasting coffee was aimed to develop the aroma and taste of coffee with certain characteristics and facilitate the process of grinding/pulverizing and extracting coffee. The roasting is done using a coffee roaster with roasting temperatures of 225°C and 250°C for 10, 15 and 20 minutes. Fourth, cooling is a step aimed to stop the roasting process, so that the roasted coffee beans produced are not over roasted. Fifth, powdering is the process of breaking down coffee beans that have been roasted into small granules. This process can facilitate the process of storage, brewing and extraction. The powder process is carried out using a blender. Sixth, sifting is a process aimed to homogenize the size of coffee grains by using a 60-mesh sieve. Sifted coffee was then analyzed which includes analysis of water content, ash content, yield, caffeine, antioxidant activity, colour analysis and browning index. Seventh, the packaging process is done using a type of aluminum foil with a clip. And finally, brewing is the process of mixing coffee grounds with hot water. The temperature of the water used in brewing coffee is 90°C. The step taken in the brewing process is 160 ml of water put in 8 g of coffee. Coffee that has been brewed is then organoleptically tested using taste and aroma parameters.

RESULTS AND DISCUSSION

Water Content

Water is one of the important components in a food product whose presence can affect the appearance, texture, taste of food, determine the acceptability, freshness and durability of food ingredients in the storage process. The results of the analysis of diversity at 5% level showed that the interaction between temperature and roasting time had a significantly different effect on the water content of Robusta coffee. The interaction between temperature and roasting time on the content of Robusta coffee can be seen in Figure 1.

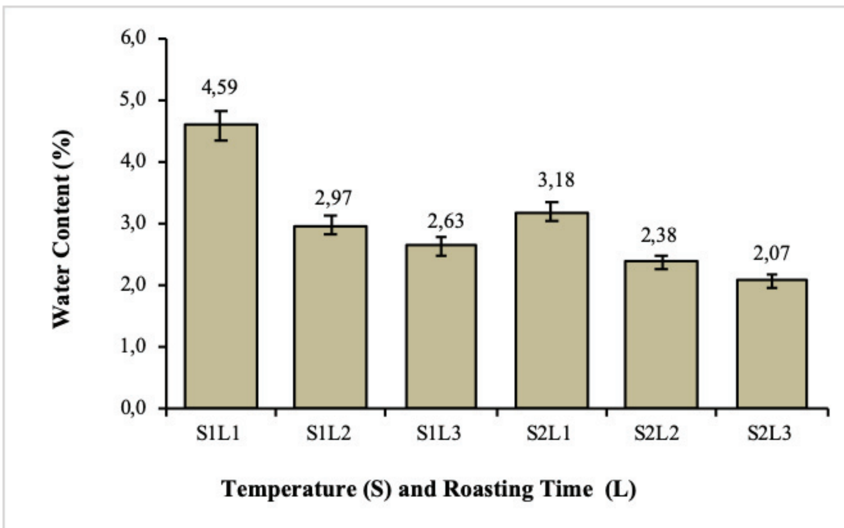

FIGURE 1. Interaction of Temperature and Roasting Time on Water Content Robusta Coffee Powder
(Note: S1L1: Roasting temperature 225°C for 10 minutes; S1L2: Roasting temperature 225°C for 15 minutes; S1L3: Roasting temperature 225°C for 20 minutes; S2L1: Roasting temperature 250°C for 10 minutes; S2L2: Roasting temperature 250°C for 15 minutes; S2L3: Roasting temperature 250°C for 20 minutes)

Based on Figure 1, it can be seen that the water content produced at the temperature treatment and roasting time ranges between 2.07% -4.60%. The highest water content value was in the S1L1 treatment (roasting at 225°C for 10 minutes) with a water content value of 4.60%. Meanwhile, the lowest water content value was in the S2L3 treatment (roasting at 250°C for 20 minutes) of 2.07 %. The graph shows that the higher the temperature and the longer the roasting process, the lower the water content produced. The water content produced in all treatments fulfilled the SNI 01-3542-2004 requirements, with a maximum water content of 7%.

Decrease in water content of coffee can be caused by heat transfer that occurs in the roasting machine into the coffee during the roasting process so that the phase contained in the coffee beans changes from the liquid phase to steam. This phase change causes the water content contained in ground coffee to decrease. The higher the roasting temperature, the water content contained in food is easier to evaporate with a shorter roasting time, while the roasting treatment uses a low temperature requires a longer time to reduce the water content. This is in accordance with the statement of [4], which states that during the roasting process there was a heat transfer in the media to the material and also the mass transfer of water. That heat resulting in changes in the mass of water from the material due to the latent heat of evaporation. This change occurs when the water content in the material has reached saturation, causing the water contained in the material to change from the liquid phase to steam. In addition, [9] stated that the greater the temperature difference between the heating medium and food, the faster the heat transfer to food and the faster the evaporation of water from food.

Ash Content

Ash is an inorganic substance from the combustion of organic material. The ash content and composition depend on the type of material and how it is used [10]. Ash content is included in non-volatile components, remains in the combustion and incandescent of organic compounds [11]. The mineral content in coffee is calcium, potassium, magnesium and non-metallic minerals such as phosphorus and sulfur which plants need in growth [12]. The results of the analysis of diversity at 5% level showed that the interaction between temperature and roasting time had a significantly different effect on the content of Robusta coffee ash. The interaction between temperature and roasting time on Robusta coffee ash content can be seen in Figure 2.

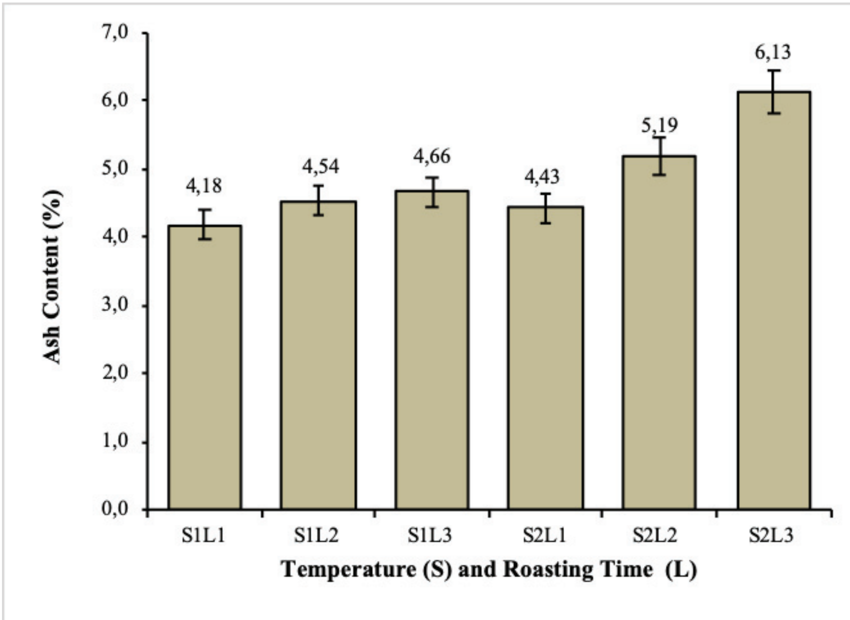

FIGURE 2. Interaction of Temperature and Roasting Time on Ash Content of Robusta Coffee Powder
(Note: S1L1: Roasting temperature 225°C for 10 minutes; S1L2: Roasting temperature 225°C for 15 minutes; S1L3: Roasting temperature 225°C for 20 minutes; S2L1: Roasting temperature 250°C for 10 minutes; S2L2: Roasting temperature 250°C for 15 minutes; S2L3: Roasting temperature 250°C for 20 minutes)

Temperature and roasting time ranged from 4.18% to 6.13%. The highest ash content was in the S2L3 treatment (roasting at 250°C for 20 minutes) with a value of 6.13% and the lowest value was in the S1L1 treatment (roasting at 225°C for 10 minutes) at 4.18%. The graph shows that the higher the temperature and the longer the roasting process, the higher the level of ground coffee ash. Ash content that meets SNI 01-3542-2004 standards is found in the treatment S1L1 (roasting at 225°C for 10 minutes), S1L2 (roasting at 225°C for 10 minutes), S1L3 (roasting at 225°C for 20 minutes) and S2L1 (roasting at 250°C for 10 minutes) with values of 4.18%; 4.43%; 4.54% and 4.66%, while the ash content that did not meet SNI standards was in the S2L2 treatment (roasting at 250°C for 15 minutes) and S2L3 (roasting at 250°C for 20 minutes) at 5.19 % and 6.13% with a standard maximum ash content of 5% for ground coffee.

Increased ash content produced in Robusta ground coffee can be caused by temperature treatment and roasting time, causing decrease in water content and other compounds such as antioxidants. Thus, the higher the temperature and the length of roasting time, the higher the ash content contained in Robusta coffee. This is in accordance with the statement of [13], that the ash content contained in the material depends on the type of material, the graying method, the time and temperature used at the time of processing, and the lower the non-mineral components contained in the material, the more it will increase the percent ash relative to the material.

Caffeine Content

Caffeine is a crystalline compound whose main constituent is a protein derivative compound called purine xanthin. The results of the analysis of diversity at the 5% level showed that the interaction between temperature and roasting time had a significantly different effect on the levels of caffeine in Robusta coffee. The interaction between temperature and roasting time on the Robusta coffee content can be seen in Figure 3.

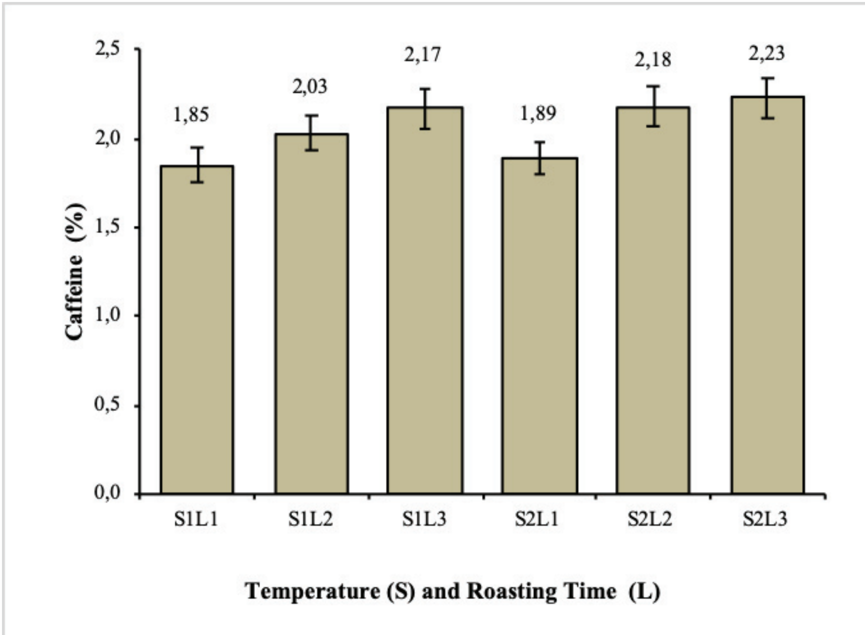

FIGURE 3. Interaction of Temperature and Roasting Time on Caffeine Content of Robusta Coffee Powder (Note: S1L1: Roasting temperature 225°C for 10 minutes; S1L2: Roasting temperature 225°C for 15 minutes; S1L3: Roasting temperature 225°C for 20 minutes; S2L1: Roasting temperature 250°C for 10 minutes; S2L2: Roasting temperature 250°C for 15 minutes; S2L3: Roasting temperature 250°C for 20 minutes)

Based on Figure 3, the produced caffeine content is ranged from 1.85% -2.23% with initial caffeine content of 1.84%. The highest caffeine content values were in the S2L3 treatment (roasting at 250° C for 20 minutes) with a caffeine content value of 2.23% and the lowest value was in the S1L1 treatment (roasting at 225°C for 10 minutes) at 1.85%. The graph shows that the higher the temperature and the longer the roasting process is carried out, the higher the caffeine levels will be. In addition, the caffeine levels that meet the SNI 01-3542-2004 standard was only found in S1L1 treatment (roasting at 225°C for 10 minutes) and S1L2 (roasting at 225°C for 15 minutes) of 1.85% and 1.89% with caffeine standards (maximum of 2% in ground coffee).

The amount of caffeine that does not meet SNI standards can be caused by the type and initial content of caffeine, where the coffee used in this study is Robusta type coffee that has a higher caffeine content compared to Arabica type coffee. Increasing the amount of caffeine can also be caused by the evaporation of water content and acidic substances such as chlorogenic acid during the roasting process, and it is suspected that the temperature and length of roasting used have not been able to vaporize the caffeine content during the roasting process. Thus, the percentage of substances which is not easy to evaporate such as caffeine, fat and minerals will increase. This is in accordance with the statement of [14], the higher the temperature and the longer the time used in the roasting process, the higher the caffeine levels. The increase in the amount of caffeine in roasted coffee is thought to be caused by the decomposition of liquid and acidic substances during the roasting process, so that the amount of non-liquid content such as caffeine, fat and mineral percentage has increased. The chemical properties of caffeine can melt at 236°C and boil at 178°C [15].

Antioxidant Activity

Antioxidants are compounds that can inhibit or prevent oxidation reactions by binding to free radicals and highly reactive molecules so that the damage process can be prevented [16]. Antioxidants in food play an important role in maintaining product quality, preventing rancidity, changes in nutritional value, changes in colour and aroma, and other physical damage caused by oxidation reactions [33]. The results of the analysis of diversity at 5% level showed that the interaction between temperature and roasting time had a significantly different effect on the level of antioxidant activity of Robusta coffee. The interaction between temperature and roasting time on the antioxidant activity of Robusta coffee can be seen in Figure 4.

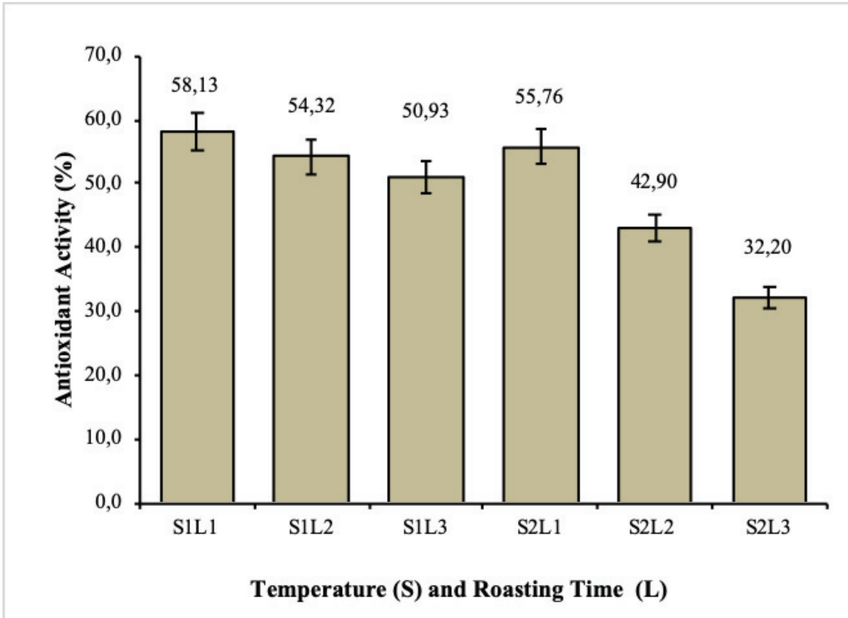

FIGURE 4. Interaction of Temperature and Roasting Time on Antioxidant Activity of Robusta Coffee Powder (Note: S1L1: Roasting temperature 225°C for 10 minutes; S1L2: Roasting temperature 225°C for 15 minutes; S1L3: Roasting temperature 225°C for 20 minutes; S2L1: Roasting temperature 250°C for 10 minutes; S2L2: Roasting temperature 250°C for 15 minutes; S2L3: Roasting temperature 250°C for 20 minutes)

Based on Figure 4, the antioxidant activity produced at the temperature treatment and roasting time ranged from 32.20% - 58.13% with an initial antioxidant activity of 60.19%. The highest antioxidant activity value was in the S1L1 treatment (roasting at 225°C for 10 minutes) with a value of 58.13% and the lowest value was in the S2L3 treatment (roasting at 250°C for 20 minutes) at 32.20%. The graph shows that the higher the temperature and the longer the roasting process is carried out, the less antioxidant activity will result. Decreased antioxidant activity in roasted ground coffee can be caused by reduced chlorogenic acid and also other types of antioxidants such as trigonelline due to heat treatment and also the time given to coffee beans during roasting process. This is consistent with the research conducted by [35] resulting in a decrease in chlorogenic acid and trigonelline in roasted treatment at 215°C for 10 minutes with values of 7% and 8% respectively with an initial content of chlorogenic acid of 24% and trigoneli at 9%, where the total initial antioxidant capacity by 90% dropped to 55% after the roasting process was carried out at 215°C for 10 minutes.

According to [17], during the roasting process, chlorogenic acid can be broken down into phenol derivatives and can cause the value of the content to be reduced in coffee beans. The content of chlorogenic acid will decrease when the temperature used during the roasting process increases. Some of the chlorogenic acid turns into melanoidin compounds, which are also antioxidants. Chlorogenic acid levels in coffee beans vary depending on factors of coffee plant varieties. In general, steeping coffee (200 ml) contains chlorogenic acid one to one and a half times higher than the caffeine content [18].

Yield

The yield is the percentage ratio between the final weight and the initial weight of the material. Calculating the percentage of yield aims to determine the efficiency of the process carried out. The more components in the material lost during the processing, the percentage of the final yield will be smaller and vice versa, the lower the components in the material lost during the processing, the percentage of the final yield will be even greater. The results of the analysis of diversity at 5% level showed that the interaction between temperature and roasting time had a significantly different effect on yield of Robusta coffee. The interaction between temperature and roasting time on

Robusta coffee yields can be seen in Figure 5.

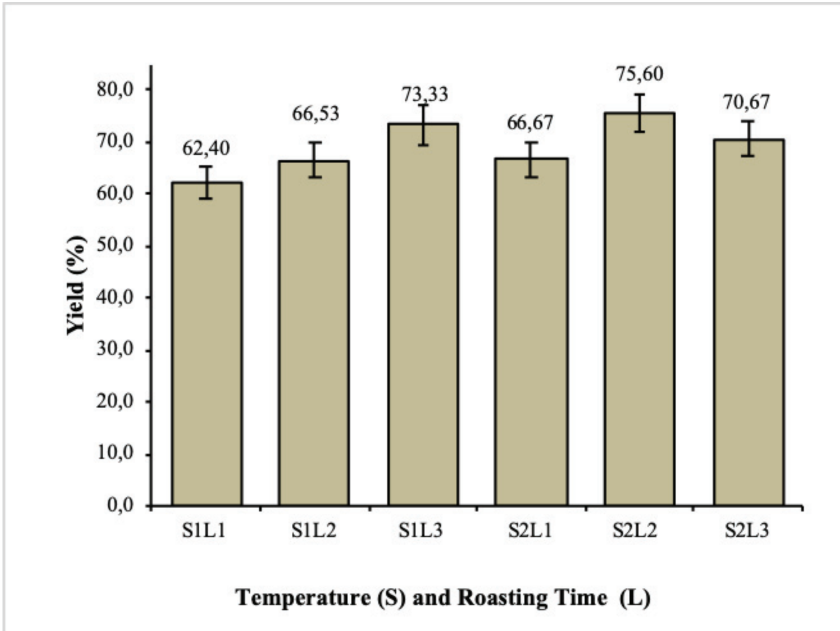

FIGURE 5. Interaction of Temperature and Roasting Time on Yield of Robusta Coffee Powder
(Note: S1L1: Roasting temperature 225°C for 10 minutes; S1L2: Roasting temperature 225°C for 15 minutes; S1L3: Roasting temperature 225°C for 20 minutes; S2L1: Roasting temperature 250°C for 10 minutes; S2L2: Roasting temperature 250°C for 15 minutes; S2L3: Roasting temperature 250°C for 20 minutes)

Based on Figure 5 the yield produced at the treatment temperature and roasting time ranges from 61.20% - 75.60%. The highest yield was in the S2L2 treatment (roasting at 250°C for 15 minutes) with a value of 75.60% and the lowest value was in the S1L1 treatment (roasting at 225°C for 10 minutes) at 61.20%. The graph shows that the lower the temperature and the shorter the roasting time, the lower the yield of ground coffee. This is not in accordance with research conducted by [19] on Arabica coffee, where the highest yield of roasted coffee is produced at roasting coffee with a temperature of 220°C for 14 minutes with a yield of 90%, while the lowest yield of coffee is produced from roasting treatment with a temperature of 250°C for 20 minutes with a yield value of 65% and also the results of research conducted by [20] with the results of the study showing that the highest yield of roasting coffee powder was obtained at 160°C and 15 minutes of roasting time with a total yield of 85.2%. While the lowest percentage of yield at a temperature of 180°C with 25 minutes roasting time is 74.8%. The higher the temperature and the roasting time, the lower the yield obtained.

The results of research that are not in accordance with the literature can be caused by the coffee beans that were not perfectly roasted so when the process of pulverizing is done, it makes difficult for roasted coffee beans to be destroyed due to hard coffee beans. The hardness resulting from roasting coffee beans can be caused by the high-water content in roasted coffee. S1L1 roasting treatment results in roasted coffee that has not been properly roasted (roasted coffee beans) that are marked with hard coffee beans, roasted brown coffee, brown coffee, no aroma of coffee is produced, and the first crack process has not yet occurred. Meanwhile, the S2L2 roasting treatment produces roasted coffee that is perfectly roasted, and the coffee beans are easy to destroy so that it produces a higher yield than the S1L1 treatment. According to [21], the higher the temperature and the longer the heating process is carried out, the smaller the hardness of the material. This proves that the temperature and duration of roasting affect the hardness value of the material. Temperature and duration used in roasting affect the rate of decrease in water content in the material, which in turn will also affect the rate of change in product hardness. When the temperature is higher and the roasting time is longer, then the water content of the material will go down faster so that the coffee will be easier to destroy.

Colour

Colour is one of the benchmarks or quality that is used as a determinant of the acceptance or rejection of a product by consumers. Colourimeter is a tool to detect colour seen based on parameters L* and °Hue value. The L* value is the value given to the brightness of a product by showing the numbers from 0 to 100. The value of 0 is black while the value 100 is white, so the higher the range of L* values obtained the brighter the colour of the product while the Hue value is obtained from the values of a and b listed on the colourimeter [22]. The results of the diversity analysis at the 5% level showed that the interaction between temperature and roasting time had a significantly different effect on the value of °Hue and L* value of Robusta ground coffee. The interaction between temperature and roasting time on °Hue and L* value of Robusta ground coffee can be seen in Figure 6.

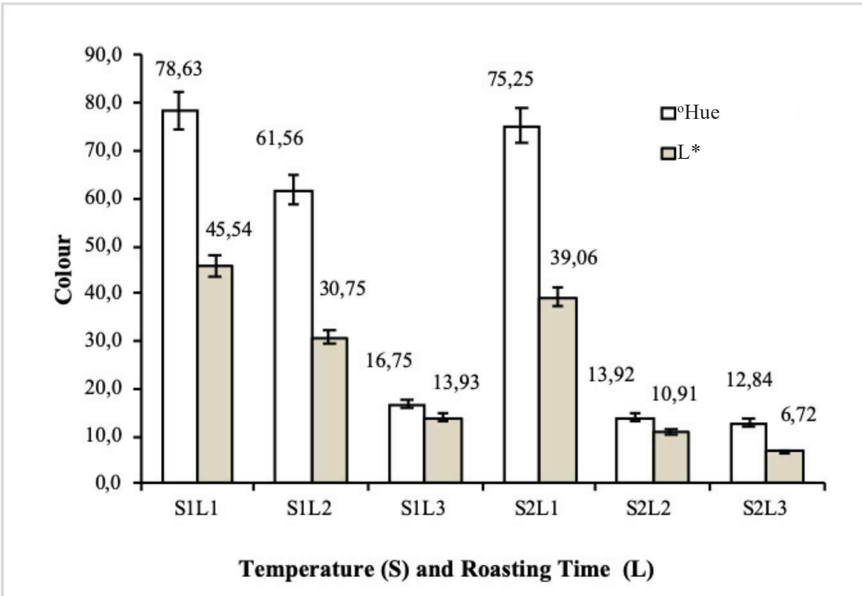

FIGURE 6. Interaction of Temperature and Time Roasting on °Hue and L Value of Robusta Coffee Powder (Note: S1L1: Roasting temperature 225°C for 10 minutes; S1L2: Roasting temperature 225°C for 15 minutes; S1L3: Roasting temperature 225°C for 20 minutes; S2L1: Roasting temperature 250°C for 10 minutes; S2L2: Roasting temperature 250°C for 15 minutes; S2L3: Roasting temperature 250°C for 20 minutes)

Based on Figure 6, the value of °Hue produced at temperature treatment and roasting time ranged from 12.84% -78.63. The highest °Hue value is in S1L1 treatment (roasting at 225°C for 10 minutes) with a value of 78.63 which indicates yellow red colour and the lowest value is in S2L3 treatment (roasting at 250°C for 20 minutes) equal to 12.84 which indicates red purple. The graph shows that the higher the temperature and the longer the roasting process, the lower the coffee °Hue value will be. The colour value of °Hue found in the S1L1 treatment can be caused by the temperature and the duration of the roasting given is lower and shorter when compared to other treatments. This treatment produces coffee beans with a brownish yellow colour so as to produce a °Hue value of 78.63. While the lowest colour of the Hue value found in the S2L3 treatment can be caused by the high temperature and roasting time by producing a dark brown coffee colour, thus producing a value of the Hue value of 12.84. Colour changes can be caused by Maillard reactions involving carbonyl group compounds (reducing sugars) and amino groups (amino acids). Maillard reaction is a non-enzymatic browning reaction between the reducing group and the primary amine group [23]. The results of these reactions produce brown material, which is often desired or sometimes a sign of deterioration [34]. According to [24], during the roasting process colour changes can be distinguished visually. The colour changes range from green to cinnamon brown and then black with oily surfaces.

The value of L produced at the temperature treatment and roasting time according to Figure 6 shows that the value of L produced ranged from 6.72 to 45.54. The highest L value was in the S1L1 treatment (roasting at 225 ° C for 10 minutes) with a value of 45.54, while the lowest value was in the S2L3 treatment (roasting at 250 ° C for 20 minutes) at 6.72. The graph shows that the higher the temperature and the longer the roasting process is carried out, the lower the value of L coffee powder. The decrease in L value in Robusta ground coffee can be caused by coffee beans during the roasting process which changes colour to darker namely blackish brown. The colour change is caused by a combination of temperature treatment and roasting time which causes the Maillard reaction. The Maillard reaction will produce melanoidin as indicated by the brown discolouration of roasted coffee beans, thus will reduce the L value of the roasted ground coffee yield. These results are consistent with [21] which states that the decrease in L value indicates that the colour of the seeds becomes darker with a combination of temperature and roasting time. The colour change to blackish brown is because during the roasting process of the coffee beans the Maillard reaction occurs. The Maillard reaction provides an important contribution in the formation of aromas and antioxidant compounds. The reaction occurs between sugar and amino acids, the end result of which is melanoidin. The presence of melanoidin is indicated by a brown discolouration in heated coffee beans.

Browning Index

Browning index is a way that is done to show an increase in brown colour caused by the browning reaction during the processing. According to [25] in general, browning index is an indirect method used to measure the colour components of the browning reaction during processing. The results of the diversity analysis at the 5% level showed that the interaction between temperature and roasting time had a significantly different effect on the value of the Robusta coffee browning index value. The interaction between temperature and roasting time on the Robusta coffee browning index can be seen in Figure 7.

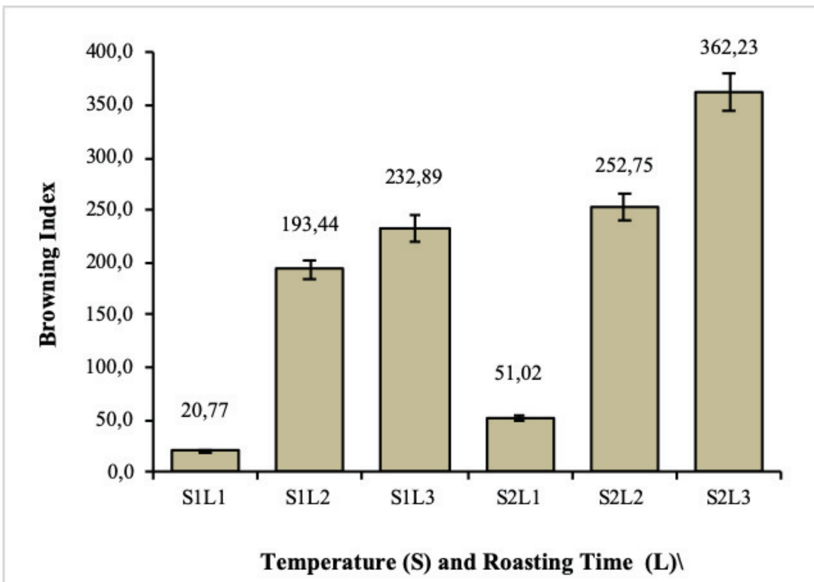

FIGURE 7. Interaction of Temperature and Roasting Time on Browning Index of Robusta Coffee Powder
(Note: S1L1: Roasting temperature 225°C for 10 minutes; S1L2: Roasting temperature 225°C for 15 minutes; S1L3: Roasting temperature 225°C for 20 minutes; S2L1: Roasting temperature 250°C for 10 minutes; S2L2: Roasting temperature 250°C for 15 minutes; S2L3: Roasting temperature 250°C for 20 minutes)

Based on Figure 7, the Robusta coffee browning index produced at the treatment temperature and roasting time ranged from 20.77% - 362.23%. The highest Robusta powder coffee browning index value was in the S2L3 treatment (roasting at 250°C for 20 minutes) with a value of 362.23% and the lowest value was in the S1L1 treatment (roasting at 225°C for 10 minutes) of 20, 77%. The graph shows that the higher the temperature and the longer the roasting process is carried out, the higher the value of the coffee powder browning index.

Increasing the value of the browning index on Robusta ground coffee can be caused by high temperature treatment and roasting time causing the coffee beans to change colour. The change in colour causes the value of the coffee browning index to increase. Increasing the browning index value in Robusta ground coffee can be obtained from the Maillard reaction and is also thought to be caused by thermal oxidation, degradation of streckers (chemical reactions that convert α-amino into aldehyde containing side chains) and polymerization of polyphenols during the roasting process. The results of this study are in accordance with the research conducted by [26] which shows that the temperature and roasting time have a significantly different effect on the roasted coffee browning index. The 200°C roasting temperature treatment for 20 minutes increased from 75 to 96 with the 200°C roasting temperature treatment for 40 minutes. The increase in the value of the browning index can be caused by the formation of brown pigments from the Maillard reaction, thermal oxidation, degradation strecker and polymerisation polyphenols during the roasting process.

Aroma

Aroma is one of the parameters in determining the quality of a food product. The distinctive aroma can be felt by the sense of smell depends on the ingredients and ingredients added to the food. Thus, the aroma can directly influence consumer's interest to try a food product [27]. The results of the analysis of diversity at the 5% level showed that the interaction between temperature and roasting time had a significantly different effect on the hedonic value and scoring of Robusta coffee brewing aroma. The interaction between temperature and roasting time on hedonic values and scoring of Robusta coffee brewing aroma can be seen in Figure 8.

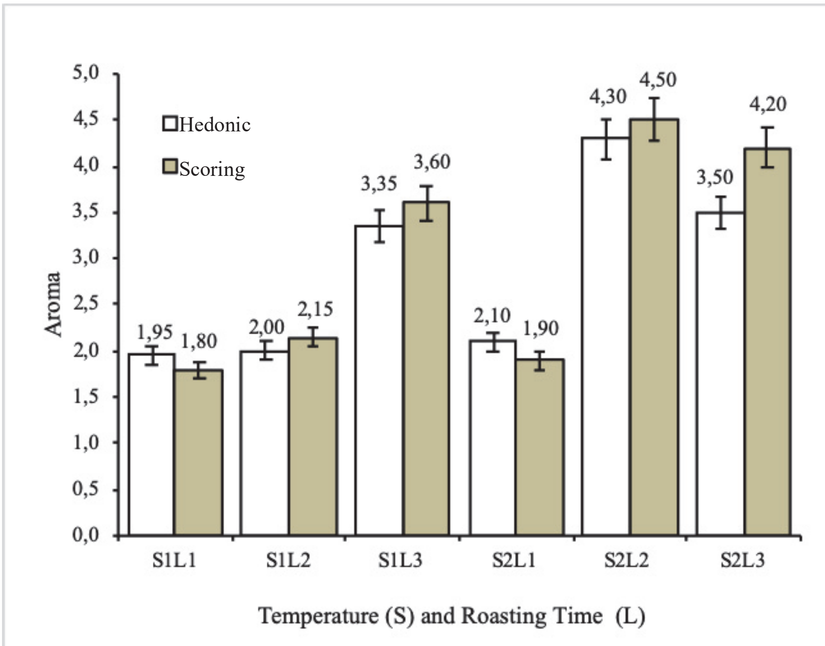

FIGURE 8. Interaction of Temperature and Roasting Time on Aroma (Hedonic and Scoring) of Robusta Coffee Brewing

(Note: S1L1: Roasting temperature 225°C for 10 minutes; S1L2: Roasting temperature 225°C for 15 minutes; S1L3: Roasting temperature 225°C for 20 minutes; S2L1: Roasting temperature 250°C for 10 minutes; S2L2: Roasting temperature 250°C for 15 minutes; S2L3: Roasting temperature 250°C for 20 minutes)

Based on Figure 8, the aroma organoleptic test using paneled hedonic methods provides Robusta coffee brewing criteria from dislike to liking with values ranging from 1.95 to 4.30. The highest value obtained in the treatment S2L2 (roasting temperature 250°C for 15 minutes) with a value of 4.30 and the lowest value obtained in the treatment S1L1 (roasting temperature 225°C for 10 minutes) with a value of 1.95. The graph shows that the higher the temperature and the roasting time for coffee will increase the hedonic value of Robusta coffee brewing aroma, but in the treatment S2L3 (roasting temperature of 250°C for 20 minutes) the hedonic value decreases. This can be caused by the temperature treatment and the roasting time which is given is slightly excessive so that the resulting ground coffee is slightly scorched, thereby reducing the hedonic value of Robusta ground coffee brewing. [28] states that aromas are odors that are difficult to measure, giving rise to different opinions in assessing quality. Differences of opinion are caused because each person has a different ability to smell, although they can distinguish scents, but each person has different preferences.

The aroma scoring value shown in Figure 8. gives the criteria for Robusta ground coffee brewing from no coffee aroma until the coffee aroma is very strong with values ranging between 1.80–4.50. The highest value obtained in the treatment S2L2 (roasting temperature 250°C for 15 minutes) with a value of 4.50 and the lowest value obtained in the treatment S1L1 (roasting temperature 225° C for 10 minutes) with a value of 1.80. The graph shows that the higher the temperature and the roasting time, the higher the scoring value of aroma in Robusta coffee brewing, but in the S2L3 treatment the coffee aroma has decreased due to the roasting treatment with a temperature of 250 ° C for 20 minutes causing a volatile aroma contained in a lot of coffee apart, causing the scoring test results of this treatment is lower when compared with the scoring value of the S2L2 treatment. The low scoring value obtained in S1L1 and S2L1 treatments can be caused by these treatments not being able to reach the roast temperature in the coffee beans so that the aroma contained in the coffee beans does not come out and produce a low scoring test value. These results are consistent with the statement of [29] which states that the higher the temperature and roasting time, the less desirable aroma will be stronger. Conversely, a low roasting temperature with a short time will produce coffee aroma that is not expected (no) with a slightly sour taste.

The aroma produced during the roasting process can be caused by the presence of volatile and non-volatile compounds formed during the roasting process which is supported by the use of temperature and duration of the roasting. Various volatile compounds in coffee are formed from the Maillard reaction. Volatile compounds are generally compounds derived from pyrazine, aldehyde, ketone, phenol, pyridine, pyrole, furan, pyrone amine, oxazole, thiazole, thiophene, alcohol, benzene, esters, organic acids and sulfur. This is consistent with the statement of [30] which states that volatile compounds contribute to the smell of the nose, the type and amount of flavor compounds formed in the roasting process is highly dependent on variations in the content of precursor compounds of rice coffee beans. Mino acid precursors that play an important role in the Maillard reaction are contained in many types so that they will add variations in the types of flavor compounds that are formed. These volatile compounds are generally compounding of pyrazine, aldehyde, ketone, phenol, pyridine, pyrole, furan, pyrone amine, oxazole, thiazole, thiophene, alcohol, benzene, esters, organic acids, sulfur. One type of nonvolatile compounds that affect the aroma of coffee is caffeol. Whereas [24] states that the formation of a distinctive aroma in coffee is caused by caffeol and other coffee-forming compounds such as trigonelline. Trigonelline compounds in coffee will degrade during the roasting process into a number of heterocyclic pyridine components which will produce a distinctive coffee aroma after roasting [7].

Taste

Taste is related to the component of material that is captured by the sense of taste (tongue). Taste is also one of the determinants in the level of panellist acceptance [31]. The results of the analysis of diversity at 5% level showed that the interaction between temperature and roasting time had a significantly different effect on hedonic values and scoring of Robusta coffee brewed taste. The interaction between temperature and roasting time on hedonic values and scoring of Robusta coffee brewing can be seen in Figure 9.

Based on Figure 9, for organoleptic tests of taste with panelled hedonic methods provide Robusta coffee powder brewing criteria from dislike to liking with values ranging from 2.20 to 4.10. The highest value was obtained at S2L2 treatment (roasting temperature 250°C for 15 minutes) with a value of 4.10 and the lowest value obtained at S1L1 treatment (roasting temperature 225°C for 10 minutes) with a value of 2.20. The graph shows that the higher the temperature and the roasting time for coffee, the higher the hedonic value of Robusta coffee brewing. However, in the S2L3 treatment (roasting temperature of 250°C for 20 minutes) the hedonic value of coffee decreased. This can be caused by the taste of coffee produced tends to be more bitter and concentrated when compared to S2L2 treatment, causing the resulting hedonic value to decrease.

The taste scoring values shown in Figure 9 provide criteria for Robusta ground coffee brewing from slightly bitter to very bitter coffee tastes with values ranging from 3.00–4.70. The highest value was obtained at S2L3 treatment (roasting temperature 250°C for 20 minutes) with a value of 4.70 and the lowest value obtained at S1L1 treatment (roasting temperature 225°C for 10 minutes) with a value of 3.00. The graph shows that the higher the temperature and the roasting time the coffee will give an increased value scoring Robusta coffee brew taste. The taste produced in steamed coffee can be derived from the degradation and formation of chemical compounds resulting from the Maillard reaction, degradation of the strecker, decomposition of amino acids, degradation of trigonelline, quinic acid, caffeine, chlorogenic acid, and lipids that occur during the roasting process. The higher the temperature and the roasting time will accelerate the degradation and formation of other chemical compounds such as caffeol produced from caffeine compounds during the roasting process. Caffeine can act as a taste and aroma found in coffee in addition to chlorogenic acid, caffeine and trigonelin. This is in line with the statement of [32] which states that the impact of roasting on taste comes from the degradation and formation or release of various chemical compounds through the Maillard reaction, Strecker degradation, decomposition of amino acids, degradation of trigonins, quinic acids and lipids. The use of high temperatures will accelerate the process of degradation and formation of chemical compounds that will affect the taste of coffee such as caffeol, chlorogenic acid dissolved in water and also trigonelin.

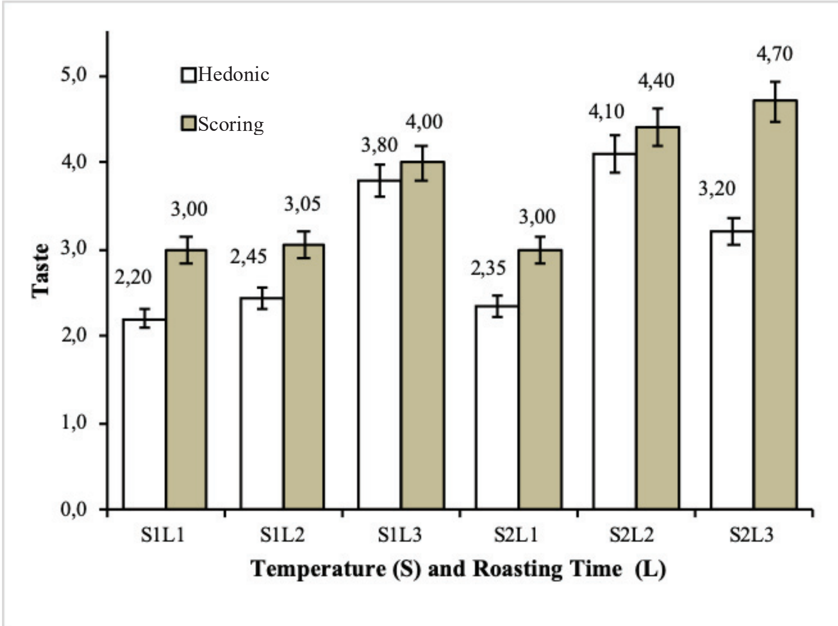

FIGURE 9. Interaction of Temperature and Roasting Time on Taste (Hedonic and Scoring) of Robusta Coffee Brewing (Note: S1L1: Roasting temperature 225°C for 10 minutes; S1L2: Roasting temperature 225°C for 15 minutes; S1L3: Roasting temperature 225°C for 20 minutes; S2L1: Roasting temperature 250°C for 10 minutes; S2L2: Roasting temperature 250°C for 15 minutes; S2L3: Roasting temperature 250°C for 20 minutes)

CONCLUSIONS

The treatment of Temperature roasting, long time roasting and interaction temperature and roasting time had a significantly different effect on all test parameters namely water content, ash content, caffeine, antioxidant activity, yield, L value and colour HUE value, browning index, aroma (hedonic and scoring) and taste (taste) hedonics and scoring).The analysis shows that the higher the temperature and the roasting time will cause the content of water content, antioxidant activity, yield and colour (L* value and °Hue value) to decrease, while the ash content, caffeine, browning index and organoleptic test of hedonic methods and scoring on the Robusta coffee taste aroma and taste parameters is increasing. Making Robusta ground coffee with a roasting temperature of 225°C and the roasting time of 20 minutes is the best treatment because it produces Robusta ground coffee with a moisture content of 2.63%; ash content 4.66%; caffeine by 2.17%; antioxidant activity by 50.93%; yield of 73.33%; Robusta coffee powder is brown (value of °Hue = 16.75 and L* value = 13.93), browning index value of 232.89 hedonic parameters of aroma and taste are somewhat preferred, as well as scoring parameters of strong coffee aroma with bitter taste.

ACKNOWLEDGMENTS

We gratefully acknowledge to Ministry of Research Technology and Higher Education of Republic of Indonesia for “Student Joint Research” funding and the Faculty of Food Technology and Agroindustry, University of Mataram for the technical support.

REFERENCES

1. W. Widodo, G. A. H, Yohanes and Astuti, "Kinerja Alsin Sangrai Kopi Tipe Fluidisasi dan Uji Kualitas Kopi Sangrai," Jurnal Teknologi Pertanian **16**, 117-126 (2015).
2. A. Svilass, A. Sakhi, L. Andersen, T. Svilass, E. Strom and . D. Jacobs, "Intakes of Antioxsidants in Coffee, Wine, and Vegetables are Related with Plasma Carotenoids in Humans.," Journal of Nutrition **134**, 562-567 (2004).
3. F. Koto, H. Kadri and Z. Rafinda, "Pengaruh Pemberian Kopi Instan Oral Terhadap Kadar Asam Urat pada Tikus Winstar". Jurnal Kesehatan Andalas **3**, 527-530 (2014).
4. J. Karyadi, J. Lunbanbatu and S. Rahayu, "Pengaruh Suhu dan Lama Penyangraian Terhadap Sifat Fisik-Mekanis Biji Kopi Robusta". Makalah Bidang Teknik Produk Pertanian.," ISSN 2081-7152, Jakarta (2009).
5. N. Purnamayanti, I. Gunadnya and G. Arda, "Pengaruh Suhu dan Lama Penyangraian Terhadap Karakteristik Fisik dan Mutu Sensori Kopi Arabika (*Coffea arabica* L)" Jurnal Biosistem dan Teknik Pertanian **5**, 39-48 (2017).
6. M. Maulana, "Analisis Kematangan Kopi Sangrai Menggunakan Pemrosesan Citra Termografi dalam Rangka Pengontrolan Mutu Kopi Sangrai Secara Otomatis.," Universitas Lampung., Lampung, 2016.
7. E. Pengabean, *The Secret Barista* (PT. Wahyumedia, Jakarta, 2012).
8. B. Edvan, R. Edison and M. Same, "Pengaruh Jenis dan Lama Penyangraian pada Mutu Kopi Robusta." Jurnal AgroIndustri Perkebunan 4, 31-40 (2016).
9. T. Estiasih and K. Ahmadi, *Teknologi Pengolahan Pangan* (BumiAksara, Jakarta, 2009).
10. J. Firmansyah, *Analisis Pangan* (Universitas Hasanuddin Press, Makassar, 2011).
11. S. Soebito, *Analisis Farmasi* (Gadjah Mada University Press, Yogyakarta, 1988).
12. R. Clarke and R. Macrae, *Coffee* (Elsevier Applied Science Publisher, London, 1985).
13. S. Sudarmadji, Suhardi and B. Haryono, *Analisa Bahan Makanan dan Pertanian*, (Liberty, Yogyakarta, 1989).
14. K. Sutrisno., *Kopi Rendah Kafein* (Penebar Swadaya, Jakarta, 2006).
15. A. Mumin, F. Kazi, A. Zainal and H. Zakir, "Determination and Characterization of Caffeine in Tea, Coffee and Soft Drink by Solid Phase Extraction and High Performance Liquid Chromatography (SPE-HPLC)" Journal of Chemistry **8**, 45-51 (2006).
16. H. Hartanto, "Identifikasi Potensi Antioksidan Minuman Coklat dari Kakao Lindak (*Theobroma kakao* L.) dengan Berbagai Cara Preparasi: Metode Radikal Bebas 1,1 Diphenyl-2- Pircylhydrazil (DPPH)" (Universitas Katolik Widya Mandala, Surabaya, 2012).
17. A. Afriliana, *Teknologi Pengolahan Kopi Terkini* (CV. Budi Utama, Yogyakarta, 2018).
18. R. Savitri, "Antioksidan dalam Secangkir Kopi," 2015. [Online]. Available: https://www.minumkopi.com/antioksidan-dalam-secangkir- kopi/. [Accessed 22 3 2018].
19. N. Purnamayanti, I. Gunadnya and G. Arda, "Pengaruh Suhu dan Lama Penyangraian Terhadap Karakteristik Fisik dan Mutu Sensori Kopi Arabika (*Coffea arabica* L)," Jurnal Biosistem dan Teknik Pertanian **5**, 39-48 (2017).
20. Kaswindi, "Pengaruh Suhu dan Lama Penyangraian terhadap Mutu Kopi Arabika Gayo" (Universitas Syiah Kuala, Darussalam Banda Aceh, 2017).
21. R. Sari., "Pengaruh Suhu dan Lama Penyangraian terhadap Sifat Fisik-Mekanis Biji Kopi Sangrai Robusta Pagaralam, Sumatera Selatan" (Institut Pertanian Bogor, Bogor, 2018).
22. S. Soekarto. *Penilaian Organoleptik untuk Industri Pangan dan Hasil Pertanian* (Bhatara Aksara, Jakarta, 1990).

23. A. Primadia. "Pengaruh Perubahan Proses Dekafeinasi Kopi dalam Reaktor Kolom Tunggal terhadap Mutu Kopi" (Institut Pertanian Bogor, Bogor, 2009).
24. M. Sivetz and H. Foote. *Coffee Processing Technology* (The AVI Publising Company, Inc., Wesport, 1972).
25. H. Chung, D. Kim, K. Youn and K. Youn, "Optimizing of Roasting Condition According to Antioxidant and Sensory Quality of Coffee Brews" Food Science and Biotechnology **23**, 1829-1835 (2013).
26. O. Shan, W. Zaman and T. Yang, "Impact of Different Temperature-Time Profiles During Superheated Steam Roasting on Some Physical Changes Robusta Coffee" Pertanika Journal Tropical Agricultural Science **39**, 311-320 (2016).
27. A. Rijal. "Pengaruh Lama Pengeringan Terhadap Daya Oksidasi Teh Daun Kelor (*Moringa oleifera*)" (Fakultas Teknologi Pangan dan Agroindustri, Universitas Mataram, Mataram, 2016).
28. B. Kartika, *Pedoman Uji Indrawi Bahan Pangan* (Pusat Antar Universitas Pangan dan Gizi, Yogyakarta, 1988).
29. N. Bhumiratana and A. Koushik, *Green Coffee Beans to Brewed Coffee: Evolution of Coffee Aroma*,: (Kansas State University, Manhattan, 2011).
30. I. Flament, *Coffee Flavor Chemistry*, (John Wiley and Sons Ltd, England: 2001).
31. M. Hafezi, B. Nasernejad and F. Vahabzadeh, "Optimation of Fermentation Time for Iranian Black Tea Production" Iran Journal Chem. Eng. **25**, 39-44 (2006).
32. W. Sunarharum, D. William and H. Smyth, "Complexity of Coffee Flavor: A Compositional and Sensory Perspective" Food Research International **62**, 315-325 (2014).
33. H. Winarsi, *Antioksidan Alami dan Radikal Bebas, Potensi dan Aplikasinya dalan Kesehatan.* (Kansius. Jakarta, 2007).
34. F.G. Winarno, *Kimia Pangan dan Gizi*. (PT Gramedia Pustaka Utama, Jakarta, 2004).
35. L.M. Votavova, Voldrich, R. Sevcik, H. Cizkova, J. Mlejnecka, M. Stolar, Fleisman. “Change of Anioxidant Capacity of Robusta Coffee During Roasting”. Jurnal Food Science **27**, 1-4 (2009).