Characteristics of roasting arabica and robusta coffee beans with rotary cylinder tube roast machine with electric heat source

Characteristics of roasting arabica and robusta coffee beans with rotary cylinder tube roast machine with electric heat source

Syafriandi, A Lubis*, R Fadhil, O Paramida
Department of Agricultural Engineering, PUSMEPTAN Syiah Kuala University, Indonesia

*Corresponding author, Email : andriani_loebis@unsyiah.ac.id

Abstract. Arabica and Robusta coffee beans have physical differences in general. In the process of roasting coffee beans with different physical forms, it is possible that there will be differences in the roasting temperature and water content of the beans after the roasting process. Arabica and Robusta coffee beans have physical differences in general. In the process of roasting coffee beans with different physical forms, it is possible that there will be differences in the roasting temperature and water content of the beans after the roasting process. In brewing coffee, it can also be affected by the roasting process. There are several factors that need to be considered in the roasting coffea bean namely early moisture of coffea beans, temperature in the roaster and the time it takes for the coffee beans to ripen as desired. The use of heat energy to get a specific aroma and taste in coffee beans is very necessary. The objective of the research is to determine how the criteria of the roast of Arabica coffea beans and Robusta coffee beans using cylindrical roaster rotates with electrical energy as its heat source. The results obtained at the treatment temperature of 205°C using a rotating cylinder tube coffee roaster using an electric heat source takes 78 minutes to reach coffee maturity with a dark roast level of maturity. Analysis of the color of coffee beans after roasting, it was found that Arabica coffee and Robusta coffee were more dominant, showing on the color track-60 with the Agtron Color Classification System scale, where the initial moisture content of dry robusta beans is 12.50% reduced to 3.66% after roasting, while the initial moisture content of arabica beans is 12.36% reduced to 3.54%.

1. Introduction

One of the agricultural products of Aceh Province is coffee, especially from the Gayo Region. This coffee product has become a strategic commodity for the community to be developed towards the agricultural industry [1,2]. One of the effects is economic growth where coffee is able to improve a series of processing processes from upstream to downstream in coffee products simultaneously and affect other stages of product flow thereby increasing community's income.

The coffee roasting system is an essential phase to realize the characteristic taste and smell of coffee beans [3]. According to [4] stated that coffee roasting is a complex heat transfer process. Reactions that occur during the roasting process such as pyrolysis, oxidation, caramelization and maillard can affect the coffee beans turn brown to blackish and the coffee tastes different according to the treatment.

According to [5] stated that roasting is a method used in coffee bean material using a certain heat source to increasing the color of the coffee as expected so that a distinctive smell and taste is obtained from the coffee beans. There are three scale levels in the roasting process, namely the lowest level of roast maturity (light roast) with a roasting temperature of around 193 ^{o}C-199 ^{o}C, a medium roast level of maturity (medium roast) with a roasting temperature of around 204^{o}C, and the highest level of roast maturity (dark roast) with roasting temperature 205^{o}C-220^{o}C.

The length of the coffee bean roasting time, the weight will decrease due to the reduced water content [6]. One of the important scales in paying attention to the quality of a product is color. Good taste and aroma can be seen from the change in color of the coffee beans when roasted [7].

Roasting with a high temperature and length of time will tend to reduce the water content.The water content will evaporate and decrease in the test materials along with the length of the roasting process. Based on the research showed that there was a relationship between the heating medium and the product material, namely the high temperature difference can accelerate the rate of evaporation. This is due to transfer of heat energy from the heat source to the test material. The reducing of the amount of water in

the coffee beans material during the roasting process were varies from 1 to 5% which is influenced by product ingredients, high temperature, and time of roasting, as well as cooling treatment [8,9].

Closed roasting has the benefit of forming a special aroma and changing the taste of coffee beans. This is because coffee beans are not affected by external odors, especially burning fuel or gas [10].

For better quality coffee beans, improvements and development of coffee bean roasters are carried out starting from a simple method of using manual roasting to using an automatic roaster that can be controlled by heat in the roasting tube and the length of time for drying coffee beans. The roasting process of coffee beans is influenced by temperature, time, the machine used and the type of fuel or heat source. A coffee roaster with a gas heat source takes 20 to 30 minutes to roast. While the rotary cylinder type roaster with a gas heat source takes 1 hour for 12.3 kg of coffee beans [11]. The use of a roaster with a gas-based heat source is technically cost-effective, in addition, there is also a roaster using electric power.

Coffee roasting research using an electric heat power is able to produce coffee beans with dark roast quality at a temperature of 205^0C with a roasting time of 90 minutes. Another study using a cylindrical tube type roaster takes 40 to 50 minutes to raise the temperature to 205^0C [12]. The objective of this study was to the differences characteristics of Arabica and Robusta coffee roasting using a Rotary Cylindrical Tube Roaster with a heat source, namely electricity.

2. Material and Methods

Several stages of implementation in this study started from determining the water content of the test materials to be roasted at >12%. Next, roast the test material namely coffee beans in a roasting tube with a temperature of 205^0C. The capacity of this cylindrical type roaster is 5-10 kg [13]. The power used by this roaster is 1800 watts. Figure 1 shows a cylindrical tube type coffee roaster. This coffee bean roaster experiment was tested on two coffee varieties namely Arabica and Robusta, carried out 3 times for each roasting. The data is taken after 6 minutes when the machine is turned on as the first roasting until the last roasting is indicated by the color of the coffee beans is dark roast. Observations were made on the parameters of temperature, time, moisture content of the coffee bean material, moisture content, electrical power requirements and the color of the agtron scales.

Figure 1. Electric heat source roaster with a power of 1800 watts.

3. Result and Discussion

3.1. Temperature and length of coffee roasting time

Robusta coffee beans roasting from initial temperature to maturity takes 114 minutes (Figure 2). The time required for roasting ranges from 36 minutes, then the temperature in the roasting tube reaches 205^0C with an average temperature increase of 4.69^0C per minute. Furthermore, when the tube temperature has reached 205^0C the tested materials are introduced into the roasting tube. There was a decrease in the heat energy in the roasting tube when the coffee beans were first inserted, namely the

temperature in the tube to 160^{0}C at 42 minutes. Roasting coffee beans in this cylindrical type roaster tube took 78 minutes so that the coffee matured at the dark roast color level. .

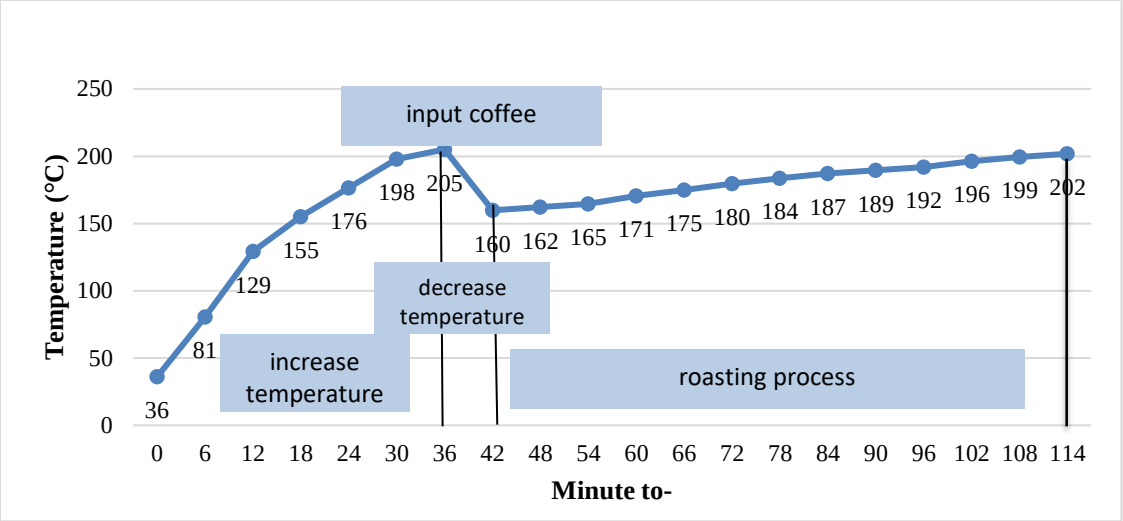

Figure 2. Robusta coffee roasting temperature graph against time.

Roasting coffee beans at an initial temperature of 36^{0}C to 205^{0}C takes 36 minutes with a temperature increase rate of 4.69^{0}C per minute as shown in Figure 3. The temperature in the tube when there are no ingredients or coffee beans has increased quite significantly. Furthermore, when the temperature in the roasting tube reaches 205^{0}C, the coffee beans are inserted, the temperature in the tube decreases to 156^{0}C at 42 minutes. Furthermore, the temperature continues to increase and it takes 78 minutes for the coffee beans to ripen and the color of the coffee beans to dark roast.

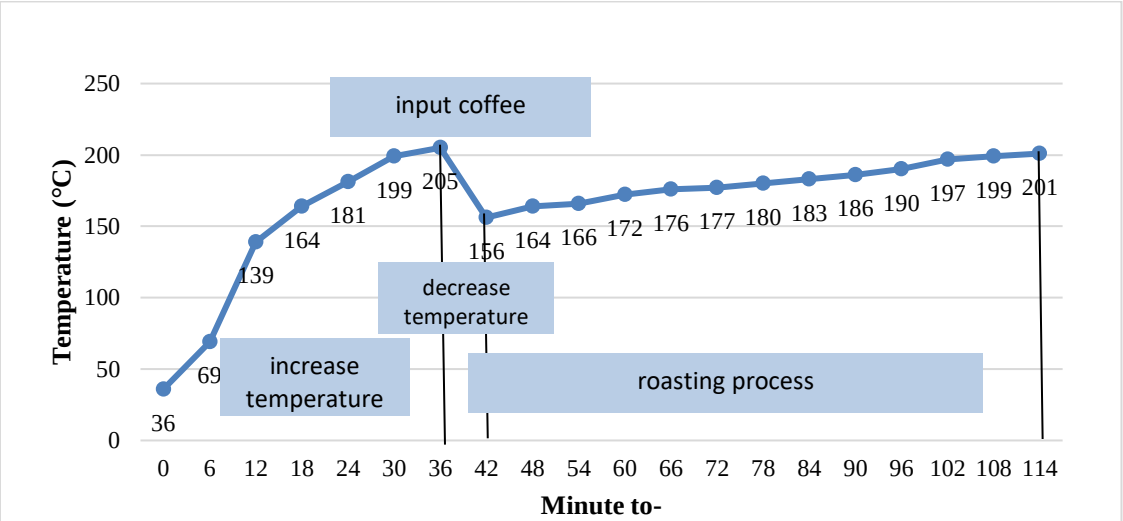

Figure 3. Arabica coffee roasting temperature graph against time.

In the coffee roasting process, heat transfer occurs by conduction and convection. The conduction process occurs when the roasted coffee beans are heated directly by the walls of the roasting tube made of stainless steel, while the convection process occurs when air flows that carry heat energy into the roaster tube and heat the coffee beans. The coffee roasting process using a rotating cylindrical tube roaster with an electric heater with a roasting temperature of 205 ^{o}C is able to roast coffee to a dark roast level of maturity and takes 78 minutes. Roasting coffee with a rotating cylinder tube coffee roaster using

an electric heat source takes quite a long time. compared to other roasting machines, especially with gas fuel, this is due to the large amount of heat energy that comes out of the engine gaps and the small heater power used.

Roasting different materials based on time, temperature, type of roaster and specific gravity of the material being tested [14]. The roasting time of coffee beans varies according to the roaster used and the desired level of maturity of the tested materials. Roasting coffee beans has an impact on changes in the surface of the coffee beans, there is a degradation of the color of the beans from green to black as an indicator of the final quality of roasting.

Roasting coffee beans to maturity is usually characterized by the presence of the first cracks and the process of discoloration. The coffee beans turn yellow due to the reaction of carbon dioxide gas and water that evaporates from the beans. This process can be characterized by a crunchy sound like the sound of cracked beans [15]. This event is very basic because all the characteristics, aroma and taste of coffee beans begin to form

3.2. Electrical energy

This experiment uses a roaster with a power source using electrical energy and secondly as a driving force for the drum cylinder player so that the coffee beans can be stirred in the tube.

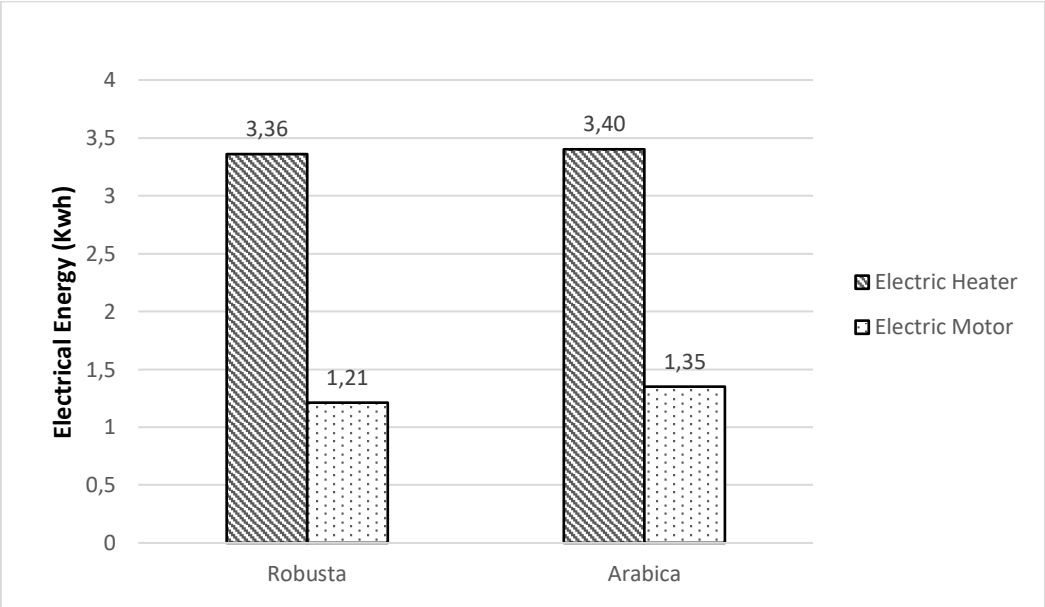

Figure 4. Electrical energy requirements for heaters and electric motors in coffee roasters.

There are differences in the electrical energy used in each type of coffee, which can be seen in Figure 4. The electrical energy requirement for the roasting of robusta coffee at the dark roast level is 3.36 kwh, and the electric energy of the motor is 1.21 kWh. Furthermore, the electrical energy in the Arabica coffee type is 3.40 kWh on average, then the electrical energy for roasting is 1.35 kWh.

The need for electrical energy in the heater is greater than the energy requirements for the electric motor. This is because the energy required by the heater to heat the temperature up to 205 ^{o}C in the roasting tube is greater than the energy used by the electric motor to rotate the cylinder tube in the coffee stirring process. The results of the analysis of electrical energy requirements testing for two types of coffee beans, namely Robusta coffee beans and Arabica coffee beans, it can be concluded that the need for electrical energy will be greater if the temperature used for roasting is higher.

3.3. Water content

In Figure 5 it can be seen that the initial moisture content of Robusta and Arabica coffee beans before roasting were 12.50% and 12.36%, respectively. Roasting robusta coffee beans decreased the moisture content in the 6th minute from 12.50% to 11.90% at 205°C. Gradually the water content of Robusta coffee beans continues to decrease to 3.66% within 78 minutes. During roasting, the water content of Robusta coffee beans decreased by 7.49%/hour. Meanwhile, in the roasting of Arabica coffee beans, the water content decreased from 12.36% to 11.60% in the 6th minute at 205°C, and the final moisture content became 3.54% for 78 minutes. When roasting occurs, the water content of Arabica coffee beans decreases at a rate of 7.47%/hour.

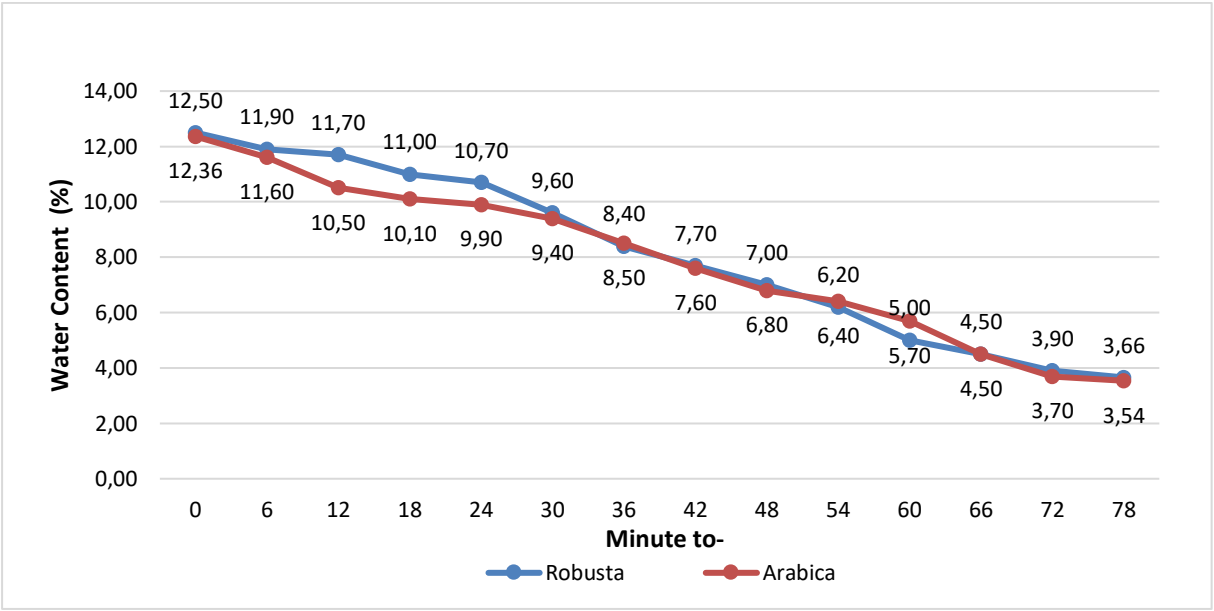

Figure 5. Decrease in Water Content of Coffee Beans When Roasted.

At high temperatures, the water content decreases in value. The higher the temperature, the more heat energy will transfer to the product so that the increase in temperature also triggers the heating of the product [16]. The water content of the coffee beans can evaporate during the roasting process with the required time of 78 minutes. According to [17], in dark roasting, the initial moisture content of coffee beans will be lost by 8 to 14%. Roasting coffee with various temperatures will result in changes in the physical characteristics of coffee beans, namely a faster decrease in water content, increased fragility of beans and accelerates changes in the dark color of coffee beans.

3.4. Color

The results of color testing, Panelists provide two color choices according to the Agtron Color Classification System from SCAA (Specialty Coffee Association of America), namely Color track-60 and Color track-65

Table 1. Coffee bean color assessment after roasting.

Numbers	Panelists	Color scale			
		Robusta		Arabica	
1.	Aqilla Coffe Roastery	*Color track*-60		*Color track*-60	
2.	Outlet Ulee Kareng Coffee	*Color track*-60		*Color track*-65	
3.	Asaa Coffee	*Color track*-60		*Color track*-60	
4.	Bay Coffee Roastery	*Color track*-60		*Color track*-60	
5.	Black Beans Koffie	*Color track*-60		*Color track*-60	

Based on Table 1, it can be concluded that the color of coffee beans after roasting on Robusta and Arabica coffee beans for the dark roast maturity level with a temperature of 205 ^{o}C tends to be the same as the color track-60. The color of the Arabica coffee beans after roasting according to one panelist matches the color track-65. The color track-60 scale shows an agtron value of 40-45 where dark brown coffee beans are produced, while the color track-65 scale shows an agtron value of 40-35 which produces very dark brown coffee beans. According to [18], the color of roasted coffee beans can vary depending on the length of roasting time and roasting temperature, air pressure in the roasting chamber and the type of coffee beans being roasted.

4. Conclusions

The roasting results showed that the roasting temperature of Arabica and Robusta coffee beans occurs at 205^{o}C in 114 minutes. The time it takes to raise the temperature in the roasting cylinder was 36 minutes, with a roasting process of 78 minutes. After roasting, a color analysis test was carried out on both types of coffee beans. The results show that the dominant coffee bean color is seen in the color trajectory-60 with the Agtron Color Classification System Scale. Robusta water content analysis results coffee beans before roasting 12.50% decreased to 3.66%, while Arabica coffee beans have a water content of 12.36%, down to 3.54%.

Acknowledgment

The authors would you like to thank the LPPM (Institute for Research and Community Service) Syiah Kuala University for funding this research.

REFERENCES

[1] Fadhil R, Maarif M, Bantacut T and Hermawan A 2017 Assessment of Innovation Potential of Gayo Coffee Agroindustry Qual. Innov. Prosper. 21 114–26
[2] Fadhil R, Maarif, M.S., Bantacut, T. and Hermawan, A. (2018b). A prospective strategy for institutional development of Gayo coffee agroindustry in Aceh province, Indonesia. Bulgarian Journal of Agricultural Science 24(6), 959–966
[3] Amri, A. F., Herawati, E. R. N., Nurhayati, R., dan Susanto, A. 2020. Identification of coffee Quality Profile as a Reference for Speciality Product Development in menorah Area, Kulon Progo, Yogyakarta. Jurnal Industri Hasil Perkebunan, 15(1), 17-28.
[4] Edvan, B. T., Edison, R., & Same, M. 2016. The Effect of Type and Roasting Time on the Quality of Robusta Coffee (Coffea robusta). Journal of Plantation Agro Industry, 4(1), 31-40.
[5] Bottazzi, D., Farina, S., Milani, M., dan Montorsi, L. 2012. A Numerical Approach For The Analysis of The Coffee Roasting Process. Journal of Food Engineering, 112(3), 243-252.
[6] Fikri, M. K., Prihandono, T., dan Nuraini, L. 2021. Effect of Temperature and Roasting Time on Density of Robusta Coffee Beans Using a Hot Air Roasting Machine. Jurnal Pembelajaran Fisika, 10(1), 29-35.
[7] Sutarsi, S., Rhosida, E., & Taruna, I. 2016. Determination of Coffee Roast Levels Based on Physical Chemical Properties Using Rotary Type Roasting Machine. Proceedings of the APTA National Seminar. Jember.
[8] Cho J S, Bae H J, Cho B K and Moon K D 2017 Qualitative properties of roasting defect beans and development of its classification methods by hyperspectral imaging technology Food Chem. 220
[9] Yüksel A N, Özkara Barut K T and Bayram M 2020 The effects of roasting, milling, brewing and storage processes on the physicochemical properties of Turkish coffee Lwt 131 1–8
[10] Afriliana, A. 2018. The Latest Coffee Processing Techniques. Deepublish: Yogyakarta.
[11] Da Silva C Q, Fernandes A da S, Teixeira G F, França R J, Marques M R da C, Felzenszwalb I, Falcão D Q and Ferraz E R A 2021 Risk assessment of coffees of different qualities and degrees of roasting Food Res. Int. 141
[12] Syafriandi, Fachruddin,F., Lubis, A., Maulina, H., and Nazura, P. 2021. Testing coffee roasting machine with electric heater as energy source. IOP Conf. Ser.: Earth Environ. Sci. 922 012073
[13] Fachruddin, F., Syafriandi, and Fadhil, R. 2021 Temperature coverage simulation of horizontal cylinder type coffee roasting machine. IOP Conf. Ser.: Earth Environ. Sci. 922 012031
[14] Fadri RA, Sayuti K, Nazir N, Suliansyah I. 2019. Review of Coffee Roasting Process and Formation of Acrylamide Related to Health. Journal of Applied Agricultural Science and Technology, 3(1), 129-145.
[15] Herawati D, Giriwono PE, Dewi FNA, Kashiwagi T, Andarwulan N. 2019. Critical roasting level determines bioactive content and antioxidant activity of Robusta coffee beans. Food Science and Biotechnology, 28, 7–14
[16] Nugroho WKJ, Rahayoe S, Meliala EA. 2009. Effect of Time Temperature History on Coffee Aroma During Roasting with Heat Conduction. Proceedings of the 10th International Agricultural Engineering Conference, Bangkok, Thailand, 7-10 December, 2009.
[17] Allesina G, Pedrazzi S, Allegretti F and Tartarini P 2017 Spent coffee grounds as heat source for coffee roasting plants: Experimental validation and case study Appl. Therm. Eng. 126 730–6
[18] SCAA. 2017. Speciality Coffee Association of America. Speciality Coffee Facts and Figures.