Moisture content, color quantification and starch content of oil palm trunk (*Elaeis guineensis* Jacq.)

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**Abstract.** Research and utilization of oil palm trunk (*Elaeis guineensis* Jacq.) have not been widely carried out. Knowledge the characteristics of oil palm trunk (OPT) as part of understanding this type for reference to further development. The aim of its study was (1) to determine the value of moisture content (MC) in fresh condition after cutting, (2) to quantify the color value (E), (3) to quantify the color change value (∆E) in transverse and longitudinal cross-section and (4) to measure the percentage of starch content (SC). Results showed that MC for base (B), middle (M), up (U) and their average were 339.68%; 444.82%; 323.24% and 369.25% respectively. E value consisted of 4 parameters, namely FT (fresh-transversal), FL (fresh-longitudinal), OT (ovendry-transversal), and OL (ovendry-longitudinal). ∆E consisted of two parameters, namely ∆ET (∆E-transversal) and ∆EL (∆E-longitudinal). Average E values for FT, FL, OT and OL were 87.61; 88.70; 78.01 and 79.34 respectively. Average values for ∆ET and ∆EL were 10.73 and 9.33, respectively. SC was 0.047% from 1114 kg of oil palm trunk’s total weight.

1. Introduction

Oil palm (*Elaeis guineensis* Jacq.) is a popular species in Indonesian plantations with an estimated area around 14.03 million hectares in 2018 [1]. The main product of oil palm plantations is palm oil which is processed from fruit. However, utilization of oil palm trunk (OPT) has not been done optimally because of its less of known potential. OPT can be an alternative producer for wood materials [2]. That is strengthened by considering its potentially by fact rejuvenation which is very large about 20-30 thousand hectares per year [2]. That potential will give about 1.5 million m³ OPT per year [3].

Research on the characteristic of OPT has been done [2, 4–6] and still going. It is important considering that many references discuss the potential of OPT. Reference to the characteristic of OPT helps us to know more about this species and as a reference to develop more optimally. Some of the characteristics are physical properties, color properties and starch quantity. Physical properties consist of moisture content (MC). By knowing MC, it will be very helpful to handle the process, especially the drying process. As it is known that a good and optimal drying process between types of wood will vary in technical implementation, one of which depends on the moisture content. Other characters that are quite important but not much attention are a color characterization which consists of color value (E) and color changes value (∆E). Color characterization is essential because it can be used as one of the
character traits of a type. Furthermore, it is known that color has to do with several chemical traits and characters [7−10]. However, there has been no research on the color characteristics carried out mainly on OPT. Starch is one of the potential ingredients. Starch can be used as the main ingredient for bioplastic. Information about starch content will explain how the potential of OPT if it leads to its utilization. Percentage of starch obtained will make it easier to calculate the techno-economic value of the OPT in starch production. Overall, this study intends to find out MC, E, ΔE and SC of OPT.

2. Data and methods

2.1. Measurement of MC, E and ΔE

Materials used were two pieces of OPT planted in Bogor with more than 25 years of age. Each tree was divided into base (B), middle (M) and up (U). B consisted of 24 replications; M consisted of 30 replications, and U consists of 30 replications. Each replicate sample had (5x5x5) cm³ in size. MC measurement follows British Standard [11]. The formula used is:

$$MC \, (\%) = \frac{FW-OW}{OW} \times 100$$  \hspace{2cm} (1)

MC : moisture content (%)  
FW : fresh weight (g)  
OW : oven dry weight (g)

Color measurement methods followed the CIELab method. CIELab is one method of measuring color values that is very simple and very easy to use [12]. E is a symbol for color values, while ΔE is color changes value. The formula used is:

$$E = \sqrt{(L)^2 + (a)^2 + (b)^2}$$  \hspace{2cm} (2)

E : color values  
a: redness  
L : lightness  
b: yellowness

ΔE is obtained by the formula:

$$E_1 = \sqrt{(L)^2 + (a)^2 + (b)^2}$$  \hspace{2cm} (3)

$$E_2 = \sqrt{(L)^2 + (a)^2 + (b)^2}$$  \hspace{2cm} (4)

$$\Delta E = E_1-E_2$$  \hspace{2cm} (5)

E₁ : color quantification when in fresh conditions (after cutting)  
E₂ : color quantification when in oven dry conditions  
ΔE : difference between E₁ with E₂

ΔE was measured by treatment of heat (oven drying) at 60º C for seven days. Measurements were carried out in fresh and dry oven conditions. Color measurements were carried out in two parts of sample sections, transverse and longitudinal sections. Color gauges used portable color reader Konica Minolta CR-10. Thus, the measurement parameters are:

E values:  
1. Fresh - Transversal cross section (FT)  
2. Fresh - Longitudinal cross section (FL)

ΔE values:  
1. ΔE transversal cross-section (ΔET)  
2. ΔE longitudinal cross-section (ΔEL)  
3. Ovendry - Transversal cross section (OT)  
4. Ovendry - Longitudinal cross section (OL)
2.2. Measurement percentage of SC
Measurement of SC began with measuring the total mass of OPT in fresh conditions. Palm trees were cut down by two trees with a height of each tree about 9 meters. After being cut down, OPT was cut into 18 parts with a length of 1 meter each, then cut into blocks of \((12 \times 12)\) cm\(^2\) in size as many as 18 pieces. The beam was made into boards measuring \((1 \times 30 \times 5)\) cm\(^3\) in 198 pieces. Boards were then inserted into ring flacker to make small particles. Particles were collected for washing using the bitter for 15 minutes. The results were then squeezed and filtered into a plastic barrel using a filter. After that, oil starch solution was applied for 24 hours. The results of precipitated oil palm were then filtered. Filtered water was collected using a container. Furthermore, starch retained in the filter was washed using water and deposited again for 3 hours. Water from the filter deposited in container was then taken by the wet starch. After that, the wet starch was in the oven at 80 °C for 24 hours. The percentage of SC was obtained by the formula:

\[
SC\ (%) = \frac{\text{starch (g)}}{\text{total weight of the trunk (g)}}
\]  

(6)

Figure 1. Logging activities and sample preparation for oil palm \((E.\ guinensis\ Jacq.)\) trunk. (photo by: Teguh Darmawan, S.T.)

Figure 2. (A) Transversal and longitudinal section of oil palm trunk, (B) Colorimeter; Portable Color Reader, Konica Minolta CR-10. (photo by: Adik Bahanawan, S.Hut.).

Figure 3. Starch extraction activity (photo by: Teguh Darmawan, S.T.).
2.3. Data analysis

Data processing was done by finding the average value of each treatment for MC, E, \(\Delta E\) and SC. Statistical tests were carried out for MC and E values using one-way variance analysis method with the level of confidence 0.05. If there are significant differences between treatments, further testing of LSD (Least Significance Difference) will be carried out. Software tools used were Microsoft Excel 2013 and SPSS Statistics 17.0.

3. Results and discussion

3.1. MC of OPT

MC in OPT was very high about 219.9%-379.4% with average 311% [13]. The results of this research showed that B, M and U of fresh OPT contained high enough MC which was similar to other research [13] as presented in table 1 below.

| Parts | MC (%) |
|-------|--------|
| B     | 339.68 a |
| M     | 444.82 b |
| U     | 323.24 ac |
| Average| 369.25 |

Significantly different at the 0.05 test level. Different letters indicate significant differences between treatments.

Table 1 explains that there is a significant difference between MC where B is significantly different from M, but it is not significantly different from U. M was also significantly different from U. Average value of B, M and U was obtained at 369.25%. MC in wood was about 30-300% [14]. But, it cannot be generalized because there were many factors example about species and environment. In this research, high MC did not contain maximum MC because logging was done in the dry season. It can be predicted that there is higher MC if cutting is done in rainy season.

High MC was influenced by the presence of parenchymal tissue that dominated OPT. This tissue was known very good at absorbing and storing water [13]. Compare with Iswanto et al. [13], the difference in values was common because there were indeed differences in environmental conditions where the sample was taken and the condition of habitat which affected the characteristics of the plant [15−17]. That characteristic included MC. High MC is presumably to be one of the weaknesses of this type against destructive organisms such as mold, fungi and insects. This knowledge is used as a reference in the drying process. Drying process was needed in this case to make MC to be balanced. Drying is a process of reducing MC or water content in accordance with surrounding conditions which is also called equilibrium [18]. High MC needs to be processed in air-drying first before the oven-dried process so that OPT does not cracked. Challenge in air-drying process was susceptible to attack wood-damaging organism. It must be a concern on the condition of air-drying place especially that it should not be too moist and sufficiently exposed to sunlight and good air circulation.

3.2. E and \(\Delta E\) of OPT

Color is one of the characteristics from lignocellulose material that can be used to distinguish from another wood spesies. Color is assumed to have a relationship with extractive content. An extractive is substances that can be extracted from lignocellulose material that can be used to assess quality specifically on its chemical properties [19]. Color is affected by phenolic substances and lignin [9]. OPT and other types of wood certainly have different colors. This color difference makes one type specifically different from another. Results of this study indicate that the standard color of OPT in fresh conditions after cutting and oven-dry conditions on transverse and longitudinal crosssection as presented in table 2 below.
Table 2. E values of OPT.

| Treatment | L  | a  | b   | E   |
|-----------|----|----|-----|-----|
| FT        | 82.85 | 6.75 | 27.23 | 87.61 a |
| FL        | 83.51 | 7.12 | 28.59 | 88.71 b |
| OT        | 75.35 | 6.39 | 23.27 | 78.01 c |
| OL        | 72.65 | 6.96 | 24.78 | 79.34 d |

Significantly different at the 0.05 test level. Different letters indicate significant differences between treatments. 
E = color value, L = lightness, a = redness, b = yellowness

Table 2 especially E values shows the standard E values of OPT. E values were about 78.01-88.71 which OPT was in fresh and ovendry conditions. While in transversal and longitudinal cross-section, there was linear relationship between greater lightness (L) and yellowness (b) with greater E value, but not redness (a) values. It can be concluded that heat treatment generally can impact in L and b values but not a value. Data in table 2 show that all E values are bigger in fresh conditions (transversal and longitudinal) than in ovendry conditions (transversal and longitudinal). FT and FL (87.61 and 88.70) > OT and OL (78.01 and 79.34). This phenomenon explains that oven-dried process will cause a part of water gone.

Table 3. \( \Delta E \) values of OPT.

| No. | Parameters | \( \Delta E \) | Average |
|-----|------------|----------------|---------|
|     |            | B   | M     | U     |        |
| 1   | \( \Delta E_T \) | 11.44 | 10.40 | 10.35 | 10.73 a |
| 2   | \( \Delta E_L \) | 9.98  | 9.77  | 8.25  | 9.33 b |

Significantly different at the 0.05 test level. Different letters indicate significant differences between treatments. 
B = base, M = middle, and U = up

Data in table 3 show that \( \Delta E_T \) is bigger than \( \Delta E_L \) in every part of the trunk (B, M, U and average). Color changed was caused by water release, so that water release in transversal cross-section was higher than in longitudinal cross-section. Water release caused color of OPT more darker. Water release also caused the changes of extractive content because it brought out little extractive content. Water release of vessels exposed in transverse cross-section was easier and greater than in longitudinal cross-section. It indicates that water and color are very closely related to where the discharge of water will carry more or less extractive substances affecting color. Lost water will cause a change in color where the overall color value in fresh conditions is greater than the color in dry conditions. It indicates that there is a relationship between the loss of water and the changing color, in the sense that the water carrying the dye disappears.

3.3. Percentage of SC
SC was collected from the sample with fresh condition after cut with a total weight of OPT which was determined 1114 kg. Table 4 below shows SC from every part of OPT and the average value.

Table 4. SC of OPT.

| Parts | Fresh weight (kg) | Parts | SC (g) |
|-------|------------------|-------|--------|
| B     | 404              | B     | 2.8    |
| M     | 434              | M     | 17.8   |
| U     | 276              | U     | 322    |
|       |                  | Mix (B+M+U) | 184.6 |
| Total | 1114             | Total | 527.2  |

Significantly different at the 0.05 test level. Different letters indicate significant differences between treatments. 
B (base), M (middle) and U (up).
SC percentage was 0.047% from 1114 kg of OPT. Another study inform that SC was 4.7% from 200 kg total weight of OPT in Langkat District, North Sumatera [20]. Ridwansyah et al. [20] explain that starch extraction from parenchyma cells at OPT was difficult to be done because of its structure and parenchyma cell composition. Low content of starch shows that this type has not been optimally used for bioproduct from starch based. However, these results certainly need to be carried out further especially on OPT from various regions so that the conclusion about general SC can be obtained.

4. Conclusion
Knowing MC will become reference in the drying process. It needs to be wise to handling OPT because its material is susceptible to fungal attacks. Color value and color change value can become standarized for color characterization of OPT. Starch can be another product from OPT that has potential to be developed. Other potential products that can be an alternative for OPT are for furniture, particle boards, laminated lumber or CLT (Cross Laminated Timber). MC, E, ΔE and SC of this research were specified where the sample was taken. It cannot be generalized with another OPT especially from another place. This research concludes that:

1. MC values for B, M and U were 339.68%; 444.82%; and 323.24% respectively with the average was 369.25%.
2. E values for FT, FL, OT and OL were 87.61; 88.70; 78.01 and 79.34 respectively.
3. ΔE values for ΔET and ΔEL were 10.73 and 9.33 respectively.
4. SC values were 0,047% or 527.2 g from 1114 kg of total weight of OPT.

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