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Changes of Mechanical Properties and Color from Arabica Coffee Cherry to Green Bean

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ABSTRACT

This study aimed to characterize the change of the hardness, fracturability, and color happened on the different processing of the arabica coffee cherry to the green bean. The characteristic of hardness and fracturability were measured using Texture Analyzer Instrument and color was measured using Colorimeter. Results of this study showed that the highest value of hardness and fracturability were 16.03±2.42 kgf, and 2.66 mm respectively, occurred in fully washed processing; otherwise, the lowest of those were 13.07±2.51 kgf and 2.20 mm respectively occurred in natural processing. Results of CIE L*a*b* analysis indicated that the level of red and yellow colors decreased steadily from cherry to natural, fully-washed, and honey green bean. Results of CIE L*c*h* analysis showed that natural green bean achieved the most clarity followed by fully-washed green bean, honey green bean, and cherry coffee; the natural green bean reached the highest value of the hue. The cherry coffee and honey green bean possessed the same hue angle. The average total color different of-of cherry-natural, cherry-honey and cherry-fully-washed, natural- honey, natural - fully washed, and honey – fully washed were 15.35, 7.09, 16.62, 8.85, 2.14 and 9.81 respectively. Mechanical properties and color play an essential role in handling and processing the coffee cherry.

Key words : arabica, hardness, fracturability, colour, coffee cherry, green bean.

1. INTRODUCTION

Recently coffee development areas in Indonesia reached 1.2 million hectares, consisting of 251 thousand hectares of arabica coffee (22.23%) and 958 thousand hectares of robusta coffee (77.77%). From this area, around 1.82% increased by the government real estate, 1.99% grown by large private plantations and another 96.15% was cultivated by smallholders, which have been involving around 1.9 million households [1].

Regarding processing from coffee cherry to green bean, in general, there have been 3 methods of processing, i.e., fully-washed processed, naturally processed, and honey processed. Fully-washed processing is one of the most common options. The processing of fully-washed processing methods required a process that consumed quite a lot of time and energy, among others by conducting the fermentation process of seeds. This damp method generally used by extensive plantations. In this method, the beans are removed from their cherry husk then fermented for 12 to 72 hours to make it easy for the mucilage to come off the seed. This methods gradually will produce parchment coffee and after their drying and shelling will produce green bean coffee. Washed process coffees usually have a bright and clean taste. In the naturally processed coffee, the husk and mucilage removed from the beans until after the coffee completed at the drying stage. This method is the most traditional process method and a longer process than other methods. Regarding a taste profile, this method resulted in the most sweetness than other processing methods and has a complex fruity taste. The honey processed coffee is a method in which the fresh coffee cherries are de-pulped, but allowed to dry without fermentation or washing. Some of the fruit is still there, but not nearly as much as in the natural process. This method was a bit less conventional than the other two ways but recently increased in popularity.

Knowledge of mechanical properties and color of coffee are essential in processing, designing, and manufacturing of equipment. Some researchers had done a study on the mechanical properties of agricultural commodities such as Cocoa [2-4], Jatropha curcas [5], Date fruit [6], Kumquat [7], Russian olive fruit [8], Almond [9], Sesame seed [10] and Fenugreek [11]; while some researchers had researched the color of agricultural products such as tomatoes [12,13], Physalis peruviana [14], citrus [15] and grapes [16]. The mechanical properties and color of agricultural crop play an essential role in providing engineering properties of the coffee bean. Some researchers [17-20] had conducted the study on mechanical properties and color of green bean coffee. Results of research stated that mechanical properties and color could be used for the design of harvesting and classification systems, as well as for a rapid determination of coffee quality [17]. The fracture force is different for the different kinds of coffee [18]. Some engineering properties varied among the beans from different colors of coffee cherries [19] and post-harvest processing factors were found to influence the physical and sensory quality of green coffee beans [20].

Regarding the color of the green bean, the green color level decreased from a fully-washed followed by natural and honey green bean [20]. The yellowness increased from natural followed by a fully washed and honey green bean. The lightness decreased from naturally followed by a fully washed and honey green bean.

The skin strength and fracturability of the arabica green bean have not been covered yet in those studies. Therefore, the study aimed to characterise the change of the mechanical properties, i.e. hardness and fracturability, and color occurred on the multiple processing from the cherry to green bean and also to supplement the database on the skin strength, fracturability and tone of green bean resulted from different post-harvest handling.

2. MATERIALS AND METHODS

2.1 Material Preparation

The coffee sample consisted of the cherry and different type of green beans. There were three types of green beans samples used, i.e., honey, natural, and fully washed. The moisture content of the cherry and green beans were 59.96% and 13.18% respectively. The samples were collected from coffee farmers located in Cupunagara village (Latitude 6046'57.71"S, Longitude 107041'37.15"E, and elevation 1153 MAMSL), Cisalak sub-district, Subang district, West Java province. The properties measured comprised of moisture content, hardness, fracturability, and color. The moisture content measured using AOAC, 1995 method [21]. The hardness and fracturability were measured using TA XT plus Texture Analyzer Stable Micro System, and the color was observed using high-quality colorimeter NH 310. The package of statistical analysis was used to evaluate the differences of each type of sample, i.e. cherry and different type of green beans.

2.2 Hardness and Fracturability

The operative condition of the TA tested on the mode of compression. The data acquisition of 200 pps and probe of P/2. Samples randomly were chosen and positioned horizontally on the platform of the Texture Analyser instrument. Measurements were performed on ten beans randomly taken from each coffee type.

2.3 Colors

The analysis methods used were CIE (Commission Internationale de L'Eclairage) L* a* b* and CIE L* c* h* coordinates. The value of L*, a* and b* obtained were used to determine the chroma, hue angle and total color difference between all three coordinates by using equation as follows [22].

$$Chroma,\ c^* = \sqrt{(\ [(a^*)]^2 + [(b^*)]^2\ )}$$

$$Hue\ angle,\ h^* = \tan^{-1}(b^*/a^*)$$

$$\Delta E^*A\text{-}B = \sqrt{(\ [(\Delta L^*)]^2 + [(\Delta a^*)]^2 + [(\Delta b^*)]^2\ )}$$

Measurements were performed on five beans randomly taken from each coffee type. Principally, the color of the sample can be described using three specific qualities of visual sensation, i.e. tonality, luminosity, and chromatism. Tonality (h*) is the characteristics of the color, i.e. red, yellow, green, and blue. The clarity is the attribute of the visual sensation according to the appearance of the sample whether less or more luminous. The chromatism (c*) is the level of color related to a lower or higher intensity of the color. Coordinate L* represents the clarity, in which L=0 is black, and L*= 100 is colorless. Coordinate a* represents the shade of red and green, in which a*> 0 indicates red color and a*< 0 means green color. Coordinate b* represents the tone of blue and yellow, in which b*> 0 shows the intensity of yellow and b*< 0 indicates the hue of blue. The total color difference (ΔE is the difference between the L*, a*, and b* of the sample and standard. The geometrical representation of the two color models depicted in Figure 1.

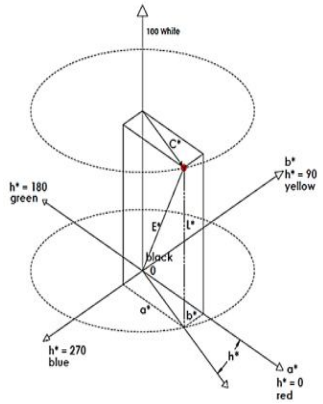

Figure 1: The CIE L*a*b* and L*C*h* geometrical coordinates systems

3. RESULTS AND DISCUSSION

3.1 Hardness and Fracturability

Table 1 shows the hardness of cherry and coffee bean produced from the different type of post-harvest processing, i.e. natural, honey and fully-washed. Table 1 shows that the fully washed green bean obtained the highest value of hardness; otherwise, the lowest of that occurred on the natural green bean. The hardness of the green bean would affect to further processing such as roasting, the more hardness of the green bean the longer time and the more energy consumption.

Table 1: The hardness of different coffee beans.

Type of bean	Hardness, kgf			
	Minimum	Maximum	Mean	Std. Deviation
Cherry	1.28	3.73	2.18	0.76
Natural	8.92	16.72	13.07	2.51
Honey	9.7	16.81	13.80	2.36
Fully-washed	10.66	19.08	16.03	2.41

Table 2 shows the fracturability of cherry, natural, honey and fully washed green bean. Table 2 shows that the fully washed green bean obtained the highest value of fracturability; otherwise, the lowest of that occurred on the natural green

bean. The fracturability indicated a qualitative toughening or hardening of the products [23], and in further processing such as roasting, the different of fracturability would affect the physical and sensory properties [24]. The characteristics can be changed, it is also reported in [25] and [26].

Table 2: Fracturability of different coffee beans.

Type of bean	Fracturability, mm			
	Minimum	Maximum	Mean	Std. Deviation
Cherry	2.55	7.42	5.13	1.71
Natural	1.25	3.43	2.20	0.61
Honey	1.3	3.5	2.30	0.74
Fully-washed	1.71	3.5	2.66	0.52

Results of paired test analysis of hardness showed that there was significant difference in pair of natural - fully-washed green bean ($t(1,9)$; $p < 0.05$); otherwise there were no significant differences in pairs of natural –honey, green beans and honey -fully-washed green beans ($t(1,9)$; $p > 0.05$). Regarding the fracturability, there were no significant differences in pairs of natural – honey, natural – fully-washed, and honey – fully-washed green beans ($t(1,9)$; $p > 0.05$). Results of multiple regression analysis indicated that the hardness of each type of green bean had a medium correlation with the fracturability, excepted for the fully washed green bean. The regression equation between the hardness and fracturability were as follows.

fCherry=-0.829 HCherry +6.933	*R=0.370*	*SEE=1.6860*
fNatural=0.117 HNatural +0.660	*R=0.483*	*SEE=0.5676*
fHoney=-0.131 HHoney + 4.113	*R=0.416*	*SEE=0.7179*
fFully-washed=0.009 HFully-washed +2.512	*R=0.042*	*SEE=0.5547*

Regarding the correlation between the fracturability and the hardness, cherry and honey green bean had different behavior with natural and fully washed green bean.

3.2 Colors

Table 3 shows the value of total color different, lightness, red/green colors, blue/yellow colors, chroma and hue angle of the cherry and three different green beans relative to the standard colors.

Table 3: Color values of the different coffee beans

Type of beans	E*	L*	a*	b*	c*	h*
Cherry	31.50±0.03	31.31±0.03	2.95±0.02	1.74±0.01	3.42±0.02	0.002±0.001
Natural	45.65±0.01	44.58±0.01	2.72±0.03	9.43±0.01	9.82±0.01	0.003±0.001
Honey	38.03±0.00	37.80±0.00	1.19±0.01	3.96±0.00	4.14±0.00	0.002±0.001
Fully-washed	47.26±0.00	46.44±0.00	1.96±0.00	8.54±0.01	8.76±0.01	0.003±0.002

Results of CIE L*a*b* measurement as shown in figure 2 indicated that the level of red color decreased gradually from cherry bean to natural, fully-washed, and honey green bean and the level of yellow color increasing steadily from cherry to honey, fully-washed and natural green bean. Results of CIE L*c*h* measurement indicated that most clarity, which stated Luminosity, was achieved by natural green bean and changed gradually to fully-washed green bean followed by honey green bean, and cherry coffee; the highest value of hue was achieved by natural green bean then decreased to fully-washed, cherry and honey green bean. The cherry coffee and honey green bean had the same value of hue.

Table 4: Total color different between cherry, honey, natural and fully washed samples

Pairs	Minimum	Maximum	Mean	Std. Deviation
Cherry - Natural	15.34	15.36	15.35	0.013
Cherry - Honey	7.06	7.12	7.09	0.028
Cherry - Fully-washed	16.61	16.65	16.62	0.025
Natural - Honey	8.84	8.86	8.85	0.012
Natural - Fully-washed	2.03	2.20	2.14	0.097
Honey - Fully-washed	9.80	9.82	9.81	0.009

Table 4 shows the total color difference of Cherry-Natural, Cherry-Honey and Cherry-Fully-washed, Natural- Honey, Natural fully washed, and honey – fully washed. Results of paired t-test analysis on the color of natural, honey and fully-washed green bean of this study showed that there were no significant differences ($t(1,2)$; $p>0.05$) in comparison with the previous research [19]. Therefore, the color of natural, honey and fully-washed green bean used in this study were in line with that of green bean used in the previous study [19].

4. CONCLUSION

Results of this study found that the mean hardness of cherry, natural, honey and fully washed green bean were 2.18±0.76 kgf, 13.07±2.51 kgf, 13.8±2.36 kgf and 16.03±2.41 kgf respectively. Their fracturability were 5.13±1.71 mm, 2.20±0.61 mm, 2.30±0.74 mm and 2.66±0.52 mm respectively.

Regarding the hardness of three different green beans, there were s no significant differences in pairs of natural –honey, green beans and honey - fully washed green beans. The significant difference occurred in a couple of natural - fully washed green bean. Concerning the fracturability, there were no significant differences in pairs of natural – honey, natural – fully washed, and honey – fully washed green beans.

The CIE (l*a*b*) geometric coordinates of cherry, natural, honey, and fully-washed green bean coffee were (31.31±0.03, 2.95±0,02, 1.74±0.01), (44.58±0.01, 2.72±0.03, 9.43±0.01), (37.80±0.00, 1.19±0.01, 3.96±0.00) and (46.44±0.00, 1.96±0,00, 8.54±0,01) respectively. The CIE (l*c*h*) coordinates of cherry coffee, natural, honey, and fully-washed green bean coffee were (31.31±0.03, 3.42±0.02, 0,002±0,001), (44.58±0.01, 9.82±0.01, 0,003±0,001), (37.80±0.00, 4.14±0.00, 0,002±0,001) and (46.44±0.00, 8.76±0.01, 0,003±0,002) respectively. The total color difference of Cherry-Natural, Cherry-Honey and Cherry-Fully-washed, Natural- honey, Natural fully-washed, and honey – fully-washed were 15,35± 0,013, 7,09± 0,028, 16,62± 0,025, 8,85± 0,012, 2,14± 0,097 and 9,81± 0,009 respectively.

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