Distribution of Oil Palm Starch for Different Levels and Portions of Oil Palm Trunk

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Abstract

It is widely known that starch can be heated to have adhesive characteristic. The properties of starch rich, low density oil palm wood from the inner part of oil palm trunk (OPT) have been seen to be possible improved through steam-densification process by using in situ starch as binding agent. For that, the distribution and characteristic of the extracted starch at different height and portions of OPT are first need to be investigated. Starch extraction of OPT was made by traditional grating-dissolving method in water. Starch distributions were found more concentrated in core portion and it increased as the heights increasing. At the first 2 m height above the ground, mean extracted starch content was 2.9%, 4.3% and 5.6% for the outer, middle and core respectively. Regardless of portion, mean extracted starch content was 4.3%, 7.4%, 7.7% and 8.5% for the first, second, third, and fourth 2 m trunk height respectively. Regardless of level, mean extracted starch content was 4.9%, 7.2% and 8.8% for the outer, middle and core portion respectively. Other study using $Na_2S_2O_5$ as solvent gave 7.15% mean starch content for the oil palm slabs (the outer portion). Further study on the extracted starch characterization, it was found that the starch from core portion turned into darker blue color than the outer, and the starch from upper level turned into darker blue color than the lower level when they were subjected to iodine test. The blue color is usually used to indicate the purity of starch, the darker the color, the purer the starch. The results suggest that both the extracted starch content and the starch purity were showing the same trend, increased from outer inside and from bottom upside, in the OPT.

Keywords: oil palm wood, parenchyma, starch content, grating-dissolving method.

Introduction

Being the largest exporter of palm oil and the second largest oil palm planter in the world, Malaysia has huge amount of unutilized OPT in the field. The dumping and open-air burning of this waste has been no longer choice since it leads to serious environmental problems. With few ongoing research which focusing on waste utilization, world already have few useful products from OPT, such as gypsum board, wood cement composites, pulp, and veneers. The gypsum board was made by using fine and coarse particles that were obtained through chipping and flaking the whole part of the trunk. The wood cement composite were engineered by using fibers mainly from the whole part of the trunk. While the outer part of OPT (density ranges between 400 to 500 kg/m³) was being concentrated on making veneers.

Unevenly distribution of vascular bundles along the radial direction of stem gives a variation of density values at different parts of the OPT. Wood from the outer part of the stem (OPW) has higher density and better properties than those from the middle and center, and it can be used as solid wood upon proper treatment. Several studies revealed that high quality solid OPW can be resulted by impregnating the material with low-molecular weight Phenol Formaldehyde (PF) resin through modified compreg method (Bakar *et al.* 2005a, 2005b; 2006, Amarullah *et al*. 2010).

The inner parts of OPT, however, have never been used as solid wood. Due to its inherent properties, the inner OPT are too soft and too porous with low in density level; lesser than 300 kg/m³ (Lim and Khoo 1986; Bakar *et al.* 2001). No detail studies have been done using this part of trunk as a solid wood. Previous study suggested that this low density and high porosity part of trunk would be not economical for the resin impregnation treatment.

However, inner parts of OPT are rich with starch. Theoretically, the starch granules can be modified into colloidal suspensions through heating process with water (Baumann and Conner 2003). Hoseney (1994) believed that the starch granules have undergone a change called gelatinization. The colloidal suspension is referring to the thickening phase of a uniform mixture between starch granules throughout the dispersion of water during gelatinization (Baumann and Conner 2003). Starch paste is one of the first glue-boiling plants that have been discovered during the Middle Ages. Current studies reported that through scanning electron microscopy, adhesion between the compressed cells of binderless particle board made from core part of the OPT has been facilitated by starch granules (Rokiah *et al*. 2011). Therefore, there is also possibility to modified *in situ* starch of OPW into adhesive characteristic through steaming as binding agent necessary for quality improvement of low density OPW. For that purpose, the distribution and characteristic of the extracted starch at different height and portions of OPT are first need to be investigated. The objective of this study was to assess the content of OPT's starch of matured oil palm trees.

Materials and Methods

Material Preparation

Investigation was made on three matured oil palm trees of about 25 years old collected from Dengkil plantation, Selangor, Malaysia. Four 13 cm thick discs from each tree were cut starting at about 50 cm from the ground and going up with an interval of 2 m. The sampling of different zones of a strip was made by applying preparation of stem samples method where a total of 6 block samples measuring 5 cm x 5 cm x 5 cm from each disk were cut representing the outer, middle, and core zones of the disk (Bakar 2000). Other 2 cm x 2 cm x 2 cm blocks from each disk were cut and dried in an oven for 24 hours at ±103°C for density and moisture content determination.

Starch Extraction Process

The extraction process of starch was done by modifying the grating and dissolving water process done by Erica *et al.* (2005). Parenchyma tissues were separated manually from vascular bundles by grating the OPW block samples in wet condition. The grated OPW samples were thoroughly mixed with 2.0 liter of distilled water, and the suspension was filtered through a muslin cloth, separating starch slurry from fibrous dregs. The fibrous material was put aside for the second filtering process.

After two repeated water-mixing step, the combined milky starch slurry was kept in a room temperature for 24 h sedimentation process. After 24 h, the supernatant liquid was discarded leaving the precipitated mass. The precipitated mass was then drain onto an aluminum tray and leaved for 12 h air drying process to obtain dried starch powder. The dried starch powder was brushed out from the tray and weighted. The percentage of starch extraction was calculated by using this formula:

$$\text{Starch content}\,(\%) = \frac{\text{Dry starch}\,(g)}{\text{Dry block}\,(g)} \times 100$$

Starch Identification Process

Starches were made up by of chains of glucose molecules. Starches can be identified in substances through iodine test by using solution of iodine and potassium iodide (I_2KI). An I_2KI solution was prepared by 1.3 g of iodine by adding in 2.0 g potassium iodide and 100 ml distilled water. With a few drops of this solution onto the starch, the color will change into dark blue or black. The dark blue color was similar to corn starch while the black is similar to tapioca starch when subjected to I_2KI drops (Bruce *et al.* 2010)

Statistical Analysis

The data were analyzed using Analysis of Variance (ANOVA) to determine the significant difference of extracted starch content at various levels and portions of OPT. Least Significant Different method was used for further analysis to evaluate significant level among the variables studied.

Results and Discussion

Starch Content at Different Radial Positions and Heights of Oil Palm Trunk

Table 1 shows the percentage of starch content distribution within oil palm trunk, in which it was increasing from base upwards and from the outer inwards.

Table 1. Starch content (%) at different levels and portions of oil palm trunk.

Radial Positions	Trunk Height 1	2	3	4
Core	5.64	8.50	10.86	10.37
Middle	4.30	6.91	8.40	9.31
Outer	2.93	6.85	3.78	5.92

Variation of Starch Content in Oil Palm Trunk with Sample Height.

The results for the mean of starch content of OPT between trunk height are summarized in Table 2. The results show that there was a positive trend between starch content and the height of OPT. The starch content for the different height of OPT ranged from 4.29% to 8.54% of OPT weight basis.

Table 2. Starch content (%) of OPT between sample heights.

Composition	Trunk Height			
	1	2	3	4
Starch	4.29	7.42	7.68	8.54
Std. Deviation	(0.91)	(1.90)	(2.89)	(3.62)

Variation of Starch Content between Radial Positions

The variation of starch content in OPT between radial position is shown in Table 3. The analysis of the starch content between radial positions showed that the core portion invariably contained higher amount of starch compared to middle and the outer portion.

Table 3. Starch content (%) of OPT between radial positions.

Composition	Radial Position		
	Outer	Middle	Core
Starch	4.87	7.23	8.84
Std. Deviation	(1.29)	(2.01)	(2.11)

Starch Indication

Blue-black complex were produced when drops of iodine and potassium iodide solution (I_2KI) was added to the starch powder sample. Outer portion at 4^{th} level of OPT resulted with no change on the colour. Middle portion at 4^{th} level of OPT gave only little change on the colour, while core portion at 4^{th} level of OPT showed an obvious change into blue-black in colour. This concluded that starch granules was more prominent in core portion at the 4th level of OPT's height.

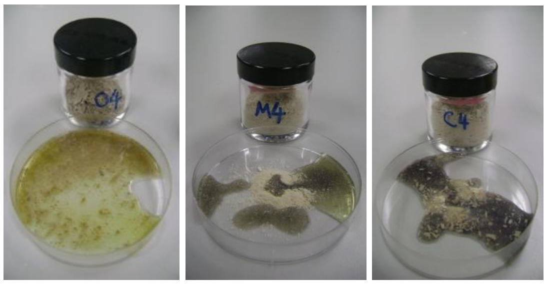

Figure 1. Changes of colour on outer, middle and core portion of oil palm starch at the 4th level of OPT's samples when subjected to I_2KI solution.

Overall, Table 1 shows the increasing percentage of starch content from base upwards and from the outer inwards. Table 2 shows that OPT samples from level 4 recorded the highest starch content which is 8.54% compared to starch content in level 1, 2, and 3 which are only at 4.29%, 7.42% and 7.68% respectively (Figure 2). This result indicated that there was a relation between the starch content with sample height in the stem. Sudin *et al*. (1988) observed that the starch content in OPT was progressively increased from the base upwards with 10% to 15% content of starch. Whilst, according to Jusoh and Imamura (1989), most common of ground parenchyma cells was the existence of starch granules, and the presence of them was more prominent in the upper part of the trunk.

The results shown in Table 3 gives an obvious value of the highest starch content of 8.84% in core portion compared to only 7.23% and 4.87% in middle and outer part of OPT respectively (Figure 3). The data also interpreted a positive trend of starch content variation along radial position from outer to the inner part. This indicates that the intensity of the starch grains is different in every portion of the trunk. This data is in line with Sudin *et al*. (1988), who found that the starch content of OPT was progressively increased from the cortex inwards. The difference in starch content between radial positions is related to the proportion of parenchyma tissues to vascular bundles of the same portion, where we can see the core portion is rich in parenchyma tissues with less number of vascular bundles comparing to the outwards portion.

Being a monocotyledonous plant, OPT is mainly stand with a mass of scattering vascular bundles throughout the ground tissues. The ground tissues are composed by a small, thick-walled sclerenchyma and a larger thin-walled parenchyma cells. The vascular bundles are being protected by the sclerenchyma, thus give strength to the stem, whilst parenchyma tissue stores starch that has been synthesized during photosynthesis. As reported by Killman and Lim (1985), the vascular bundles per unit area decreases toward the inside portion and increases towards the top of the stem. Apart from that, as we go nearer the rind of the stem, the vascular bundles are rich and closer to one another. Therefore, it can be said that, oil palm has a very complex trunk which is different in every heights, and differ from one portion to another. These give the impact on a great variation of density values. Figures showed samples of the outer part of the trunk, at different height, with clear and darker colour of mature vascular bundles (Figure 4) and lighter colour which shows immature cells of vascular bundles (Figure 5) embedded in parenchyma tissues.

The presence of sponge-like parenchyma tissues resulted to be the highest in the core part of the trunk and vice versa for the vascular bundles (Figure 6). The figure also shows the percentage of parenchyma is linearly same with the percentage of starch. This indicates that parenchyma does hold the starch granules, in line with what Jusoh and Imamura (1989) has been reported that starch globules do exist in the ground parenchyma cells. Figure 1 concluded that starch granules was more prominent in core portion at 4th level of OPT's height as the picture shows the starch powder samples turn into blue-black in colour. Through iodine test, it can be said that the outer part of OPT does not gives any change in colours (Figure 4) due to the highly congested vascular bundles per unit area which minimizes the amount of parenchyma that can holds starch granules.

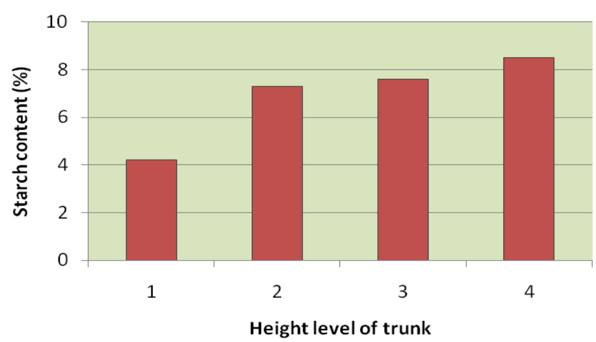

Figure 2. Percentage of starch at different levels of oil palm trunk.

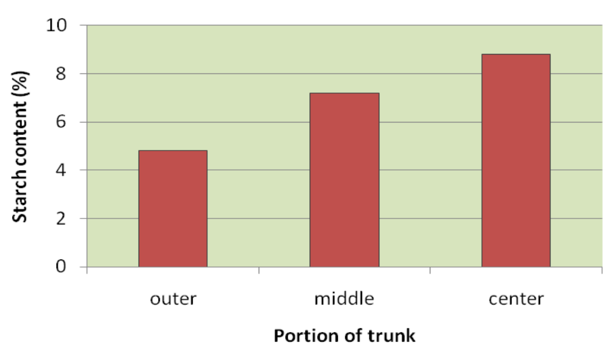

Figure 3. Percentage of starch at different portions of oil palm trunk.

Other study (Noor *et al.* 1997), using $Na_2S_2O_5$ as solvent gave 7.15% mean starch content for the oil palm slabs. Through Humphreys and Kelly method, starch analysis has been performed by Rokiah *et al*. (2011) gave 17.17% of starch in core portion of OPT. A remarkable 55.5% starch content in OPT's parenchyma was found by Tomimura (1992) through the same Humphreys and Kelly method.

Figure 4. Great numbers of mature vascular bundles embedded in parenchymatous tissues at the lower heights of OPT.

Figure 5. Great numbers of immature vascular bundles embedded in parenchymatous tissue at the upper heights of OPT.

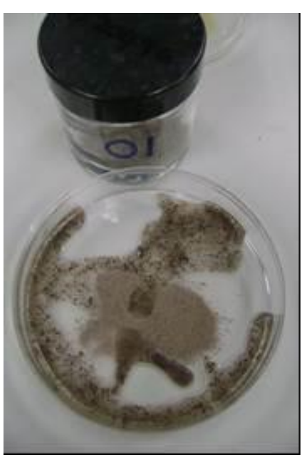

Figure 6. Zero colour changes on outer portion at the first level of OPT's starch samples when subjected to I_2KI solution.

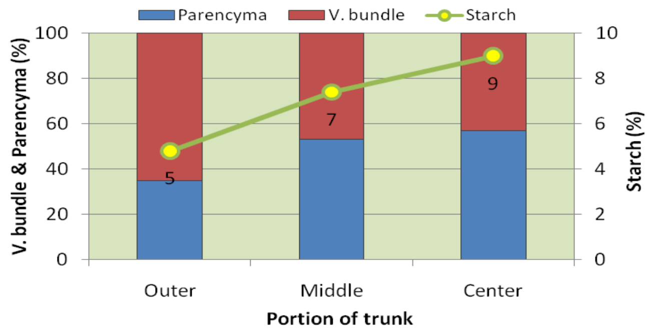

Figure 7. Average percentage of starch, parenchyma and vascular bundles at different portions of oil palm trunk.

Conclusions

There are positive trend of starch content between trunk height levels and radial positions of the sample in OPT. The starch content is increasing as the trunk height gets higher. The highest amount of starch is recorded at the top level of OPT and decreased towards the bottom of the oil palm trunk. Core portion at the highest trunk height of OPT is recorded having highest amount of starch.

References

Amarullah, M.; E.S. Bakar; Z. Ashaari; M.H. Sahri; F. Febrianto. 2010. Reduction of Formaldehyde Emission from Phenol Formaldehyde Treated Oil Palm Wood Through Imrpovement of Resin Curing State. Journal of Tropical Wood Science and Technology 8(1): 9-14.

Bakar, E.S. 2000. Pemanfaatan Batang Kelapa Sawit (*Elaeis guineensis* Jacq.) Sebagai Bahan Bangunan dan Furniture. Jurusan Teknologi Hasil Hutan, IPB. 150p.

Bakar, E.S.; Y.S. Hadi. 2001. Improvement of Oil Palm Wood: Impregnated with Phenolic Resin. Journal Teknologi Hasil Hutan 14(2): 24-31.

Bakar, E.S; P.M. Tahir; M.H. Sahri; H.S. Yap. 2005a. Oil-Palm Wood Treated with PF Resin by the Compreg Method: Influence of Solution Concentration and Impregnation period. Proc. International Symposium on Wood Science and Technology (IAWPS 2005) 1: 86-87

Bakar, E.S; P.M. Tahir; M.H. Sahri. 2005b. Properties Enhancement of Oil Palm Lumber Through the Compreg Method. Proc. International Symposium on Wood Science and Technology (IAWPS 2005) 2: 91-92.

Bakar, E.S; F. Febrianto; I. Wahyudi; Z. Ashaari. 2006. Polygon Sawing: An Optimum Sawing Pattern for Oil Palm Stems. Journal of Biological Science 6(4): 744-749.

Baumann, M.G.D; A.H. Conner. 2003. Carbohydrate Polymer As Adhesives. In Handbook of Adhesive

Technology. (Ed. Pizzi, A and K.L. Mittal.), Marcel Dekker, Inc. NY.
Bruce, A.; M. Bruce; E. Holbein; Massimo, F. Marcone; K. Seetharaman. 2010. A New Method for Quantifying Iodine in A Starch-iodine Matrix. Carbohydrate Research 345(18): 2698-2704.
Erica, D.; C. Marney; S. Silene; O. Vilpoux. 2005. Effects of Extraction Methods on Yam (*Dioscorea alata*) Starch Characteristics. Starch/Stärke 57: 153-160.
Hoseney, R.C. 1994. Principles of Cereal Science and Technology. Second Edition. American Association of Cereal Chemist, Inc. St. Paul, Minnesota.
Killman, W.; S.C. Lim. 1985. Anatomy and Properties of Oil Palm Stem. Proceedings of the National Symposium on Oil Palm By-Products for Agrobased Industries, Kuala Lumpur. PORIM Bulletin 11: 18-42.
Lim, S.C; K.C. Khoo. 1986. Characteristics of Oil Palm Trunk and Its Potential Utilization. The Malaysian Forester 49(1): 3-22.
Noor, M.A.M.; A.M.D. Mohd; M.N. Islam; N.A. Mehat. 1997. Physico-chemical Properties of Oil Palm Trunk Starch.
Jusoh, M.Z.; Y. Imamura. 1989. Anatomical Characterization of Vascular Bundles in Oil Palm Trunks. Presented in the 2nd Pacific Regional Wood Anatomy Conference Forest Products Research and Development Institute Los Banos (College), Laguna, Philippines. 10pp.
Sudin, R.; A.R. Mohd. Ali; Z. Mohd. Amin. 1988. Chemical Components in Oil Palm Trunk Influencing Wood-Cement Board Making. Cited: Hong, L.T. and Killman. 1989. Some Aspects of Parenchymatous Tissues in Palm Stems. The 2nd Pacific Regional Wood Anatomy Conference Forest Products Research And Development Institute Los Banos (College), Laguna, Philippines. 449-455.
Rokiah, H.; N.A.W.N. Wan; S. Othman; F. Kawamura; S. Hiziroglu; M. Sato; T. Sugimoto; T.G. Seng; R. Tanaka. 2011. Characterization of Raw Materials and Manufactured Binderless Particleboard From Oil Palm Biomass. Material and Design 32(1): 246-254.
Tomimura, Y. 1992. Chemical Characteristics and Utilization of Oil Palm Trunk. JACQ 25. 283-288.

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