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EFFECT OF ETHANOL TREATMENT ON SHRINKAGE OF OIL PALM TRUNK FOR THE DRYING PROCESS

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ABSTRACT. *Oil palm trunk is one of the promising biomass materials due to the high volume of unused waste components and increasing worldwide demand to replace conventional wood. This study investigated the feasibility of using ethanol as a drying agent for oil palm trunks with different dimensional surfaces (radial, tangential and longitudinal sections). The radial shrinkage percentage for the outer layer is 1.50% (untreated) and 1.22 % (treated). In comparison, the inner layer of the untreated sample was recorded at 2.54 % shrinkage and the treated sample was at 2.29%. The tangential sample for the inner untreated sample shows 2.60% and the treated sample shows 2.40%. The same pattern of shrinkage was shown for the tangential section on the outer layer as 1.81% and 1.10% of the untreated and treated sample respectively. For the longitudinal surface, the inner layer section of the untreated sample was recorded at 0.39% compared to the treated sample at 0.25%. In comparison, a longitudinal surface section for the outer layer of the untreated sample was recorded at 0.38%, while the treated sample was recorded at 0.33% shrinkage percentage. The effect of ethanol treatment on the shrinkage is significantly different between different sections (P-value: 0.01) and between the outer and inner layers (P-value: 0.02). The result suggested that ethanol treatment could be an option for the oil palm trunk drying process. Dried oil palm trunks can be utilized as a potential substitution for biomass and wood to produce various products.*

KEYWORDS. Oil palm trunk (OPT), shrinkage percentage, moisture content, ethanol

INTRODUCTION

The Malaysian wood industry is facing challenges in terms of sustaining the growth of the industry which is now critical due to a rapidly approaching shortage of raw materials (Ab Latib et al., 2022). Alternative sources have been sought after from sustainable biomass to replace natural timber fields. (Amira et al., 2020). Oil palm trunk is one such source that has been widely accepted as it is very economical compared to solid wood. In addition, its performance is also comparable to solid wood in terms of stability and resistance to weather albeit with slight modification needed before its use (Hashim et al., 2012; Sulaiman et al., 2012).

Oil palm *(Elaeis guineensis)* of the palm family (*Arecaceae*) grows in the wildlands of West Africa and has been developed into an agricultural crop worldwide. The oil palm was introduced to Malaysia in early 1870 as an ornamental plant (Teoh, 2002). It then becomes the largest commercial plantation in Malaysia to date. As the largest commercial plantation, oil palm plantation creates huge quantities of oil palm trunks, oil palm shells, oil palm fronds, empty fruit brunch, and other related biomass (Kaniapan et al., 2021). Out of all oil palm-related biomass, the oil palm trunk is considered to be the highest value in terms of potential to be exploited (Abdul et al., 2012; Abdul Hamid et al., 2015; Eom et al., 2015).

Oil palm trunk has higher moisture content than other wood, ranging from 120% to over 500% (Lim & Gan, 2005; Wong et al., 2019). It is difficult to dry the moisture from oil palm trunk as it usually takes 7 to 12 days with a recovery rate of only 18.26% while the remaining lumber (81.70%) was considered a waste to dry via the industrial kiln dry process (Anis et al., 2016; Rais et al., 2021). The total drying time is an important parameter for oil palm trunks as it affects dimensioning, reduces degradation, prevents biological staining, and reduces transport costs (Murphy et al., 2021). On the other hand, reducing drying time will increase the defect on the wood surface such as cracking and twisting (Bakar et al., 1998).

The oil palm trunk drying method using ethanol has enormous potential as it has been used in many applications. For instance, ethanol also was used previously as a drying agent in medicinal plants (Silva et al., 2018), improving the pulping process from wood (Hochegger et al., 2019), and also for the precipitation of lignin (Hamzah et al., 2020). The advantages of ethanol are that it is a relatively cheap solvent, has complete miscibility with water, has a hardening effect, has a powerful dehydration capacity, and has a penetrability (Lai & Lü, 2012). Therefore, in this study, shrinkage of oil palm trunk using ethanol has been studied to explore the potential of ethanol as a treatment method for the drying process of the oil palm trunk.

MATERIALS AND METHODS

Oil palm trunk collection and preparation

A 25-year-old oil palm tree has been harvested from an oil palm plantation in UiTM Jengka, Pahang, Malaysia. Before the logging process, the tree height and diameter at breast height (DBH) were checked and recorded to ensure that the oil palm trunk was at a suitable size for the sampling (Migolet et al., 2020; Tan et al., 2014). A chainsaw (Husqvarna 372XP) was used in felling the oil palm tree. The top and the bottom part were removed, leaving approximately ~3 m of the oil palm trunk section, and subsequently, it was then cut into a disc shape. The disks were tagged with the outer and inner layer parts (Figure 1) by estimating 70% distance of the disc from the center of its inner layer while the remaining 30% was considered as the outer layer (Hashim et al., 2012). Disc shape oil palm trunk was then cut into cube sizes of 2 cm X 2 cm X 6 cm with sectional segregation of tangential, radial, and longitudinal parts. All samples were run in biological triplicates.

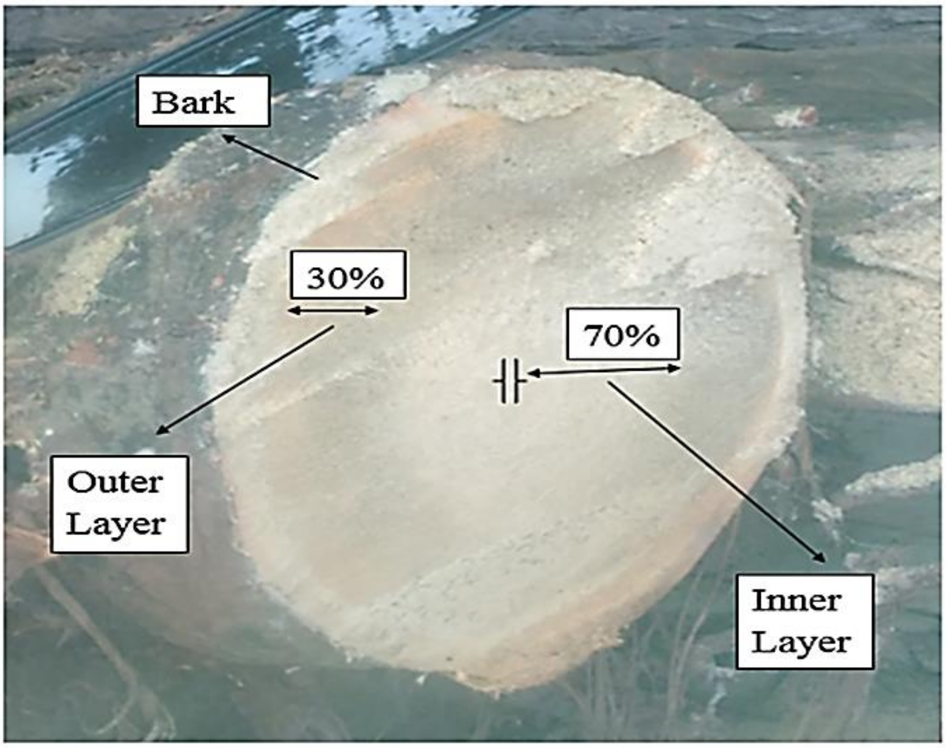

Figure 1. Disc cutting design of oil palm trunk. The inner layer was marked as 70% distance from its core and the remaining 30% distance was designated as an outer layer.

Ethanol-treated oil palm trunk samples

Oil palm trunk samples cut into cube sizes were then measured using a veneer caliper (Mitutoyo) before soaking with ethanol for calculation afterward. Ethanol (Supelco®) with 85% concentration was used for the soaking treatment process. Samples were soaked fully submerged in a closed container to prevent the early evaporation of ethanol for 24 hours (Figure 2). Next, the samples were dried using a drying oven (Memmert) with a constant temperature of 103±2 °C. The moisture content of each sample was determined by weighing the sample using an analytical balance (Shimadzu) before and after drying treatment until it came to a constant weight.

Figure 2. The soaking treatment process of cube-sized oil palm trunk (OPT) with ethanol. The samples were kept in a closed container at room temperature for 24 hours before drying.

Moisture and shrinkage calculation for the ethanol treatment process

Moisture Content (MC) from cube-sized oil palm trunk (OPT) soaked with ethanol was calculated following the equation as per British Standard Methods for testing small clear specimens of timber (BS373:1957).

$$\text{Moisture content (MC) \%} = \frac{air\ dried - oven\ dried}{oven\ dried} \times 100\%$$

Shrinkage of the cube-sized oil palm trunk (OPT) soaked with ethanol samples was also calculated following the equation as per British Standard Methods for testing small clear specimens of timber (BS373:1957) and the mean was recorded.

$$\text{Radial section shrinkage (\%)} = \frac{width\ green - width\ oven\ dry}{width\ green} \times 100\%$$

$$\text{Tangential section shrinkage (\%)} = \frac{width\ green - width\ oven\ dry}{width\ green} \times 100\%$$

$$\text{Longitudinal section shrinkage (\%)} = \frac{width\ green - width\ oven\ dry}{width\ green} \times 100\%$$

Statistical Analysis

Analysis of variance (ANOVA) of two factors without replication was carried out to assess statistical differences between radial, tangential, and longitudinal sections.

RESULTS AND DISCUSSION

The moisture content of different layers of oil palm trunk

Moisture content (median) of the prepared oil palm trunk (OPT) samples treated and untreated for both inner and outer layers is shown in Figure 3. The median moisture content of the untreated sample is 375% for the outer layer and 578% for the inner layer (Figure 3). The median moisture content for treated samples was 385% for the outer layer 585% for the inner layer and (Figure 3). Differences in moisture content between the inner layer and outer layer of oil palm trunk samples are due to the presence of parenchyma cells in the core layer higher compared to the outer layer. As a result, this affects the moisture content because parenchyma cell tends to absorb moisture (Mhd Ramle et al., 2012).

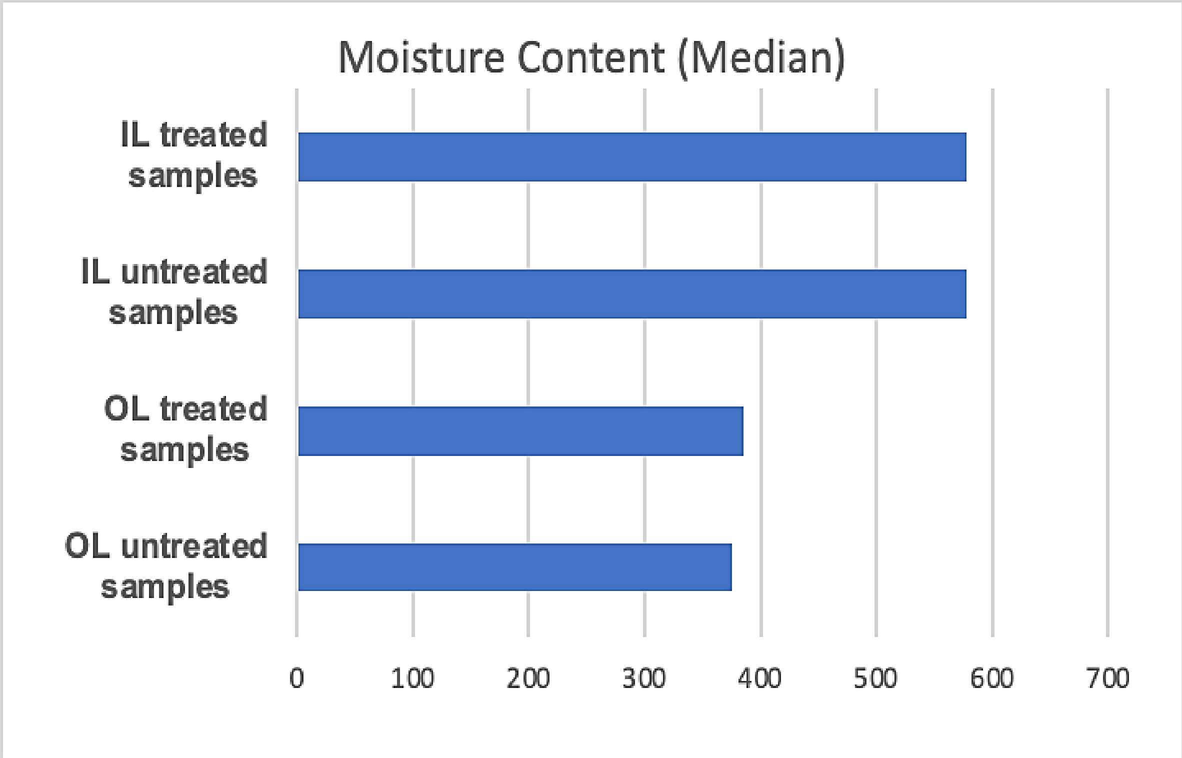

Figure 3. The median moisture content of untreated and treated samples of oil palm trunk (OPT) for both the inner layer (IL) and outer layer (OL).

Shrinkage of different sections of oil palm trunk

The radial layer section in the oil palm trunk is characterized by the vertical plane from the pith at the center of the tree heading out towards the bark, while the tangential section is made perpendicular to the rays and tangential to the annual rings and face of the oil palm trunk (Rosli et al., 2021)**.** On the other hand, the longitudinal section is a cut along the long axis of a structure.

Overall, the use of ethanol decreased the percentage of shrinkage significantly on radial, tangential and longitudinal surfaces (*p-value: 0.01*). On the radial surface section, the outer layer showed 1.50% shrinkage for an untreated sample and 1.22 % for the treated sample. In comparison, the inner layer of the untreated sample was recorded at 2.54 % shrinkage and the treated sample was at 2.29% (Table 1). The tangential sample for the inner untreated sample shows 2.60% and the treated sample shows 2.40% (Table 1). The same pattern of shrinkage was shown for the tangential section on the outer layer was 1.81% and 1.10% of untreated and treated samples respectively (Table 1). For the longitudinal surface, the inner layer section of the untreated sample was recorded at 0.38% compared to the treated sample at 0.33% (Table 1). In comparison, a longitudinal surface section for the outer layer of the untreated sample was recorded at 0.39% while the treated sample was recorded at 0.25% shrinkage percentage.

Table 1. Shrinkage percentage (mean) of a treated and untreated sample of radial, tangential and longitudinal layers.

	Radial		**Tangential**		**Longitudinal**	
	Untreated	Treated	Untreated	Treated	Untreated	Treated
Outer Layer	1.50	1.22	1.81	1.10	0.39	0.25
Inner Layer	2.54	2.29	2.60	2.40	0.38	0.33

From the data collected in this study, it is apparent that the shrinkage percentage of the inner layer of tangential, radial, and longitudinal sections is significantly higher compared to the outer layer (*P-value: 0.02*). The inner layer has parenchyma cells and more moisture than the outer layer and consequently could cause the sample to shrink faster compared to the outer layer (Mhd Ramle, 2021; Mhd Ramle et al., 2012). It has been presented that the feature of the vascular bundle is dense, fibrous, and at least hygroscopic while the parenchyma feature is soft, spongy, and highly hygroscopic (Abdul Hamid et al., 2015; Erwinsyah et al., 2007).

In this study, it was shown that ethanol could contribute significantly to the overall drying process of the oil palm trunk, especially for shrinkage. This improvement in drying properties was recorded despite the short time of exposure (24 hours), hence future studies should include different soaking times in ethanol. This was also the case for other plant-based materials such as coumarin leaves (Silva et al., 2018), pineapple (de Freitas et al., 2021), and melon (da Cunha et al., 2020). However, another important function of ethanol in the drying process is to improve attributes of the dried material such as rehydration capacity and shrinkage (Funebo et al., 2002), color (Pang, 2006) aroma retention (Corrêa et al., 2012) and vitamin C retention ((Santos & Silva, 2009). In general, ethanol made the sample stable quickly and prevented the sample from overdrying and damaging its physical properties (de Freitas et al., 2021; Funebo et al., 2002). This improvement of plant material by ethanol is an attractive prospect for the oil palm trunk drying process in which the material is being protected before conversion to end-products such as chipboard, composite panels, and plywood.

CONCLUSION

In this study, it can be concluded that between three-surface directions (tangential, radial, and longitudinal), the tangential section has the most shrinkage, followed by radial and longitudinal. It is also clear in this study that the inner layer of the oil palm trunk is easily shrunk after ethanol treatment in comparison to the outer layer. This is due to the presence of parenchyma cells in a core layer that easily absorbs and releases water in comparison to the presence of a vascular bundle in the outer layer that reduces the rate of shrinkage. The shrinkage between untreated and treated samples shows that the treated sample has higher shrinkage percentage compared to the untreated sample (*P-value: 0.01*). The shrinkage percentage of the inner layer of tangential, radial, and longitudinal sections is significantly higher compared to the outer layer (*P-value: 0.02*). The shrinkage was recorded despite the short exposure of samples to ethanol (24 hours) and related to the drying time. However, another important property of ethanol is to prevent over-drying of the oil palm trunk. From this study, it can be summarised that ethanol could be the solution for dimensional stability of oil palm drying.

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