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 high volume of unused waste component and increasing worldwide demand to replace conventional wood. The purpose of this study was to investigate the feasibility of using ethanol as drying agent for oil palm trunk with different dimensional surface (radial, tangential and longitudinal sections). For untreated samples, radial shrinkage percentage for inner layer is 1.5% and for outer layer is 1.22%. In comparison, inner layer of untreated sample was recorded at 2.54 % shrinkage and treated sample was at 2.29%. As tangential sample for inner untreated sample shows 2.6% and treated sample shows 2.4%. Same pattern of shrinkage shown for tangential section on outer layer as 1.81% and 1.1% of untreated and treated sample respectively. For longitudinal surface, inner layer section of untreated sample was recorded at 0.39% compared to treated sample at 0.25%. In comparison, longitudinal surface section for outer layer of the untreated sample was recorded at 0.38% while the treated sample was recorded at 0.33% shrinkage percentage. The result suggested that ethanol treatment could be an option for oil palm trunk drying process. Dried oil palm trunk can be utilised as potential substitution of biomass and wood for production of various product.

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 that is now critical due to a rapidly approaching shortage of raw materials (Ab Latib et al., 2022). Alternative sources had been sought after from sustainable biomass to replace natural timber (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, it’s performance also comparable to solid wood in terms of stability and resistance to weather albeit slight modification needed prior to 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 the early 1870 as an ornamental plant (Teoh, 2002). It then become largest commercial plantation in Malaysia to date. As the largest commercial plantation, oil palm plantation creates huge quantities of oil palm trunk, oil palm shell, oil palm frond, empty fruit brunch and other related biomass (Kaniapan et al., 2021). Out of all oil palm related biomass, oil palm trunk 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 compared to other wood. Lim and Gan (2005) claimed that oil palm trunk moisture range from 120% to over 500%. It is difficult to dry the moisture from oil palm trunk as it is usually taking 14-29 days to dry via industrial kiln dry process. The total drying time is an important parameter for oil palm trunk as it affects dimensioning, reducing degradation, prevent biological staining, and reduce transport cost (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).

Oil palm trunk drying method using ethanol has an enormous potential as it was used in many applications. For instance, ethanol also was used previously as drying agent in medicinal plant (Silva et al., 2018), improving pulping process from wood (Hochegger et al., 2019) and also for precipitation of lignin (Hamzah et al., 2020). The advantages of ethanol is that it is relatively cheap solvent, a complete miscibility with water, a hardening effect, a powerful dehydration capacity, and 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 treatment method to for the drying process of oil palm trunk.

Materials and methods

Oil palm trunk collection and preparation

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

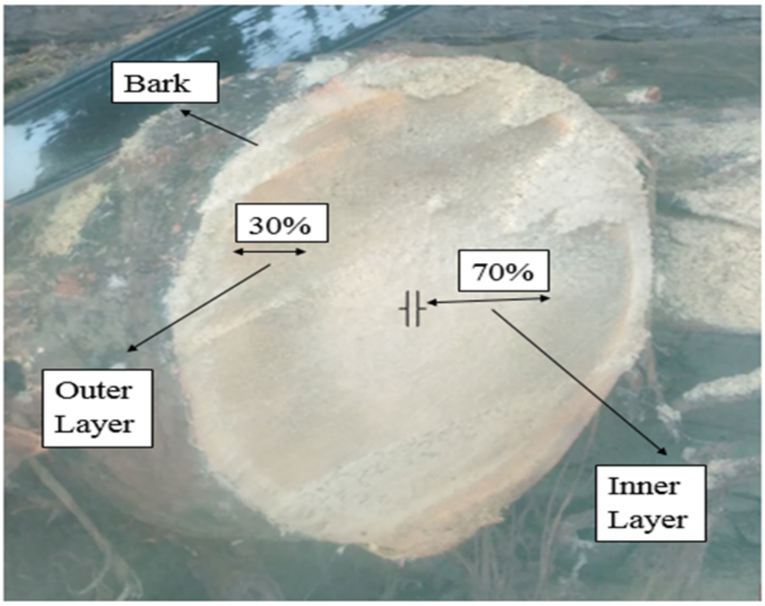

Figure 1. Disc cutting design of oil palm trunk. The inner layer was marked as 70% distance from its core and the remaining 30% distance was designated as outer layer.

Ethanol-treated oil palm trunk samples

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

Figure 2. 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 prior to drying.

Moisture and shrinkage calculation for 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 specimen 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 specimen of timber (BS373:1957).

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

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

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

Results and Discussion

Moisture content of different layer of oil palm trunk

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

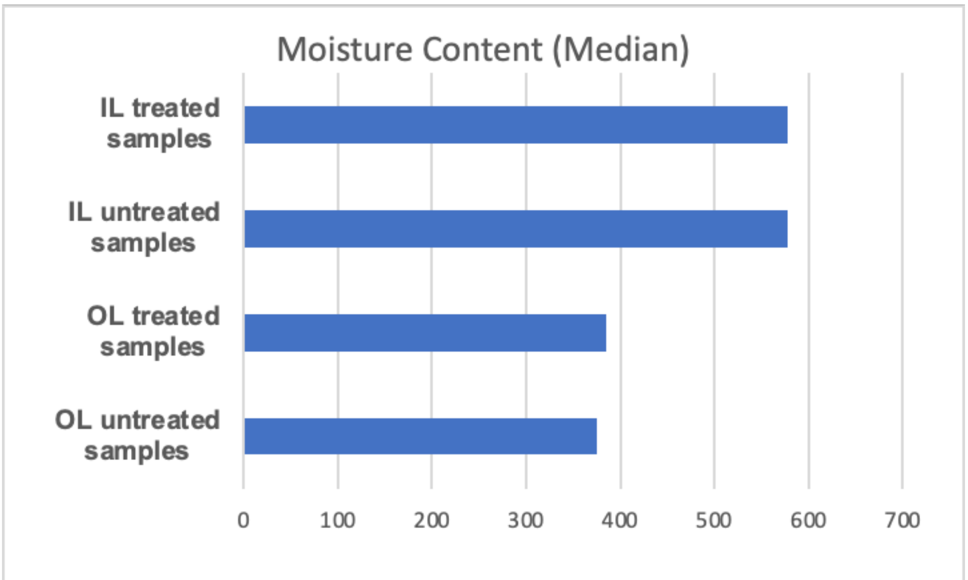

Figure 3. Median moisture content of untreated and treated samples of oil palm trunk (OPT) for both the inner layer (IL) and outer layer (OL).

Shrinkage of different sections of oil palm trunk

Radial layer section in oil palm trunk is characterized by the vertical plane from the pith at the center of the tree heading out towards the bark while 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, longitudinal section is a cut along the long axis of a structure.

Overall, the use of alcohol decreased the percentage of shrinkage significantly on radial and tangential surface (see Figure 4 and Figure 5). On radial surface section, outer layer shown 1.5% shrinkage for untreated sample and 1.22 % for treated sample. In comparison, inner layer of untreated sample was recorded at 2.54 % shrinkage and treated sample was at 2.29% (Figure 4). As tangential sample for inner untreated sample shows 2.6% and treated sample shows 2.4% (Figure 5). Same pattern of shrinkage shown for tangential section on outer layer as 1.81% and 1.1% of untreated and treated sample respectively (Figure 5). For longitudinal surface, inner layer section of untreated sample was recorded at 0.39% compared to treated sample at 0.25% (Figure 6). In comparison, longitudinal surface section for outer layer of the untreated sample was recorded at 0.38% while the treated sample was recorded at 0.33% shrinkage percentage.

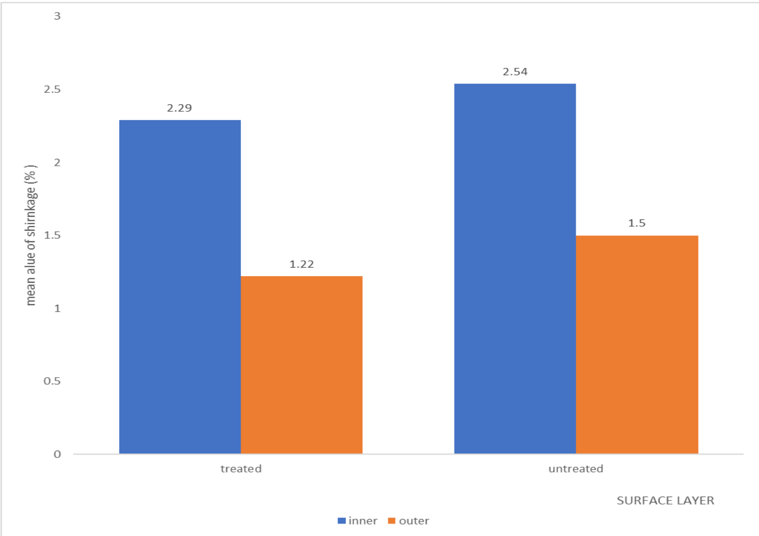

Figure 4. Shrinkage percentage of treated and untreated sample of radial layer

From the data collected in this study, it is apparent that shrinkage percentage of tangential, radial, and longitudinal sections is slightly higher compared to outer layer (see Figure 4-6). The inner layer has parenchyma cell and has more moisture than outer layer and consequently could cause sample to shrink faster compare to outer layer (Mhd Ramle, 2021; Mhd Ramle et al., 2012). It had been presented that the feature of the vascular bundle is dense, fibrous and at least hygroscopic while 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 did not contribute significantly to the overall drying process of the oil palm trunk. It is possible that this is due to the short time of exposure (24 hours), hence future studies should include different soaking time 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), colour (Pang, 2006) aroma retention (Corrêa et al., 2012) and vitamin C retention ((Santos & Silva, 2009). In general, ethanol made the sample stable quickly and prevent the sample from over drying and damaging the physical properties (de Freitas et al., 2021; Funebo et al., 2002). This improvement of plant material by ethanol is an attractive prospect for oil palm trunk drying process in which the material is being protected prior to conversion to end-products such as chip board, composite panels, and plywood.

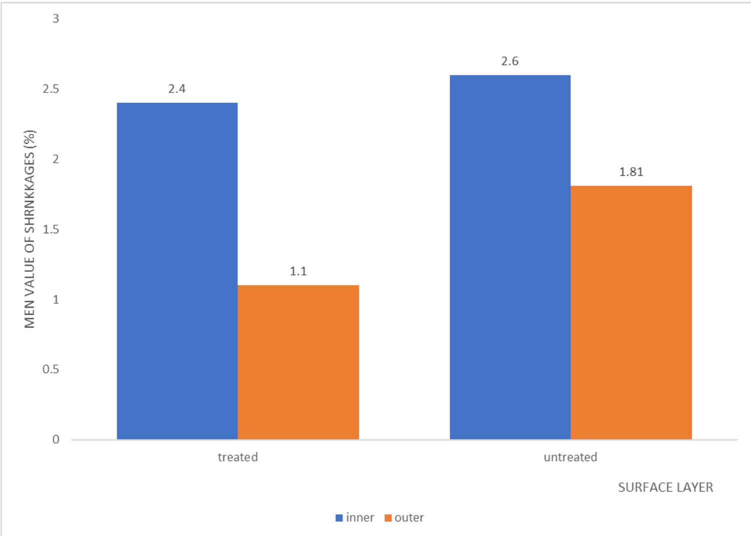

Figure 5. Shrinkage percentage of treated and untreated sample of tangential layer

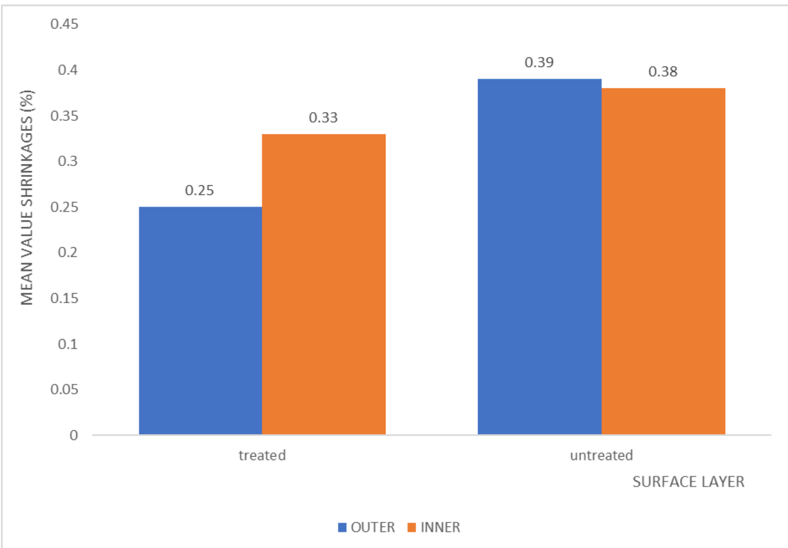

Figure 6. Shrinkage percentage of treated and untreated sample of longitudinal layer

Conclusion

In this study, it can be concluded that between three-surface direction (tangential, radial, and longitudinal), the tangential section has most shrinkage followed by radial and lastly longitudinal. It is also clear in this study that inner layer of oil palm trunk is easily shrunk after ethanol treatment in comparison to outer layer. This is due to present of parenchyma cell in core layer that easily absorb and released water in comparison to the presence of vascular bundle in outer layer that reducing the rate of shrinkage. The shrinkage between untreated and treated sample shown that untreated sample has higher shrinkage percentage compared to treated sample. This could be due to 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 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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