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Identifications of Wavelenght, Absorbance and Reflectance of Robusta Coffee During the Postharvest Process

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ABSTRACT

Spectrometer is one of the tools that can produce a spectrum of light with certain wavelengths. A wavelength produced by measurements using a spectrometer will produce absorbance, reflectance and transmittance values. The result of light absorbed by the object is called absorbance, the light reflected by the object is called reflectance, while that which is not absorbed and not reflected by the object is called transmittance. Objective. The purpose of this study was to identify the wavelength, absorbance, reflectance of Robusta coffee and its relationship to color during postharvest process. Spectrometer was using to measure wavelenght, absorbance and reflectance before and after postharvest process. The results obtained shows that the absorbance value of fresh green, fresh yellow and red coffee were 0,98 %, 0.18% and 0.27%, respectively. However, after going through the post-harvest process there is a change in the absorbance value where green coffee that has been dried using the yellow honey method has decreased by 0.92% and the black honey method is 0.38% while yellow and red coffee beans have increased at wavelengths ranging from 300-400 nm and 400-500 nm, as well as roasted coffee. While the reflectance value can be seen that fresh green coffee has a reflectance value of 92%, yellow coffee is 89% and red is 69%. However, after going through the post-harvest process where green and yellow coffee that has been dried using the black honey and yellow honey methods has decreased and red coffee beans have increased at wavelengths around 900-1000 nm, as well as roasted coffee, therefore, can be concluded that the post-harvest process causes the absorbance and reflectance values to change at the same wavelength.These findings are expected could provide the information regarding the change of wavelength, absorbance and reflectance during coffee processing.

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1. INTRODUCTION

One of the mainstay commodities in Indonesia that is growing rapidly is coffee. Coffee plants have different maturity levels and different harvesting times. The level of maturity of coffee fruit is very important, this can affect the quality and chemical compounds present in coffee fruit. In the processing of coffee skin to be used as a useful product, testing is needed to ensure the quality and quality of the material. Tests were carried out on the color of the coffee skin using a colorimeter tool and testing the bioactive content such as tannins, and antioxidants contained in coffee. In addition, wavelength testing was also carried out using a spectrometer to determine the absorbance and reflectance values of coffee fruit before and after treatment. Coffee color testing was also carried out using a colorimeter [1].

Colorimetry is one of the tools used to measure color. Colorimeters are very sensitive to the measured light and some of the many colors absorbed by an object or substance. Colorimeter is a quantitative analysis technique for colored samples used to determine the concentration of a substance based on the color intensity of the solution. Colorimetry is a method of chemical analysis based on the comparison of the intensity of the color of the solution with the color of the standard solution. The color variation of a system changes as the concentration of a component changes, forming the basis of what chemists commonly call colorimetric analysis. The symbol "L" indicates the brightness of the color which has a value ranging from (0), the "+a" value of the color indicates red and "-a" indicates green which ranges from (10-100). The "+b" value indicates a yellow color and "-b" indicates a blue color that ranges from (10-100) [2].

A spectrometer is a device that can produce a spectrum of light with a certain wavelength. Wavelength is defined as the distance traveled by a wave in forming a hill of a certain time interval. The wavelength is symbolized by the Greek letter lambda. A wavelength produced by measurements using a spectrometer will produce absorbance, reflectance and transmittance values. The result of light absorbed by the object is called absorbance, light reflected by the object is called reflectance, while that which is not absorbed and not reflected by the object is called transmittance. The wavelength interval used in measuring reflectance and absorbance of coffee fruit is 800-2500 nm. The higher the absorbance value produced by the material, the reflectance value will decrease, if the reflectance value is large, the absorbance produced also decreases [3].

The working principle of the spectrometer according to the Lambert-Beer law is that when monochromatic light (light consisting of only one type of frequency and uniform wavelength) passes through a material or media, it will cause some of the light to be absorbed by the material, light that is not absorbed will be reflected and light that is missed will be emitted. Absorbance is defined as the polarization of light absorbed by media or chemical components that have a certain wavelength that will give a certain color. A high absorbance value indicates that the intensity of the absorbed light is greater. The requirements of the Lambert-Beer law are when the radiation used must be monochromatic, the radiation energy absorbed by the media does not give a chemical reaction, also the sample (solution) that is absorbed must be homogeneous [4].

The spectrum of light wavelengths absorbed (absorbance) by molecules depends on the difference in the basic energy level with the excited energy of the molecule so that the spectrum of absorbed light can provide information about the difference in energy levels in molecules. In quantum mechanics, the energy level of a molecule is proportional to the energy of light radiation in the form of photons, referred to as photon energy [5].

Coffee processing using the yellow and black honey methods affects color changes. This can be detected by changes in wavelength, absorbance, and reflectance. The yellow honey method involves sorting by immersing coffee cherries in water. Floating cherries are discarded and separated. The submerged cherries are then separated between the outer skin and the mesocarp. The black honey method, on the other hand, involves sorting by separating coffee cherries from impurities. Next, the cherries are immersed and the submerged portion is processed by peeling the skin. Existing research has only identified color changes, without measuring changes in wavelength and reflectance, thereby this research analized the relationship of wavelenght, absorbance and reflectance to color before and after postharvest process..

2. MATERIALS AND METHODS

2.1 Time and Place

This research was conducted from August 23, 2023 to November 2023. Located at the Processing Laboratory, Agricultural Engineering Study Program, Department of Agricultural Technology, Faculty of Agriculture, Hasanuddin University, Makassar.

2.2 Tools

The tools used in this research are a shooting place, petri dish, spectrometer, colorimeter, pulper machine, roasting machine, huller machine, bucket, blender, sack, and leptop.

2.3 Material

The material used in this study is robusta coffee with different maturity levels characterized by different color levels, namely green, yellow, and red. Samples used 20 beans for each treatments.

2.4 Research Procedure

The research procedures carried out in this study are.

2.4.1 Preparation

Prepare coffee with different maturity levels, namely robusta coffee for green (150 days after flowering), yellow (210 days) and red (240 days) from Bantaeng. In this research stage, the samples will be observed when the coffee is still fresh and after processing.

2.4.2 Sortir

Sorting the coffee cherries first to separate the coffee cherries from leaves, twigs and other foreign objects. Wash the coffee cherries thoroughly using running water.

2.4.3 Coffee Spectral Measurement

Take a fresh coffee sample and put it in a Petri dish. Prepare four lights. Connect the spectrometer and make sure the device is connected. Open the Spectrawiz software. Set on the setup menu then select XTiming resolution control then select 1-low = >fastest. Select the setup menu then click spectral smoothing controls then select averge dark baseline. Open the scope menu and make sure it has a straight line. Click the black light, then click the yellow light. Open the lux light meter application to find out the lighting level of the lamp. Select %T:R to take the reflectance value, and AU to take the absorbance value. Set the integration time. The spectral measurement of the sample is done before and after treatment.

2.4.4 Color Measurement

Measuring the color og fresh and roasted coffee using a colorimeter.

2.4.5 Pulper

Clean coffee is then pulped to separate the beans from the skin.

2.4.6 Yellow Honey and Black Honey

Yellow honey is one of the washing methods carried out after the pulper process. At this stage, green, yellow and red coffee beans are washed to remove the mucus present on the coffee beans while the black honey method, the coffee that has been pulped is directly dried along with the horn skin.

2.4.7 Drying

Drying the green, yellow and red coffee skins and beans using sunlight for approximately one week for both the black honey and yellow honey methods. The drying stopped until moisture content was reaching to 12 %.

2.4.7 Huller

Separating the horn skin from the coffee beans using a huller machine (Coffee dried using the black honey method).

2.4.8 Roasting

Roasting the dried coffee skins and beans using both the black honey and yellow honey methods using a temperature of 180 oC during five minutes.

2.5 Research Parameters

The parameters used in this study are as follows:

2.5.1 Abrosbance and Reflectance

Absorbance and reflectance were observed using a spectrometer.

$$A = \text{Log } T = \text{Log } \frac{l1}{l0} \times 100\ \% \qquad (1)$$

Description A Absorbance, T Absorbance, reflectance or wavelength value, L1 Incoming light, L0 Light intensity after passing through the sample.

2.5.2 Color

Color is observed using a colorimeter tool by determining the L*a*b value of the robusta coffee sample and then calculating the total amount of color change.

$$\Delta E = \sqrt{(L0 - L1)^2} + (a0 - a1)^2 + (b0 - b1)^2 \qquad (2)$$

Description ΔE Total color difference, L* Brightness of material, a* Degree of greenness or redness of the material, b* Bluish or yellowish level of material

3. RESULTS AND DISCUSSION

3.1 Robusta Coffee Discolation Data

Table 1. Color Change Data of Coffee Beans from Fresh Condition to After Roasting

Treatment type	Coffee fresh			After the roasting			Total color change (ΔE)
	L	a	b	L	a	b	
Green black honey	17.53	-4.26	15.97	14.81	6.07	12.66	11.18
Green yellow honey	17.53	-4.26	15.97	10.23	3.09	13.36	10.68
Yellow black honey	16.81	-5.22	15.48	11.54	5.00	12.66	11.85
Amber yellow honey	16.81	-5.22	15.48	14.53	3.07	13.03	8.95
Red black honey	16.88	12.05	14.97	13.37	3.14	11.04	10.35
Red amber honey	16.88	12.04	14.97	11.59	5.08	9.97	10.08

Table 1 shows data on changes in bean color from fresh coffee to after roasting. Black honey method coffee beans have a higher level of brightness than yellow honey method coffee beans. This is because the yellow honey method is soaked and washed before drying so that it gives a neutral color while in the natural method the coffee beans are still dried along with the horn skin which can give a higher brightness level than the yellow honey method. This is in accordance with the statement of [6], that soaking and washing can cause coffee beans to undergo oxidation which causes oxygen gas to enter the beans resulting in a change in the color of the coffee beans. Color changes (ΔE) of coffee beans on Table 1 is relatively much lower compare to color changes of coffee skin (Table 2) from fresh to after roasting treatment.

Table 2. Data on Color Change of Coffee Skin from Fresh Condition to After Roasting

Treatment type	Coffee fresh			After the roasting			Total color change (ΔE)
	L	a	b	L	a	b	
Hijau	17.53	-4.26	15.97	12.55	3.81	8.58	12.02
Kuning	15.02	-4.79	8.1	11.08	3.96	11.26	12.01
Merah	16.88	12.05	14.97	11.06	4.50	9.16	11.16

Table 2 shows that the brightness level of green coffee skin is higher than that of yellow and red coffee skin. This is because immature green coffee has different compositions such as high moisture levels and the content present in green coffee. Some factors affecting color change after roasting are that green coffee will undergo chemical changes during the roasting process which will provide new compounds that provide a distinctive taste and aroma and a high level of brightness. Yellow and red coffee beans generally have a thicker skin during the roasting process, the color will be darker. Different color changes occur due to the processing process starting from washing, drying, and roasting for several minutes at a predetermined temperature. In this research process, color measurement is carried out using a colorimeter tool. This is in accordance with [7] that the roasting process changes the color of coffee beans as roasting progresses from green to brownish or blackish.

3.2 Grafik Spektral Absorban dan Reflekttan

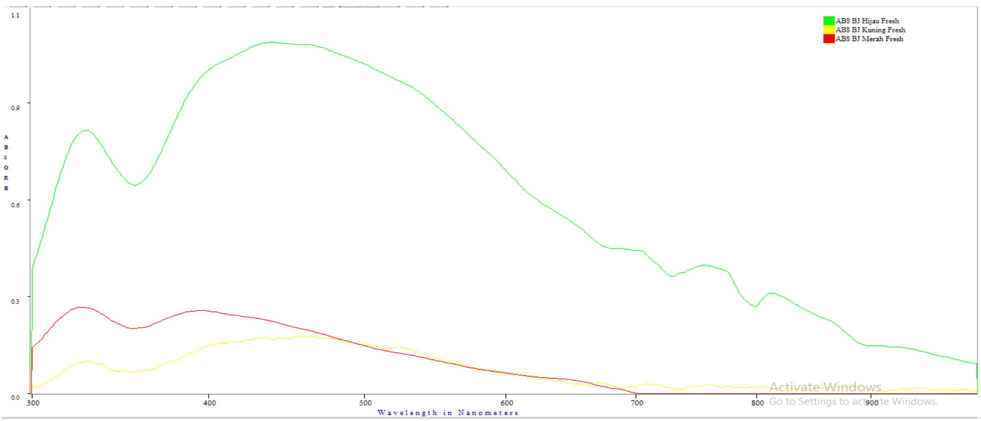

Figure 1. Land use map 2011.

Figure 1 shows the absorbance measurement on fresh coffee. In the graph, it can be seen that green coffee has a maximum wavelength around 400-500 nm with an absorbance value obtained of 0.98%, yellow color is 0.18% with a wavelength around 400-500 nm and red 0.27% around 300-400 nm. Of the three color spectra, the absorption produced by green coffee is higher than that of yellow and red coffee. The difference in absorption value is influenced by the brightness of the coffee. Based on Table 1, green coffee has a brightness level (L) of 17.53, red coffee 16.81, and yellow coffee 16.88. The results showed that the higher the brightness level of coffee and the light intensity also increased, the absorbance produced also increased. Light absorption can occur in other samples with lower wavelengths or smaller absorbance values. In accordance with the statement of [5] that the wavelength spectrum that has been absorbed by molecules depends on the difference in energy levels.

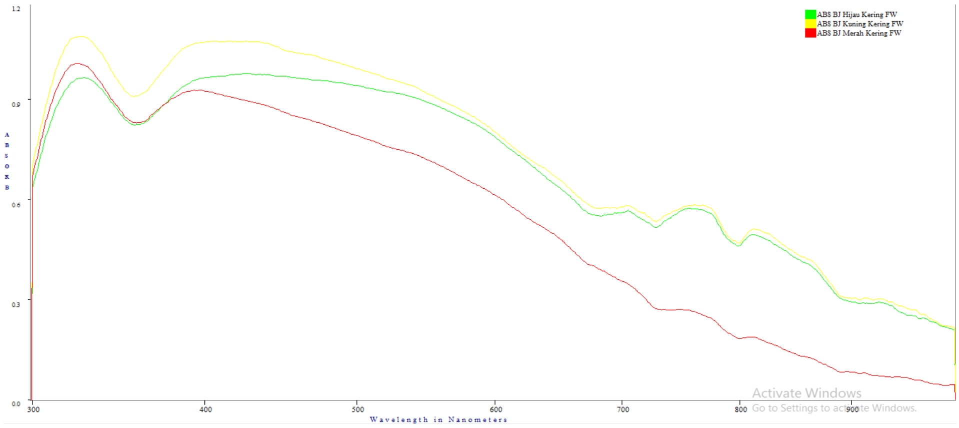

Figure 2. Absorbance graph of coffee beans after drying using the yellow honey method.

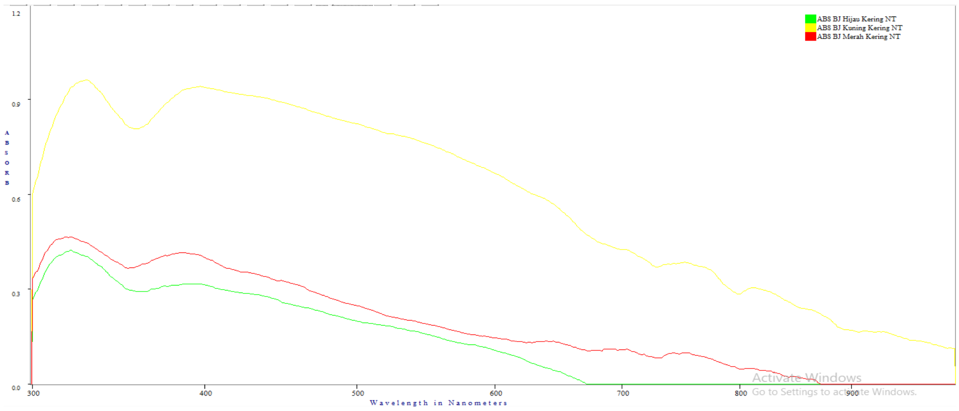

Figure 3. Absorbance graph of coffee beans after drying using the black honey method.

Based on Figure 2, the absorbance graph of dried coffee beans with the yellow honey method has the highest absorbance value in the yellow color spectrum of 0.97%, red color 0.94% and green 0.92% with wavelengths ranging from 300-400 nm. Figure 3 shows the absorbance graph of black honey method coffee beans where the highest absorbance value is in the yellow color spectrum of 0.98%, green 0.38%, and red 0.55% with a wavelength of 300-400 nm. From the two graphs, it can be seen that the absorption of coffee beans with the natural method tends to be higher than in the yellow honey method. In the black honey method, the coffee skin is still attached to the coffee beans during the drying process which contains more organic compounds including sugar and mucus which affect the absorption value. Whereas the yellow honey method involves the loss of the skin before the drying process which causes the amount of organic compounds in the coffee to decrease. Along with drying, coffee beans lose water and undergo chemical changes that can affect the ability to absorb certain substances. A proper drying process can help maintain the quality and flavor characteristics of coffee. This is in accordance with the statement [8] that a good drying process not only affects the physical properties of coffee beans such as the level of hardness, moisture content, color in coffee but also can improve the taste of coffee beans.

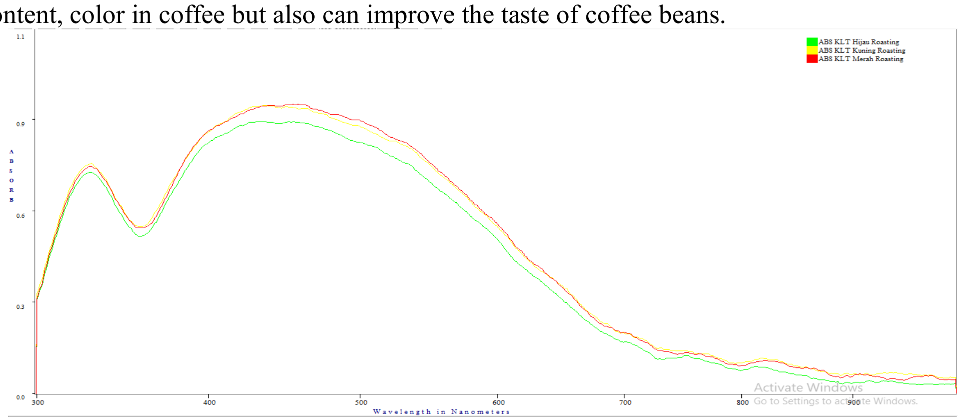

Figure 4. Absorbance Graph of Coffee Skin after Roasting

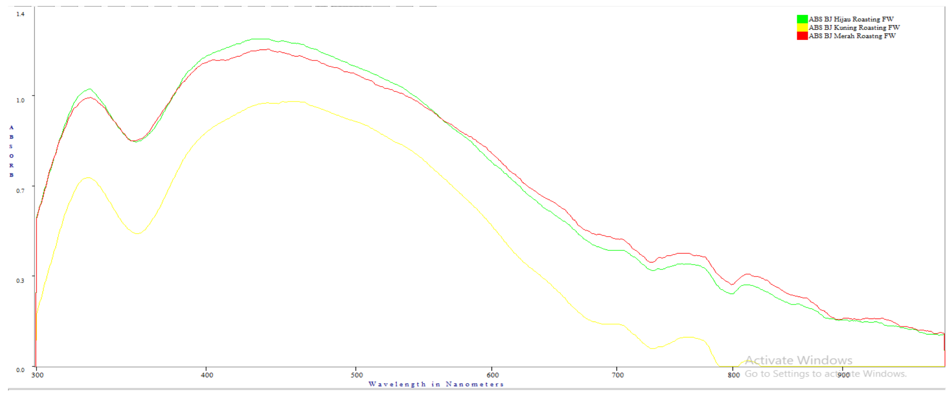

Figure 5. Absorbance graph of coffee beans after roasting using the yellow honey method.

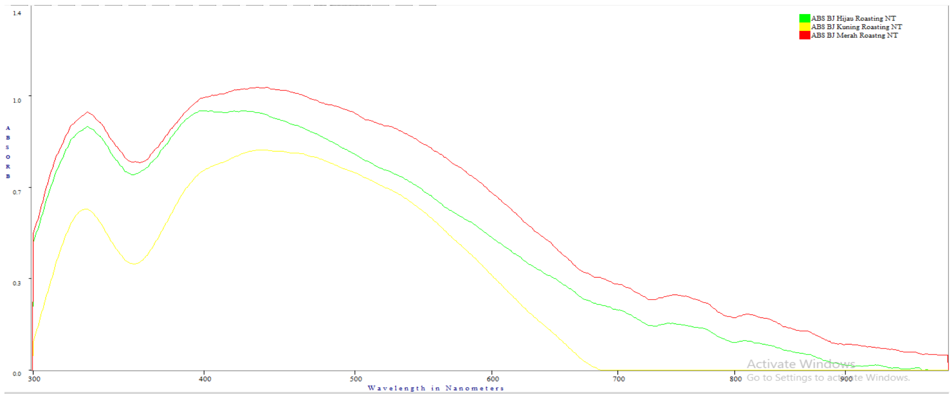

Figure 6. Absorbance graph of coffee beans after roasting using the black honey method.

Based on the coffee graph, Figure 4 shows that red coffee skin has a higher absorbance than green and yellow coffee skin, which is 0.94%. Figure 5 shows green beans with the yellow honey method have a greater absorbance value than yellow and red coffee, which is 1.29%. While Figure 6 shows the largest absorption value of red coffee beans at 1.03%, the difference in absorbance value against wavelength is caused by coffee processing such as washing, drying and roasting processes using two methods, namely black honey and yellow honey. The roasting method used including temperature and roasting time can give different results. It is also influenced by light intensity and coffee color. The darker the color of the coffee, the smaller the absorbance level tends to be at a certain wavelength. The brighter the color of the coffee, the absorption value obtained also increases. This is in accordance with [4] statement that, a high absorbance value indicates a large absorbed light intensity.

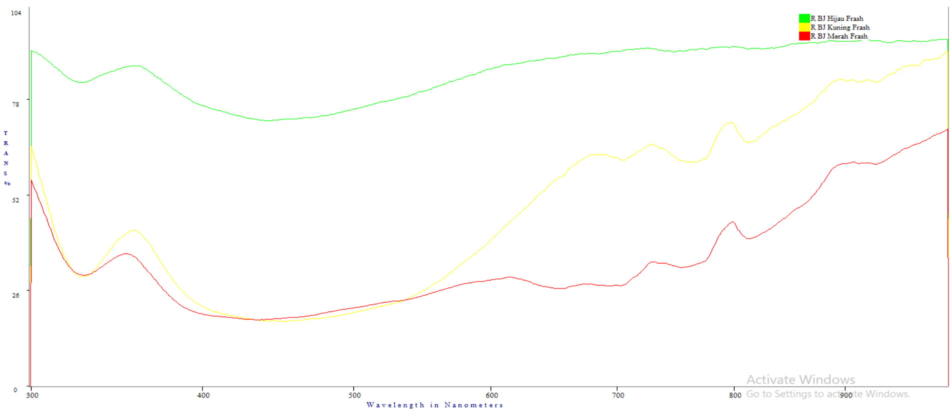

Figure 7. Reflectance graph of fresh coffee.

Based on Figure 7, the reflectance graph of fresh coffee shows the highest reflectance value is in the green color spectrum of 92%, in the red spectrum of 69%, and the yellow spectrum of 89% with wavelengths ranging from 800-1000 nm. The light reflected from the coffee surface can be related to the color of the coffee. Based on Tables 1 and 2, the brightness of green coffee is higher than that of yellow and red coffee. Fresh coffee generally has higher reflectance values at higher wavelengths. Light hitting the coffee surface is not fully absorbed, but rather reflected. This is in accordance with the statement of [2] that any light that hits the sample, some of the light will be absorbed by the object. If the color of the sample is bright, some photons will be reflected and the process of traveling light randomly can occur hundreds of times.

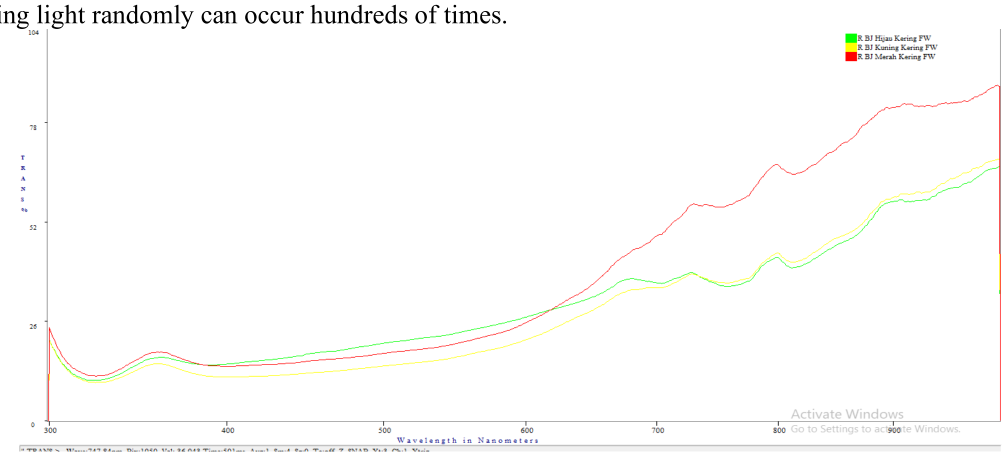

Figure 8. Reflectance Chart of Coffee Beans after Drying Using the Yellow Honey Method.

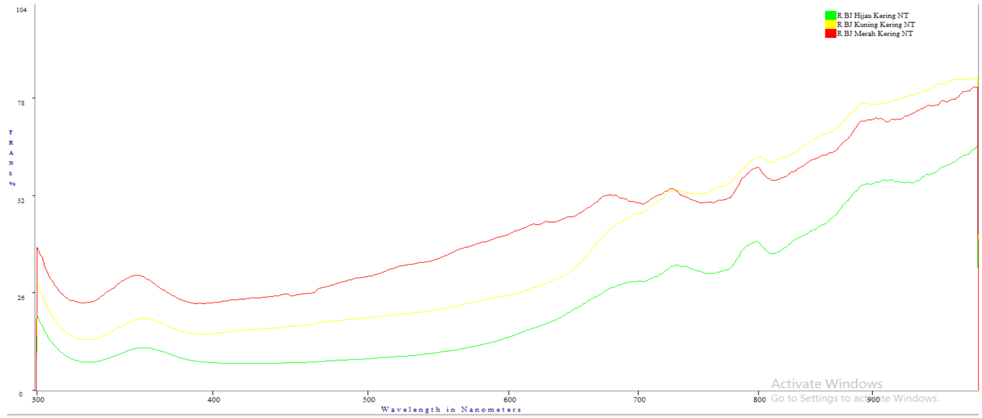

Figure 9. Reflectance graph of coffee beans after drying using the black honey method.

Based on the reflectance graph of coffee beans with the drying method. Figure 8 in the yellow honey method, the highest reflectance value is in the red color spectrum of 79%, the yellow spectrum of 79% and the green spectrum of 75% with wavelengths ranging from 900-1000 nm. Figure 9 in the black honey method, the highest reflectance value is in the yellow spectrum of 81%, the red spectrum of 79%, and the green spectrum of 73% with wavelengths ranging from 900-1000 nm. Different reflectance values are influenced by the washing and drying process which causes color changes. Coffee beans dried by black honey require a longer time to dry compared to the yellow honey method. In the black honey method, the coffee beans are dried together with the horn skin while in yellow honey drying the coffee is clean without the horn skin so that during the drying process the washed coffee beans are exposed directly to the sun's heat which results in a change in the color and brightness of the coffee. This is in accordance with the statement of [6] that soaking and washing can cause coffee beans to oxidize which causes oxygen gas to enter the beans resulting in discoloration of the coffee beans.

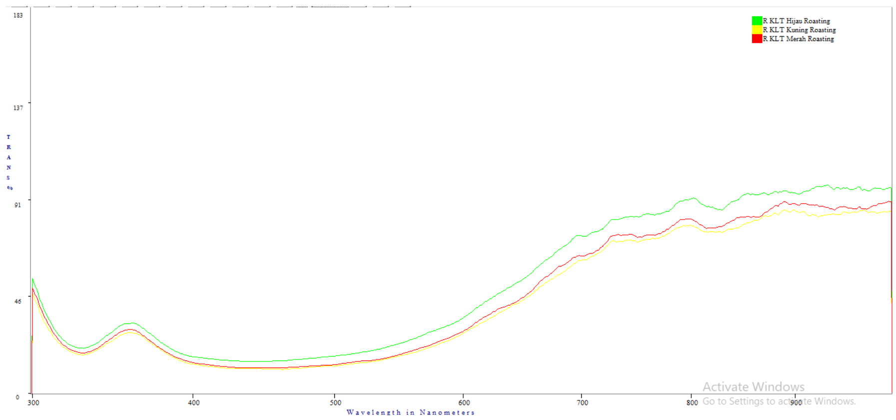

Figure 10. Reflectance graph of coffee skin after roasting.

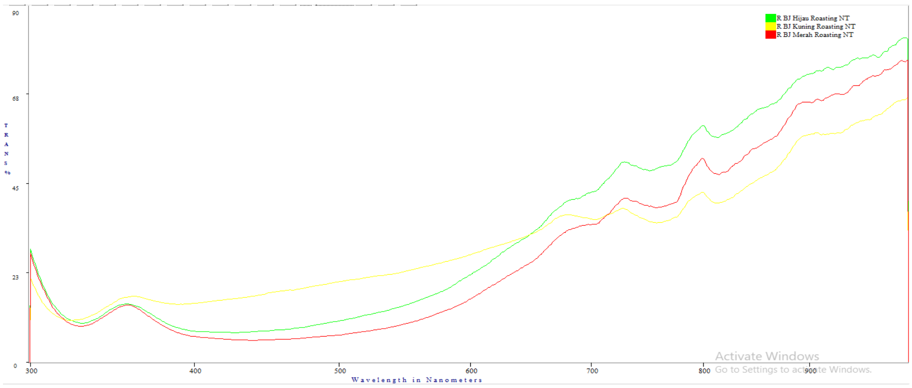

Figure 11. Reflectance Graph of Coffee Beans after Roasting Using the Black Honey Method.

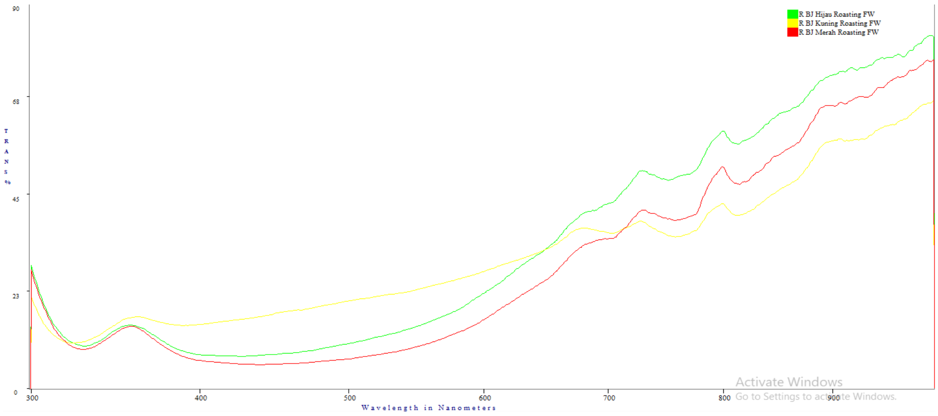

Figure 12. Reflectance Chart of Coffee Beans after Roasting Using the Yellow Honey Method.

Based on Figure 10, the roasting skin graph, the highest reflectance value is in the green color spectrum of 96% with a wavelength of 900-1000 nm. Figure 11 shows the highest reflectance value, namely the green color spectrum of 87% at a wavelength of 900-1000 nm. While Figure 12 shows the highest reflectance value is in the green color spectrum of 87%. From the three graphs it can be seen that the largest reflectance value is in the green color spectrum with a wavelength of 900-1000 nm. The difference in reflectance value is influenced by the intensity of light and the level of color brightness in the coffee sample. Color changes occur due to the roasting process where coffee beans will undergo complex chemical changes. As the roasting temperature increases, the coffee beans will tend to be darker and their texture may change. Darker beans tend to give more luster and low reflectance values. This is in accordance with the statement of [7] that coffee changes color from green to brown, and then turns black with an oily surface due to the heat generated during the roasting process. The higher the temperature and the longer the roasting, the darker the coffee color will be.

Table 3. Wavelength, absorbance and reflectance data during the post-harvest process

Measurement	Sample	Absorbance (%)	Reflectance (%)	Wavelengt (nm)	
				Absorbance	Reflectance
Before treatment	Fresh green	0,98	92	400-500	900-1000
	Yellow fresh	0,18	89	400-500	900-1000
	Red fresh	0,27	69	300-400	900-1000
After drying yellow honey method	Green seeds	0,92	75	300-400	900-1000
	Yellow seed	0,97	76	300-400	900-1000
	Red seed	0,94	89	300-400	900-1000
After drying by black honey method	Green seed	0,38	73	300-400	900-1000
	Yellow seed	0,98	81	300-400	900-1000
	Red seed	0,55	79	300-400	900-1000
After roasting yellow honey method	Green seed	1,29	87	400-500	900-1000
	Yellow seed	0,99	75	400-500	900-1000
	Red seed	1,2	75	400-500	900-1000

After roasting black honey method	Green seed	0,97	87	400-500	900-1000
	Yellow seed	0,73	75	400-500	900-1000
	Red seed	1,03	75	400-500	900-1000
After roasting	Green skin	0,89	96	400-500	900-1000
	Yellow skin	0,93	92	400-500	900-1000
	Red skin	0,94	94	400-500	900-1000

Based on Table 3, the wavelength data shows the absorbance value of fresh green coffee is 0.98%, fresh yellow coffee is 0.18% and red coffee is 0.27%. However, after going through the post-harvest process there is a change in absorbance value where green coffee that has been dried using the yellow honey method has decreased by 0.92% and the black honey method by 0.38% while yellow and red coffee beans have increased at wavelengths ranging from 300-400 nm and 400-500 nm, as well as roasted coffee. While the reflectance value can be seen that fresh green coffee has a reflectance value of 92%, yellow coffee is 89% and red is 69%. However, after going through the post-harvest process where green and yellow coffee that has been dried using the black honey and yellow honey methods has decreased and red coffee beans have increased at wavelengths around 900-1000 nm, as well as roasted coffee. The absorbance or reflectance value can change at the same wavelength due to the nature of the material can interact with light, where the sample has bioactive content, the level of humidity and the level of brightness of the coffee color that affects the way light interacts so that in measuring the absorbance and reflectance values there are varying absorption and reflection values. Besides that. The relationship of absorbance and reflectance values to wavelength can be seen in the table where the higher the reflectance value, the absorbance obtained decreases. This is in accordance with the statement of [3] that the higher the absorbance value produced by the material, the reflectance value will decrease, if the reflectance value is large, the absorbance produced also decreases.

4. CONCLUSION

Based on the research "Identification of Wavelenghts, Absorbance and Reflectance of Robusta Coffee During the Postharvest Process" that has been carried out, the following conclusions can be drawn:

1. The post-harvest process causes absorbance and reflectance values to change at the same wavelength due to the influence of material properties that can interact with light.
2. The higher the brightness of the coffee, the higher the absorbance value obtained. The darker the color of the coffee, the absorbance value obtained tends to be smaller. Light that hits the surface of the coffee is not fully absorbed but some are reflected (reflectance) and some are missed (transmittance).

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