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Physical Mechanical Characteristics of Robusta Coffee Beans With Temperature Treatment and Roasting Time

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ABSTRACT

Lombok is one of the coffee-producing areas with a large planting area spread across several districts. Looking at the large area of coffee plants, it is hoped that this can maximize coffee processing. One of the coffee processing areas that is of concern is the roasting process, which is important in forming the distinctive aroma and taste image of coffee. Efforts to maintain coffee quality are carried out by controlling the temperature and roasting time under optimal conditions purpose of this study the effect of temperature and roasting time on the physical and mechanical properties of Robusta coffee beans in Karang Sidemen Village, North Batukliang District, Central Lombok Regency District, Central Lombok Regency. This research used a completely randomized design with a factorial pattern with two variables, namely roasting temperature and roasting time. The observation data was analyzed using a variety of fingerprints produced which were significantly different at the 5% level in several tests carried out, namely the degree of acidity (pH), water content, seed yield, and hardness. The results of the research showed that the best treatment to produce the physical and mechanical characteristics of Robusta coffee beans was at a temperature of 190°C with a roasting time of 12 minutes, namely having a yield of 91.48%, pH 5.53, hardness of 53.77%, color L(Lightness) 33.28, water content 1.35%, and the lowest total value of minimum defective seeds was 18.05 (quality 2).
Keywords: Coffee, Robusta, Roasting, Mechanics Physical

ABSTRAK

Lombok merupakan salah satu daerah penghasil kopi dengan memiliki luas area tanaman yang tersebar di beberapa Kabupaten. Melihat dari perluasan area tanaman kopi tersebut diharapkan dapat memaksimalkan dalam pengolahan kopi. Salah satu pengolahan kopi yang menjadi perhatian adalah proses penyangraian, dimana tahapan ini penting dalam pembentukan aroma dan citra rasa khas pada kopi. Upaya untuk mempertahankan mutu kopi maka dilakukan dengan mengendalikan suhu dan waktu penyangraian pada kondisi yang optimal. Penelitian ini bertujuan untuk mengakaji pengaruh suhu dan waktu peyangraian terhadap sifat fisik dan mekanis biji kopi robusta di Desa Karang Sidemen, Kecamatan Batukliang Utara, Kabupaten Lombok Tengah. Penelitain ini menggunakan Rancangan Acak Lengkap pola faktorial dengan dua variabel, yaitu suhu penyangraian dan waktu penyangraian. Data hasil pengamatan dianalisis dengan analisis sidik ragam dihasilkan berbeda nyata pada taraf 5% pada beberapa pengujian yang dilakukan, yaitu derajat keasaman (pH), kadar air, randemen biji, kekerasan. Hasil penelitian menunjukkan bahwa perlakuan terbaik untuk menghasilkan karakteristik fisik mekanis biji kopi robusta pada perlakuan suhu 190°C dengan waktu penyangraian 12 menit, yaitu memiliki rendemen sebesar 91,48%, pH 5,53, kekerasan 53,77%, warna L(Kecarahan) 33,28, kadar air 1,35% dan total nilai biji cacat minimum yang terendah 18,05 (mutu 2).

Keyword: Kopi, Robusta, Penyangraian, Fisik

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1.Introduction

Coffee is the most widely cultivated flagship plantation commodity in Indonesia. Lombok Island has become one of the regions with fairly abundant coffee production. Coffee plantations in Lombok cover a quite extensive area, Spread across several districts, Namely Central Lombok 1,131 hectares, West Lombok 626 hectares, North Lombok 1,353 hectares, And East Lombok 2,048 hectares. (BPS Nusa Tenggara Barat, 2018). Seeing this potential, It is hoped that Lombok coffee can be explored and accepted as an export commodity. To support and strengthen the identity of Lombok coffee, The strategy taken is through its proper processing. This processing method aims to maintain the quality and superiority of the coffee so that it can be accepted by a wider market and compete effectively with other similar products in the coffee industry. (Murad et al., 2019)Roasting is an important component in forming coffee's characteristics. Without the roasting process, the quality of the coffee beans will not meet the established standards.

Coffee roasting aims to create specific organoleptic properties such as aroma, taste, And color from the quality of the coffee beans. Therefore, The roasting phase is a crucial phase for bringing out the taste and aroma characteristics of the coffee.(Amri et al., 2020). The roasting process not only affects the physical properties of the coffee beans but also influences their chemical properties, Which can enhance the flavor and aroma of the coffee beans. Therefore, What needs to be considered in this roasting process is how to control the temperature and time during the roasting. Differences in roasting temperature and time for each batch result in varying quality of robusta coffee beans, Thus requiring control in the roasting process. Efforts to enhance added value and desired characteristics require controlling the roasting process by adjusting the temperature and time, Thereby avoiding quality degradation caused by over-roasting and preventing the emergence of undesirable flavors. From this foundation, It is necessary to monitor the temperature and time of coffee roasting about physical-mechanical characteristics to determine the optimal conditions for higher-quality coffee beans.

Research Purposes
The purpose of this studied the effect of temperature and roasting time on the physical and mechanical properties of Robusta coffee beans in Karang Sidemen Village, North Batukliang DisThe purpose of this study the effect of temperature and roasting time on the physical and mechanical properties of Robusta coffee beans in Karang Sidemen Village, North Batukliang District, Central Lombok Regencytrict, Central Lombok Regency.

2. Research Materials And Methods

The ingredients used in this research were robusta coffee beans in Karang Sidemen Village, North Batukliang District, Central Lombok Regencytrict, and Central Lombok Regency. The tools used in this research were grinder, roaster, hardness tester, colorimeter, term digital, analytical balance, oven, stopwatch, desiccator, moisture meter, digital camera, pH meter, magnetic stirrer, measuring cup, beaker, filter paper, caliper, Coffee packaging in aluminum foil standing pouch size 16 × 24 cm.

The model that is used in this research is a Completely Randomized Design with a factorial arrangement with two variables: the first variable is the roasting temperature, which includes three levels 180 ℃ (S1), 190 ℃(S2), and 200 ℃ (S3), while the second variable is the roasting duration, which also consists of three levels: 8 minutes (T1), 10 minutes (T2), and 12 minutes (T3). The research stages start with preparing 29 kg of robusta coffee beans with a moisture content of 12% (wb), which have been hulled. The coffee beans were then manually sorted to remove foreign objects such as stones and to select intact or unbroken coffee beans, resulting in approximately 27 kg of coffee beans for 9 experiments, each weighing 1 kg with three repetitions. Then the coffee beans are sorted using the SNI 01-2907-2008 method for physical quality testing, which includes the presence of live insects, odor (rotten and moldy), defect value, and coffee bean impurities. This sorting is done by taking 300 grams of coffee beans, and then separating the good beans from the damaged or defective ones. The number of defective coffee beans is then counted. The total defect value obtained is summed up and expressed as the total defect value to determine the quality category according to SNI. After the coffee beans are sorted and the defect assessment is completed, they are then placed into aluminum foil standing pouch packaging. Prepare theroasting machine before the samples are inserted. This machine has a roasting capacity of 1-3 kg with a time control limit of 0 to 60 minutes and a temperature control limit of 0 to 250°C. Next, the roasting process is carried out by inserting one kilogram of coffee beans into the machine per

sample, resulting in a total of 27 kg of roasted coffee beans used in this study. The roasted coffee beans are then removed from the machine and cooled for 10 minutes while being stirred to dissipate the heat from the roasting process. After cooling, the coffee beans were weighed again to determine the weight loss during roasting and then ground with a grinder until a specific powder size was obtained.

Then the observation continued with a physical observation of the coffee bean moisture content using the oven method. (SNI 01-2907-2008). Next, Measure the color value of brightness level L (Andarwulan et al., 2011), the acidity of coffee beans pH (AOAC.2012), and hardness testing on coffee beans using a hardness tester. Objective observations were made through physical examination of the yield of roasted coffee beans using a scale.

3. Results and Discussion

3.1 Value Of Coffee Bean Defects

The test results of the average robusta coffee beans in this study did not find foreign objects such as stones and were free from live insects and odor (rot and mold). Based on the analysis results, The impurity content of the coffee bean samples did not exceed 0.50%. (Table 1).

Table 1. Value Of Coffee Bean Defects

No	Type Of Defect	Treatment		
		defective value	**S3T3**	**S2T3**
1	1 (one) brown coffee beans	0.25	0.76	0.13
2	1 (one) medium-sized coffee husk	0.50	0.2	0
3	1 (one) small-sized coffee husk	0.20	0.32	0.17
4	1 (one) large-sized coffee bean horn skin	0.50	0.18	0
5	1 (one) medium-sized coffee bean horn skin	0.10	0.34	0.52
6	1 (one) Biji Pecah	0.20	22.78	17.23
quality quantity			24.58	18.05
Quality Category			2	2

Information : S3T3= 200 ^{0}C, 12 minutes ; S2T3= 190 ^{0}C, 12 minutes

Based on the research results above, in general, the best quality robusta coffee beans are produced under treatment S2T3 (190 °C, 12 minutes) with a total defect value of 18.05 (quality 2), while the lowest total defect value is obtained under treatment S3T3 (200 °C, 12 minutes) with a value of 24.58 (quality 2). From the analysis data, it shows that the total quality value of class 2 ranges from 18 to 25. Based on the defect value criteria in SNI, which is from 12 to 25 for class 2, all samples in this study meet class 2 quality. Quality 2 is considered quite good in the whitening of coffee beans. The categories of defects that occur in this study may be due to the processing of coffee beans, which causes the beans to easily break, have husked skins, and turn brown. Broken coffee beans can be categorized as defective beans because if these beans are roasted together with whole beans, they will affect the taste and aroma of the brewed robusta coffee.

The defect of cracked beans occurs during the peeling of the parchment skin, specifically if the huller does not work perfectly. This is in line with the statement of (Novita et al., 2010) that cracked seed defects can also be caused during the peeling of coffee fruit skin. (pulping). This is due to the differences in the physical characteristics of coffee cherries, which vary in shape and size, potentially causing the removal of the parchment along with the fruit skin. As a result, coffee beans are more prone to physical damage and changes

in flavor compared to beans still protected by the parchment. Maintaining the quality and good grade of coffee will be easily accepted by consumers, allowing the price to compete in the global market with similar products. Quality is a characteristic that a product must possess to distinguish it from other products by consumer expectations (Muzaifa et al., 2016).

3.2 Yield of Robusta Coffee Beans

Table 2. Robusta Results of the Duncan's Multiple Range Test (DMRT) On The Yield Of Robusta Coffee Beans (%)

Roasting Time (minutes)	Roasting Temperature ^{o}C			Average
	180	190	200	
8	82.30	82.63	79.66	81.53^{c}
10	81.16	87.18	81.60	83.30^{b}
12	82.69	91.48	82.26	85.49^{a}
Average	82.05^{b}	87.10^{a}	81.86^{a}	

Information: Different letters after the average value indicate a significant difference in the Duncan test (P < 0.05).

Based on the results of the analysis of variance in Table 2, the roasting time has a significant effect (P<0.05) on the yield of roasted robusta coffee beans, and the interaction of treatments significantly affects the yield of roasted robusta coffee beans. Based on the average yield of roasted coffee beans, coffee beans roasted for 12 minutes produced a higher yield of 85.49%, compared to roasting for 10 minutes which resulted in 83.30%, and roasting for 8 minutes which resulted in 81.53%. Additionally, Table 2 shows an interaction between the treatment at 190°C and the roasting time of 12 minutes, which produced the highest yield of 91.48%, significantly different from the treatment at 200°C for 8 minutes which resulted in the lowest yield of 79.66%. Therefore, the high and low yield of coffee beans depends on the duration and temperature of the roasting. The longer the roasting time and the higher the temperature used, the greater the weight loss of the coffee beans. The roasting process of coffee beans also results in the evaporation of volatile compounds such as esters, ketones, and aldehydes, thereby affecting the yield value of the coffee beans.

3.3 pH value

Table 3. The results of the Duncan's Multiple Range Test (DMRT) On The Acidity Degree Test Of Robusta Coffee Beans

Roasting Time (minutes)	Roasting Temperature ^{o}C			Average
	180	190	200	
8	5.20	5.34	5.39	5.24^{c}
10	5.16	5.55	5.65	5.47^{b}
12	5.38	5.53	5.73	5.59^{a}
Average	5.31^{c}	5.45^{b}	5.55^{a}	

Information: Different letters after the average value indicate a significant difference in the Duncan test (P < 0.05).

Table 3 shows the results of the analysis of temperature and roasting time on the acidity level of robusta coffee beans. The average pH value of robusta coffee beans at a treatment temperature of 200°C is higher, at 5.55, compared to 180°C which results in a pH of 5.31, and 190°C which results in a pH of 5.45. Additionally, the pH value of robusta coffee beans at a roasting time of 12 minutes shows a significant difference compared to roasting times of 8 and 10 minutes. The average pH of robusta coffee beans roasted for 12 minutes is higher, at 5.59, compared to 10 minutes which results in a pH of 5.47, and 8 minutes which results in a pH of 5.24. The table also shows an interaction between the treatment at 200°C and a roasting time of 12 minutes, which results in the highest pH of 5.73, significantly different from the treatment at 180°C for 12 minutes which results in the lowest pH of 5.16. The increase in temperature and roasting time will cause a rise in pH, which is due to the degradation of important compounds contained in coffee beans. This is in line with the statement. (Pamungkas et al., 2021) Which states that the acidity level of coffee will be affected by the roasting level; the higher the roasting level, the more the pH of the coffee tends to increase.

The pH value found in robusta coffee beans indicates the amount of acid content present in those coffee beans.

The acids that form the pH value are free acids resulting from the release of glycosidic bonds (Widyotomo et al., 2009). Acidic compounds in coffee beans are formed during the roasting process, where these acids are transformed into acetic acid, malic acid, citric acid, and phosphoric acid, which contribute to the formation of acidity in coffee. Coffee with a pH above 4 is considered safe and suitable for consumption; therefore, the variations in roasting temperature and duration in this study produced coffee with a pH above 4 that meets the quality standards for consumption and complies with the Indonesian National Standards. (SNI).

3.4 Moisture Content

Table 4. Results of the Duncan's Multiple Range Test (DMRT) On The Moisture Content Of Robusta Coffee Beans (%)

Roasting Time (minutes)	**Roasting Temperature ^{o}C**			**Average**
	180	**190**	**200**	
8	1,42	1,38	1,37	1,39^{a}
10	1,38	1,38	1,35	1,37^{ab}
12	1,36	1,35	1,25	1,32^{b}
Average	1,38^{a}	1,37^{a}	1,32^{b}	

Information: Different letters after the average value indicate a significant difference in the Duncan test (P < 0.05).

Table 4 shows that the average moisture content in the treatment with an 8-minute roasting time is higher, At 1.39%, compared to the 10-minute roasting time which results in 1.37%, and the 12-minute roasting time which results in 1.32%. Additionally, the table also shows that the interaction between 200°C temperature and 12-minute roasting time results in the lowest moisture content, at 1.25%, which is significantly different from the treatment at 180°C for 8 minutes results in the highest moisture content, at 1.48%. The phenomenon of decreasing moisture content during the roasting process is related to the rate of water diffusion within the coffee bean cell structure. The lower the water content in the coffee beans, the slower the evaporation rate because the water molecules are positioned further from the surface of the beans. (Sutarsi et al., 2016). Based on the table above, it shows that the moisture content does not exceed 2% and is by the Indonesian National Standard (SNI 01-3542-2004) which states that the maximum moisture content of ground coffee is 7%.(bb).

3.5 Color (CIELAB)

Table 5. Results of the Duncan's Multiple Range Test (DMRT) On The Color Of Robusta Coffee Beans

Roasting Time (minutes)	**Roasting Temperature ^{o}C**			**Averag e**
	180	**190**	**200**	
8	26.64	32.69	30.31	29.88^{c}
10	25.41	34.76	32.25	30.80^{b}
12	30.16	33.28	32.42	31.95^{a}
Average	27.40^{c}	33.58^{a}	31.66^{b}	

Information: Different letters after the average value indicate a significant difference in the Duncan test (P < 0.05).

The results of the analysis of variance show that the average color value of robusta coffee beans at a temperature treatment of 190°C is higher, at 33.58, compared to a roasting temperature of 200°C which yields a value of 31.66 and a temperature of 180°C which yields a value of 27.40. The color value of robusta coffee beans with a roasting time of 12 minutes shows a significant difference compared to roasting times of 8 and 10 minutes. Based on the average values, the color of robusta coffee beans roasted for 12 minutes is higher, at 31.95, compared to the 8-minute roasting time which yields 29.88, and the 10-minute roasting time which yields 30.80. Table 5 shows an interaction between the treatment at 190°C and the roasting time of 10 minutes, which resulted in the highest L color value, namely 34.76, significantly different from the treatment at 180°C for 10 minutes which resulted in the lowest value, namely 25.41. The decrease in L value indicates that the color of the coffee beans becomes darker during the roasting process. The color change to dark brown occurs because, during roasting, coffee beans undergo the Maillard reaction. This reaction leads to the formation of compounds with carbonyl groups (reducing groups) and amino groups. This process results in a non-enzymatic browning reaction that produces complex compounds known as melanoidins. The brown color change in the

heated coffee beans is an indication of the presence of melanoidins.

3.6 Hardness

Table 6. The results of Duncan's multiple range test (DMRT) On The Hardness Of Robusta Coffee Beans

Roasting Time (minutes)	Roasting Temperature ^{o}C			Average
	180	190	200	
8	45.28	41.08	42.80	43.05^{b}
10	49.58	41.02	43.25	44.62^{b}
12	48.07	53.77	44.67	48.83^{a}
Average	47.64^{a}	45.57^{ab}	43.57^{b}	

Information: Different letters after the average value indicate a significant difference in the Duncan test (P < 0.05).

Table 6 shows that the average hardness value of robusta coffee beans with a roasting temperature of 180°C is significantly different from the roasting times of 190°C and 200°C. The treatment with a roasting temperature of 180°C resulted in a higher hardness value of 47.64 compared to the 190°C treatment, which resulted in 45.57, and the 200°C treatment, which resulted in 43.57. From the table above, it can be seen that the interaction between 190°C and a roasting time of 12 minutes resulted in the highest hardness of 53.57, which is significantly different from the 190°C treatment for 8 minutes, resulting in the lowest hardness of 41.08. Based on the three roasting temperature variations tested, the higher the temperature applied, the lower the hardness of the material.

This indicates that the roasting temperature affects the hardness level of the material. The temperature used in roasting influences the rate of moisture reduction in the material, Which in turn affects the change in material hardness. This is in line with (Supriana et al., 2020), Who stated that roasting coffee at different temperature variations will cause changes in the physical properties of the coffee beans, Leading to faster moisture reduction, increased brittleness, And accelerated color change. Coffee beans roasted at higher temperatures tend to have lower average breakage tension values. Conversely, Coffee beans roasted at lower temperatures show higher average breakage tension values. When the roasting temperature is higher, The moisture content in the material decreases more quickly, Making it easier for the coffee beans to break apart. (Nugroho et al., 2009).

4. Conclusions and Recommendations

4.1 Conclusions

The physical-mechanical characteristics of robusta coffee beans influenced by roasting temperature and time show a significant effect on the degree of acidity (pH) and L value (Lightness), but roasting temperature does not affect yield and moisture content. The interaction between roasting temperature and time significantly affects the physical-mechanical characteristics of robusta coffee beans at a 5% level, influencing moisture content, yield, acidity (pH), hardness, and color. The best treatment to produce the physical-mechanical characteristics of robusta coffee beans was found at a temperature of 190°C with a roasting time of 12 minutes, resulting in a yield of 91.48%, pH 5.53, hardness of 53.77%, L color value (brightness) of 33.28, moisture content of 1.35%, and the lowest total defect value of 18.05 (quality 2).

4.1 Recommendations

To obtain more comprehensive results, it is recommended that future research includes parameters of chemical characteristics and organoleptic tests.

References

Amri, A. F., Herawati, E. R. N., Nurhayati, R., & Susanto, A. (2020). Identifikasi Profil Kualitas Kopi Sebagai Acuan Pengembangan Produk Spesialti Di Kawasan Menoreh, Kulon Progo, Yogyakarta. *Indonesian Journal of Industrial Research*, *15*(1), 17–28.

Andarwulan, N., Kusnandar, F., & Herawati, D. (2011). Analisis pangan. In *Dian Rakyat. Jakarta* (Vol. 3).

Murad, M., Sukmawaty, S., Sabani, R., Ansar, A., & Kurniawan, H. (2019). Introduksi TTG Pasca Panen

dan Pengolahan Kopi pada Industri Rumah Tangga Guna Meningkatkan Nilai Tambah di Kecamatan Tanjung Kabupaten Lombok Utara. *Jurnal Ilmiah Abdi Mas TPB*, *2*(1), 339201.

Muzaifa, M., Patria, A., Bakar, A. A., Rahmi, F., Hasni, D., & Sulaiman, I. (2016). *Kopi Luwak: Produksi, mutu dan permasalahannya*. Syiah Kuala University Press.

Novita, E., Syarief, R., Noor, E., & Mulato, S. (2010). Peningkatan mutu biji kopi rakyat dengan pengolahan semi basah berbasis produksi bersih. *Jurnal Agroteknologi*, *4*(01), 76–90.

Nugroho, J., Lumbanbatu, J., & Rahayoe, S. (2009). Pengaruh suhu dan lama penyangraian terhadap sifat fisik-mekanis biji kopi robusta. *Seminar Nasional Dan Gelar Teknologi Faperta. UGM*.

Pamungkas, M. T., Masrukan, M., & Kuntjahjawati, S. A. R. (2021). Pengaruh suhu dan lama penyangraian (roasting) terhadap sifat fisik dan kimia pada seduhan kopi arabika (coffea arabica l.) dari Kabupaten Gayo, Provinsi Aceh. *Agrotech: Jurnal Ilmiah Teknologi Pertanian*, *3*(2), 1–10.

Supriana, N., Ahmad, U., Samsudin, S., & Purwanto, E. H. (2020). Pengaruh metode pengolahan dan suhu penyangraian terhadap karakter fisiko-kimia kopi robusta. *Jurnal Tanaman Industri Dan Penyegar*, *7*(2), 61.

Widyotomo, S., Mulato, S., Purwadaria, H. K., & Syarief, A. M. (2009). Karakteristik proses dekafeinasi kopi Robusta dalam reaktor kolom tunggal dengan pelarut etil asetat. *Pelita Perkebunan*, *25*(2), 101–125.