Effect of Position of Old Oil Palm Trunk Segment on The Chemical Contents of the Extracted Sap

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Abstract. Replanting oil palm (*Elaeis guineensis*) produces a significant amount of trunk biomass, which is frequently permitted to break down naturally on the ground and may result in phytopathogenic problems. The sap from trunk oil palms is abundant in bioactive substances and fermentable sugars that can be converted into various valuable products. The aim of this study was to assess how the chemical contents of sap from old oil palm trunks was affected by the trunk's position. The research employed a completely randomized design with trunk position as treatment. The sap was extracted in the following method: the felled unproductive oil palm trunks were cut into 1 m sections at 3, 4, and 5 meters above the ground. The trunks were split vertically in half and then planed using a planer thicknesser. The resulting pith was then pressed with a screw press and filtered. The chemical content analysis included reducing sugars, starch, phenolics, flavonoids, antioxidant activity (DPPH). Results showed the best position of the trunk that produced good oil palm sap was found to be at the bottom with a sap yield of 12.26% and chemical characteristics pH of 5.33; total soluble solid of 11,68°brix; reducing sugar of 2,91%; starch content of 166.64 ppm; total phenolic content of 46.08mg/100g GAE; flavonoid content of 8.92mg/100g QE and antioxidant activity of 93.52%.

Keyword: antioxidant, DPPH, flavonoid, oil palm trunk, phenolic, sap.

1 Introduction

Oil-producing crops account for one-third of the total agricultural land area dedicated to crop production worldwide [1]. Therefore, oil crops are among the dominant land users compared to those of used for other commodities. One of the largest oil-producing crops in the world is the oil palm. Oil palm contributes the highest proportion of total oil production, amounting to 25% [2]. Indonesia is one of the world's largest oil palm producers, with production increasing by 1.29% in 2022, reaching 46.82 million tons [3]. The total oil palm plantation area in Indonesia covers 15.44 million hectares [4]. Oil palm trees begin producing fruit at around three years after planting and cease productivity at 25 years of age [5]. Beyond this age, the fruits produced are of lower quality [6], thus requiring replanting.

Unproductive oil palm trees are generally felled, and their trunks are left in the field to naturally degrade. However, the degradation process of oil palm trunks requires several years [7]. Prolonged trunk decomposition in the field can negatively affect the environment, as it may lead to Ganoderma infection, which disrupts the growth and development of young oil palm plants [8]. Therefore, appropriate handling or utilization of old oil palm trunks is necessary to improve the efficiency of plantation management.

Oil palm trunks contain 70–80% water, which includes sugar components (glucose, xylose, arabinose, and fructose) and starch content of up to 26.9% [9]. The chemical composition of oil palm trunk sap is influenced by the position of the trunk segment. The middle portion contains the highest water content [9], whereas the basal section consists of older tissues with denser secondary cell walls [10].

The chemical composition of trunk sap determines both the yield and quality of the resulting liquid sugar. According to Yamada et al. [11], higher sugar content in sap from old oil palm trunks produces greater yields of liquid sugar. Therefore, this study aimed to evaluate the effect of trunk position during sap extraction on the chemical composition.

2 Material and Methods

2.1 Materials and Equipment

The materials used in this study were oil palm trunks from plantations in South Lampung, Indonesia, that were already unproductive (approximately 25 years old). The trunks were cut 2 meter above the ground and then divided into three sections of 1 meter each (bottom, middle, and upper, Figure 1). Chemicals used for analysis included 2% Na_2CO_3 Merck by Germany, 2% $AlCl_3$ Merck by Germany, 50% Folin-Ciocalteu reagent Merck by Germany, DPPH solution Merck by Germany, and ethanol p.a. 96% Merck by Germany. The equipment used consisted of a pH meter, Atago refractometer, and UV-Vis spectrophotometer (Aquamate 8100).

2.2 Methods

This study employed a completely randomized design (CRD) without factorial treatment, with trunk position (bottom, middle, and upper) as the treatment factor. The resulting data were analyzed using analysis of variance (ANOVA) and further tested with the HSD (Honestly Significant Difference) test at a 5% significance level. Data were presented in tables and graphs using Microsoft Excel Data Analysis.

2.3 Preparation of Oil palm Trunk Sap

The extraction process was carried out by cutting aged oil palm trunks 2 meters above ground level (Figure 1) and then segmenting them into 1-meter sections (bottom, middle, upper). The pith portion of the trunk was then shredded into fibers using a planer thicknesser machine and pressed to obtain sap with normal temprature. The extracted sap was filtered using 200-mesh filter paper and subsequently analyzed.

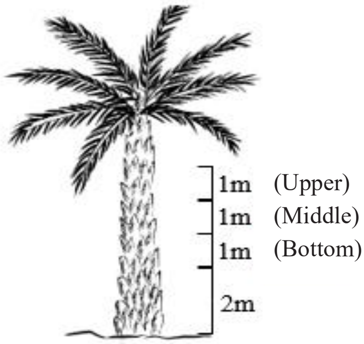

Figure 1. Illustration for trunk segmenting: bottom, middle, and upper

2.4 Observations

2.4.1 Yield

Yield was calculated by cutting each trunk section (bottom, middle, upper) into 50 cm segments, then quartering them vertically and weighing (Wb). The sap was extracted from the pith through size reduction and pressing, and the resulting sap was weighed (Wn). The yield was calculated using the following formula:

$$Yield\ (\%) = \frac{Wn}{Wb} \times 100\% \quad (1)$$

2.4.2 pH

The pH was measured using a HANNA HI 2550 pH/ORP & EC/TDS/NaCl meter by immersing the electrode into 10 mL of sap sample, then waiting until the displayed value stabilized.

2.4.3 Total soluble solids

Total soluble solids were measured using an ATAGO DTM-1 refractometer. Two drops of sample were placed on the prism surface, the prism cover was closed, and the knob adjusted until the chromatic boundary line was aligned with the cross line. The reading was observed through the refractometer eyepiece.

2.4.4 Reducing sugars content

Reducing sugars content analysis method following Anggraeni and Schumacher [12]. Sample sap 0.5 mL was mixed with 0.5 mL DNS (Dinitrosalicylic Acid) reagent, then heated in boiling water for 5 minutes. The mixture was cooled, diluted to 5 mL with distilled water, homogenized, and the absorbance was measured at 540 nm. Results were compared with a glucose standard curve (0.1–0.5 mg/mL).

2.4.5 Starch content

Starch content analysis method following ICUMSA method [13] Sampel (15 mL of sap) was placed in a 50 mL volumetric flask, mixed with 25 mL calcium chloride–acetic acid solution, and heated in boiling water for 15 minutes with continuous shaking. After cooling, the volume was adjusted to volume with distilled water. A 15 mL aliquot was transferred into a 25 mL volumetric flask and divided into "sample" and "blank." Each was mixed with 2.5 mL 1N acetic acid solution. The "sample" was then added with 5 mL Lugol's iodine solution and topped up to the mark with distilled water. The absorbance was measured at 770 nm and calculation was based on the starch standard curve developed from 10 to 80 ppm.

2.4.6 Total Phenolic Content

Total phenolic content analysis method following Nurdjanah et al. [14]. Sample (5 mL of sap) was mixed with 0.5 mL Folin reagent, homogenized, and incubated for 3 minutes. Then, 0.5 mL of 20% Na_2CO_3 solution was added, followed by incubation in the dark for 30 minutes. Absorbance was measured at 742 nm and calculation was based on a gallic acid standard curve (20–140 mg/L) [3].

2.4.7 Total Flavonoid Content

Total flavonoid content analysis method following Nurdjanah et al. [14]. Sampel (5 mL of sap) was mixed with 5 mL $AlCl_3$ in methanol, incubated for 10 minutes, and the absorbance was read at 415 nm. Results calculated using a quercetin standard curve (5–30 mg/L).

2.4.8 Free Radical Scavenging Activity

Antioxidant activity was tested using the DPPH method, following Nurdjanah et al. [14]. DPPH (0.0078 g) was dissolved in 100 mL of 96% ethanol. Then, 2 mL of this solution was mixed with 1 mL of sap sample, incubated in the dark for 30 minutes, and absorbance was read at 517 nm.

3 Result and Discussion

3.1 Yield

The sap yield obtained in this study ranged from 9.82% to 12.26%. These values were lower compared to the those of studied by Khalid et al. [15] and Dirkes et al. [7], which reported yields of 28% and 50%, respectively. This discrepancy can be attributed to several factors, such as cultivar, planting conditions, fertilization, and environmental factors [16][17]. According to Sarma et al. [17], sap yield tends to increase during the rainy season. These factors can affect stem conditions such as moisture content, starch, stem circumference, and others. The sap yields from different trunk sections were 12.26% for the bottom section, 11.47% for the middle section, and 9.82% for the upper section (Figure 2). The bottom section contained relatively more water compared to the middle and upper sections. Hassan et al. [10] reported that the basal part of the oil palm trunk contains larger parenchyma tissues than the middle and upper sections, which function as storage for food reserves and water in the plant.

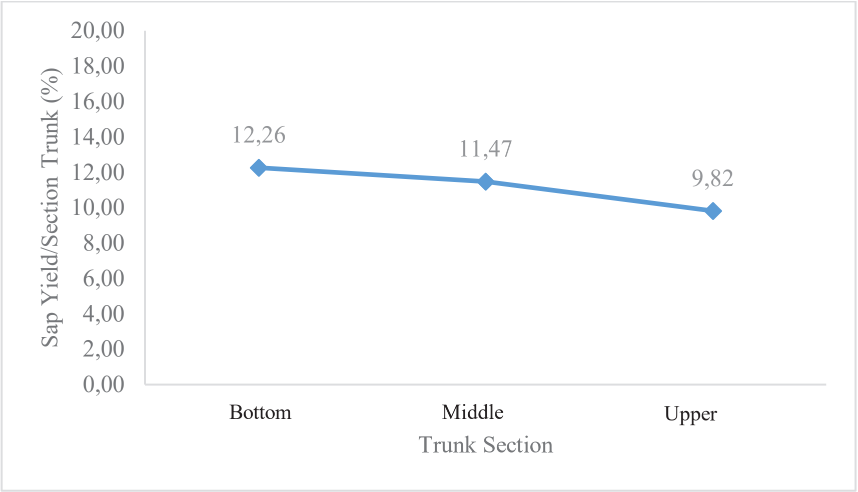

Figure 2. Sap yield from oil palm trunk section

Table 1. Sap characteristic for total soluble solid, pH, reducing sugar and starch content.

Section	pH	Total Soluble Solid (°Brix)	Reducing Sugar (%)	Starch Content (ppm)
Bottom	5,33±0,01^{c}	11,68±0,18^{c}	2,91±0,13^{c}	166,64±3,81^{c}
Middle	5,49±0,01^{b}	13,58±0,15^{a}	3,41±0,16^{b}	481,17±4,79^{a}
Upper	5,55±0,02^{a}	13,13±0,13^{b}	3,87±0,06^{a}	447,18±1,85^{b}

3.2 pH

The pH values of oil palm trunk sap differed significantly ($P < 0.05$) among the trunk sections. Table 1 shows that the pH of sap increased from the bottom to the middle and upper sections, with values of 5.33, 5.49, and 5.55, respectively. Previous studies reported pH values of pressed trunk sap of 5.16 [18] and 5.4 [19]. The slightly acidic pH of oil palm trunk sap is influenced by environmental factors such as season and soil conditions [19]. Juanssilfero et al. [20] also reported a pH of 5.0 for pressed trunk sap, indicating that the slightly acidic pH of pressed sap is normal.

3.3 Total Soluble Solids

The total soluble solids of oil palm trunk sap also differed significantly ($P < 0.05$) among trunk sections. As shown in Table 1, the bottom, middle, and upper sections contained 11.68°Brix, 13.58°Brix, and 13.13°Brix, respectively. According to Husna et al. [21], total soluble solids in sugarcane sap include sugars, starch, minerals, and other organic components. In this study, sap from the middle section of the trunk had higher soluble solids than those of from the bottom and upper sections. This is because the middle section of aged oil palm trunks has larger vascular tissues compared to the bottom and upper parts [10]. Vascular tissues may differentiate into parenchyma cells, and parenchyma in the middle trunk tends to be larger than in the bottom and upper sections. Yusra et al. [22] and Horiyama et al. [23] noted that parenchyma cells act as storage tissues for plant food reserves.

3.4 Reducing Sugars

The reducing sugar content in sap from the bottom, middle, and upper section showed a significant difference (P < 0.05). As shown in Table 1, reducing sugar contents were 2.91%, 3.41%, and 3.87% for the bottom, middle, and upper sections, respectively. Reducing sugars were higher in the upper section, this was possibly related to plant growth and development functions. According to Ciereszko [24], glucose or trehalose-6-phosphate (Tre6P) plays a regulatory role in growth and metabolic processes in plants. Reducing sugars are carbohydrates capable of reducing electron acceptors [25]. All monosaccharides (glucose, fructose, galactose) and disaccharides such as lactose and maltose, except sucrose and starch, are classified as reducing sugars [26].

3.5 Starch

Starch content in oil palm trunk sap also differed significantly (P < 0.05) among trunk sections. As shown in Table 1, the middle section had the highest starch content (481.17 ppm), followed by the upper (447.18 ppm) and bottom sections (166.64 ppm). Oil palm is one of the tree species that stores starch in parenchyma cells rather than fibers [27]. According to Omar et al. [28], variation in starch content is related to the proportion of parenchyma to vascular tissue. Oil palm trunks are structurally complex, and trunk section affects tissue density. Hassan et al. [10] noted that the basal section is denser than the middle and upper sections, while the latter contain larger and more abundant parenchyma cells.

Table 2. Sap characteristic for phenol content, flavonoid content and free radical scavenging activity.

Section	Phenol Content (mg/100g GAE)	Flavonoid content (mg/100g QE)	Free Radical Scavenging Activity (%)
Bottom	46,08±0,72^{a}	8,92±0,32^{a}	93,93±0,18^{a}
Middle	40,86±1,25^{b}	5,26±0,32^{b}	91,42±0,75^{b}
Upper	37,17±0,41^{c}	4,15±0,14^{c}	90,59±1,30^{b}

3.6 Total Phenolic Content

The total phenolic content of oil palm trunk sap differed significantly (P < 0.05) among trunk sections. As shown in Table 2, the bottom, middle, and upper sections contained 46.08 mg/100 g GAE, 40.86 mg/100 g GAE, and 37.17 mg/100 g GAE, respectively. According to Hebbar et al. [29], fresh palm sap typically contains about 0.33 g/L of phenolics. Phenolic compounds are secondary metabolites that function as protective mechanisms against ultraviolet radiation and pathogens [30]. The basal trunk contained the highest phenolic content, associated with the tree's defense mechanism against pathogens. Suwandi et al. [31] noted that one of the most destructive diseases in oil palm, basal stem rot caused by Ganoderma spp., infects and decays root and stem tissues, thereby disrupting water and nutrient translocation. Thus, phenolic accumulation is highest in the basal bottom section, followed by the middle and upper sections.

3.7 Total Flavonoid Content

The flavonoid content of oil palm trunk sap also differed significantly (P < 0.05) among trunk sections. As shown in Table 2, the bottom, middle, and upper sections contained 8.92 mg/100 g QE, 5.26 mg/100 g QE, and 4.15 mg/100 g QE, respectively. Flavonoids are a subgroup of phenolics and are classified as secondary metabolites [29][17]. The highest flavonoid content was found in sap from the basal section, consistent with the role of flavonoids in plant defense against root rot pathogens in oil palm [31]. In palms, dihydroflavonoids are commonly reported [32].

3.8 Free Radical Scavenging Activity

Free radical scavenging activity, measured by the DPPH assay, differed significantly (P < 0.05) among trunk sections for both sap and liquid sugar. The highest antioxidant activity was observed in sap from the bottom section, followed by the middle and upper sections, with scavenging percentages of 93.93%, 91.42%, and 90.59%, respectively. Phenolic compounds are the main contributors to antioxidant activity [33][29][34]. As shown in Table 2, phenolic content was highest in the bottom section, consistent with stronger scavenging activity. According to Gulcin and Alwasel [35], DPPH radicals exhibit a deep violet color, which fades to yellow or transparent upon reduction through hydrogen atom transfer from antioxidants.

4 Conclusion

The result of analysis position of the oil palm trunk significantly influenced the yield and chemical composition. Sap yield was highest in the bottom position was 12.26% and chemical characteristics pH was 5,33; total soluble solid was 11,68°brix; reducing sugar was 2,91%; starch content was 166,64ppm; phenol content was 46,08mg/100g GAE; flavonoid content was 8,92mg/100g QE and antioxidant activity using DPPH was 93,52%. These findings imply that sap collected from different trunk sections may be converted into a range of useful compounds; more investigation into these issues is necessary.

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