Effects of Different Resin Content and Particle Sizes on Properties of Three Layered Particleboard Using Oil Palm Frond

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ABSTRACT

The objective of this study was to examine the properties of three layered particleboard from oil palm frond (OPF) at different ratios of resin content and particle sizes within face/back and core. Four different ratios of resin content; 12:10:12, 12:8:12, 10:10:10 and 10:8:10 were used with the particle size of 2mm for core and 1mm for face/back. Urea Formaldehyde (UF) was used as a binder with addition of wax and without wax. The target density was 500kg/m³. The properties of bending strength, internal bonding (IB), thickness swelling (TS) and water absorption (WA) were evaluated base on JIS A-5908 standard. The results, showed that modulus of rupture and modulus of elasticity were perform better with particleboard using ratio 12:8:12 bonded with UF without wax and meet the standard. The internal bond strength was parallel with bending strength except for board using 12:10:12 ratio bonded using UF with addition of wax. Samples using resin content at12:8:12 ratio had the lowest thickness swelling and water absorption but did not meet the above standard. The thickness swelling and water absorption rates were reduced in samples prepared with addition of wax. The ratio of resin content within the layers affected the properties of particleboard manufactured from oil palm frond. Based on the findings of this study, oil palm frond has the potential to be used in manufacturing particleboard, and further study is required to improve its dimensional stability.

Keyword: *particleboard, oil palm frond, UF, Wax, resin content*

Introduction

Particleboard is a wood-based composite consisting of varying shapes and sizes of particles of lignocelluloses material bonded together with an adhesive and consolidated under heat and pressure. The worldwide demand of particleboard has been growing. The adhesives used to bond the particles come from synthetic or natural adhesives derived from the wood itself by chemical reactions (Gamage et. al., 2009).

The industrial use of wood as a raw material for particleboard is well established. However, with the increasing price of wood, there is a need to find alternative sources of raw materials for particleboard manufacture. Alternative material was developed using lignocelluloses such as oil palm biomass to reduce the use of solid wood as a main material. Due to the shortage of wood supply as raw material for producing wood based products, many researches were carried out to find out the new material. This was related with the oil palm industry to generate hundred tons of oil palm frond waste that can be fully utilized by making particleboard (Basiron, 2007).

Oil palm is a lignocellulosic material rich in carbohydrates in the form of starch and sugar containing cellulose, hemicelluloses and lignin (Murai et. al., 2009). It is an abundant waste material at replantation and harvesting sites in Malaysia and in many parts of South East Asia (Sreekala et. al., 1997). Large quantities of this waste are left in the field as underutilized resources. Oil palm is now considered to be one of the most promising non-wood lignocellulosic raw materials for various types of wood-based panels (Sulaiman et. al., 2009).

The abundance and sustainability of oil palm fronds make this biomass an ideal raw material for the production of value-added, environmentally friendly, particleboard composite panels. Therefore, the objective of this study was to evaluate its suitability in particleboard production using different ratios of resin content within face/back and core. The physical and mechanical properties of the panels including the modulus of rupture (MOR), modulus of elasticity (MOE), the internal bond (IB) strength, the thickness swelling (TS) and the water absorption (WA) were determined.

Material and Methods

Oil Palm Frond (OPF) was harvested from the DPIM plantation at UiTM Jengka, Pahang. The fronds were taken from oil palm trees that were approximately 10-15 years old. Leaflets were removed from the fronds. The fronds were then chipped to 3-5cm size. Next, the chips were put into the ring flakers to produce particles. The size is usually less than 5.0mm. After being air-dried, the particles were screened to get the desire size of particles: core; 2mm and face/back; 1mm. The particles were than oven dried at 90±5°C until the desire moisture contain attained.

Urea Formaldehyde (UF) was used as a binder. The UF was supplied by a private company in Klang, Selangor.

UF was used with addition of wax and without addition of wax. Three layered particleboard from oil palm frond (OPF) were fabricated with different ratios resin content and particle sizes within face/back and core. Four different ratios of resin content; 12:10:12, 12:8:12, 10:10:10 and 10:8:10 were used with particle size for core; 2mm and face/back; 1mm. The target density is 500kg/m³. The dried particles were then put in the mixer together with the resin.

The mould used was 340mm X 340mm. The mats were compressed in a computer controlled hot press at a temperature of 165°C for 6 minutes. Pressed panels were cut into test samples based on JIS A-5908 after they had been conditioned in a climate chamber at a temperature of 20 °C and a relative humidity of 65%.

Results and Discussions

Modulus of rupture (MOR) and Modulus of elasticity (MOE)

Table 1, Figure 1 and Figure 2 show the bending strength (Modulus of Rupture; MOR and Modulus of Elasticity; MOE) of particleboard from OPF at different ratios of resin content. The results showed that MOR value for panels bonded using 12:8:12 ratio was higher compared to panels bonded using other ratios. Compared to panels bonded with addition of wax, panels bonded using UF without addition of wax were higher in both MOR and MOE strengths. The addition of wax affected the properties of the panels which was reduced the value of MOR and MOE. This might be due to the chemical substance in wax that reacts with UF which causes weaker adhesion of the OPF particles. As can be seen from Figures 1 and 2, the value of MOR and MOE for panels bonded using 12:10:12, 10:10:10 and 10:8:10 ratios were in range. However panels bonded using 12:8:12 was ratio showed a slightly higher value.

Table 1: Modulus of rupture and modulus of elasticity of three-layer particleboard from oil palm frond at different resin content ratios

RATIO	UF & WAX		UF	
	MOR (MPa)	MOE (MPa)	MOR (MPa)	MOE (MPa)
12:10:12	9.59 (2.20)	1336.49 (272.78)	11.47 (3.52)	1482.87 (380.48)
10:10:10	12.18 (5.54)	1551.05 (672.22)	13.99 (4.05)	1640.91 (319.77)
12:08:12	14.92 (4.50)	1852.81 (528.73)	17.60 (4.76)	2151.78 (451.34)
10:08:10	10.45 (4.94)	1570.16 (581.67)	15.60 (4.90)	1907.55 (608.10)

*Results in parenthesis indicate the standard deviation

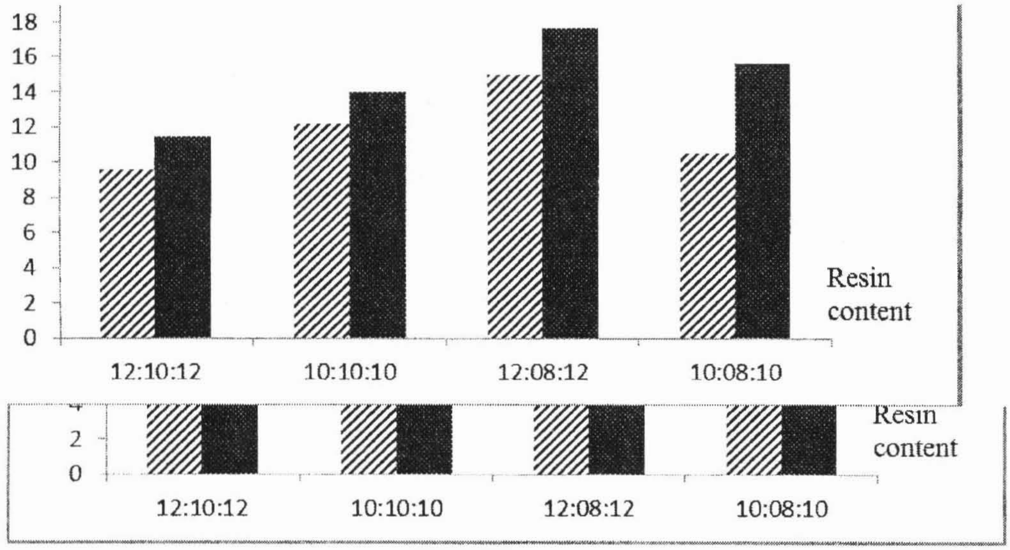

Figure1: Modulus of rupture (MOR) of three-layer particleboard from oil palm frond ar different resin content ratios

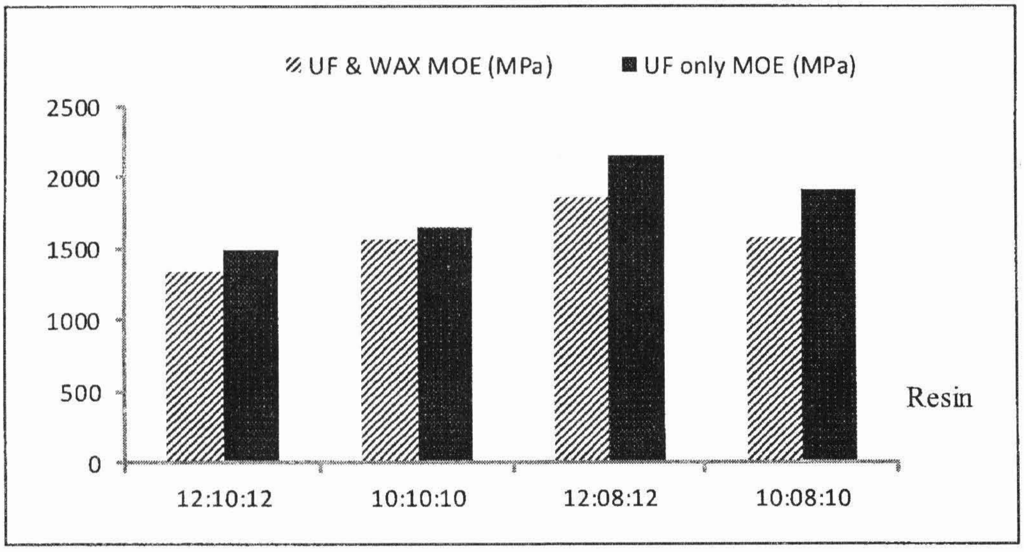

Figure 2: Modulus of elasticity (MOE) of three-layer particleboard from oil palm frond ar different resin content ratios

Internal Bonding Strength (IB)

Table 2 and Figure 3 show the internal bonding (IB) strength of particleboard from OPF at different ratios of resin content. From the results obtained, it can be seen that panels manufactured without addition of wax were higher in all ratios except for 12:10:12. With addition of wax, the IB strength was slightly decreased. The IB value for panel bonded using12:8:12 without addition of wax was better compared to other three ratios of resin content.

Table 2: Internal Bonding strength of three-layer particleboard from oil palm frond at different resin content ratios

RATIO	UF & WAX	UF
	IB (MPa)	IB (MPa)
12:10:12	0.49 (0.07)	0.38 (0.16)
10:10:10	0.37 (0.13)	0.38 (0.10)
12:08:12	0.31 (0.08)	0.53 (0.20)
10:08:10	0.25 (0.05)	0.42 (0.18)

*Results in parenthesis indicate the standard deviation

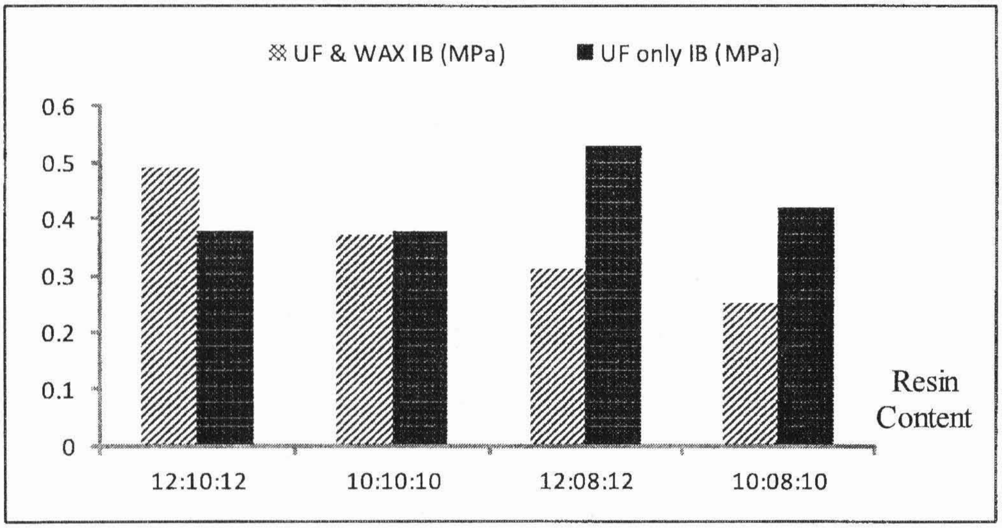

Figure 3: Internal Bonding strength of three-layer particleboard from oil palm frond at different resin content ratios

Water Absorption

Figure 4 shows the water absorption rate for panels bonded using addition of wax, while Figure 5 shows panels bonded without addition of wax. From the results, it can be seen that, panels bonded without addition of wax was had slightly higher water absorption compared to panels bonded with addition of wax. Within the ratio of resin content, the water absorption rate for the panel bonded at 12:8:12 was lower compared to other three ratios. The additional of wax on the panel reduced the rate of water intake. Increasing the resin content improves the thickness stability of particleboard.

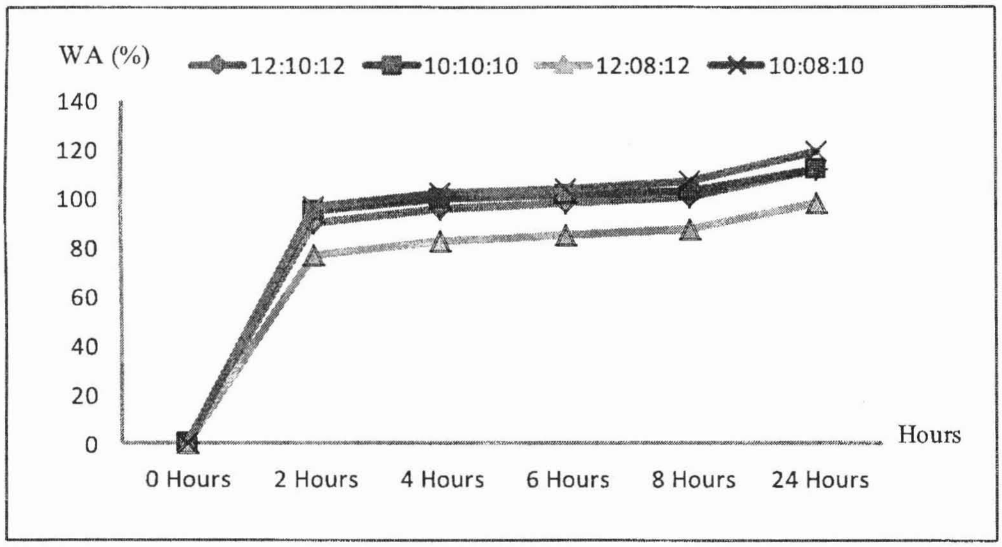

Figure 4: Water Absorption of three-layer particleboard from oil palm frond at different resin content ratios with addition of wax

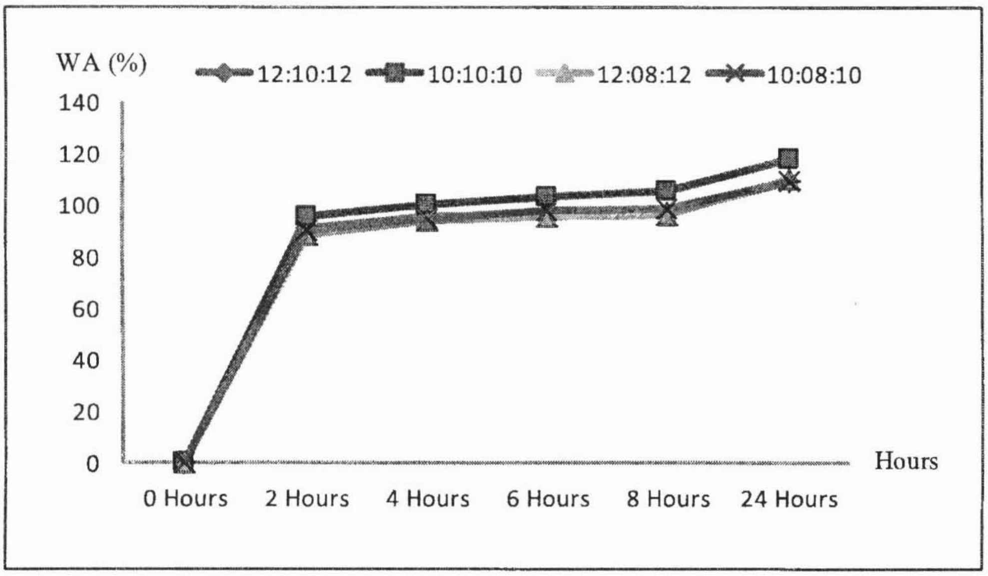

Figure 5: Water Absorption of three-layer particleboard from oil palm frond at different resin content ratios without addition of wax

Thickness Swelling

Figure 6 shows thickness swelling rate for panels bonded using addition of wax, while Figure 7 shows panels bonded without using addition of wax. Similar to water absorption, panels bonded using addition of wax was lower at thickness swelling rate compared to panels bonded without addition of wax. However, within the ratio resin content, panel bonded at 12:10:12 ratio showed the lowest thickness swelling rate compared to other three ratios.

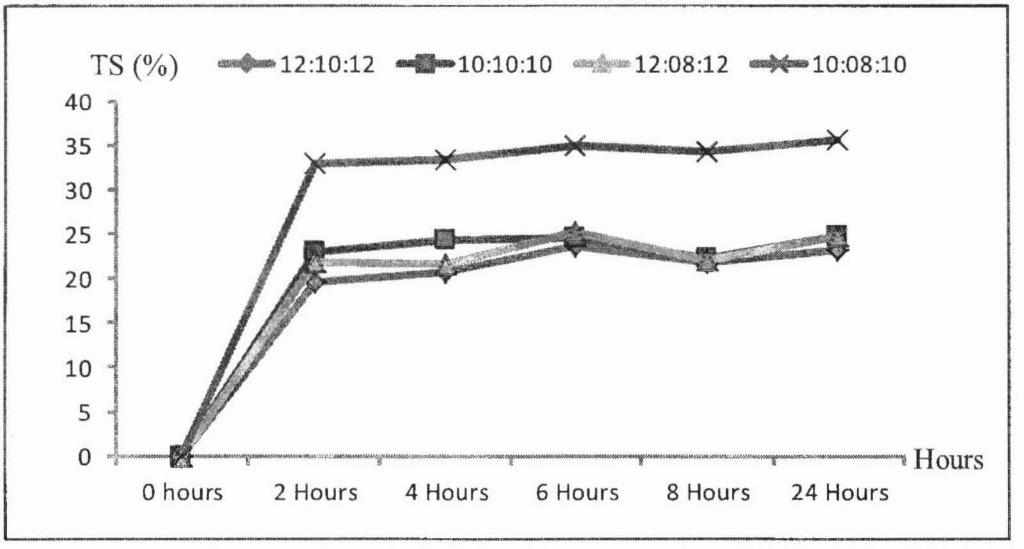

Figure 6: Thickness swelling of three-layer particleboard from oil palm frond at different resin content ratios with addition of wax

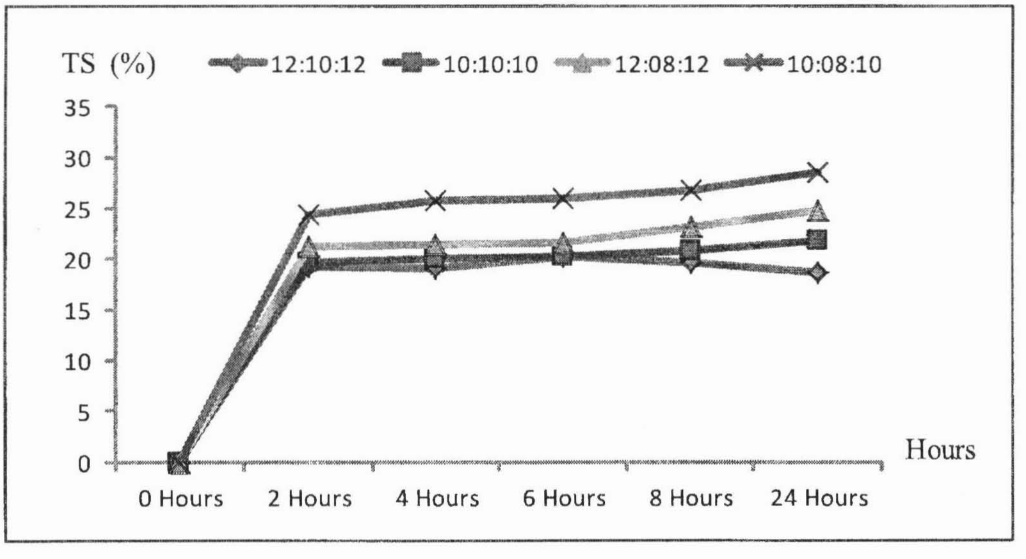

Figure 7: Thickness swelling of three-layer particleboard from oil palm frond at different resin content ratios without addition of wax

Conclusion

From the investigation, the ratio of resin content within the layers affected the physical and mechanical properties of particleboard manufactured using OPF. It may be concluded that, OPF is a suitable material to produced particleboard with a slight resistance effect on the absorption of water into the board with addition of wax. Resin content had significant effect on the MOR, MOE and IB strength, whereas higher ratio of resin content increased the mechanical properties. As a result, the three layered board made from 12:8:12 fully satisfied the minimum requirement set by JIS A 5908:2003 Particleboard (2003) standard for general uses. However, the utilization of OPF to manufacture particleboard requires further investigation to minimize the negative effect of the properties.

References

Haygreen, J.G. & Bowyer, J.L., (2009). Forest products and wood science, third ed. Iowa State University Press, USA, ISBN 0-81382-256-4.

Howard A. Miller, (1977). Particleboard Manufacture, Noyes data Corporation, New Jersey.

Jamaludin Kasim, (1999). Properties of particleboard and thermoplastic composite from bamboo (Gigantochloa scortechinii). PhD Thesis. Universiti Putra Malaysia.

JIS – A 5908. Particleboards. Japanese standards association. Tokyo, Japan; (2003). p. 1–24.

Murai, K., Uchida, R., Okubo, A., and Kondo, R., (2009). Characterization of the oil palm trunk as a material for bio-ethanol production, Mokuzai Gakkaishi , pp. 346–355.

Sreekala, M.S., Kumaran, M.G. and Thomas, S., (1997). Oil palm fibers: morphology, chemical composition, surface modification and mechanical properties, J Appl Polym Sci, pp. 821–835.

Gamage, N., Setunge, S., Jollanda, M. and Hague, J., (2009). Properties of hardwood sawmill residue-based particleboards as affected by processing parameters, Ind Crop Prod **29** (2009), pp. 248–254.

Sulaiman, O., Salim, N., Hashim, R., Yusof, L.H.M., Razak, W. and Yunus, N.Y.M. (2009). Evaluation on the suitability of some adhesives for laminated veneer lumber from oil palm trunks, Mater Des, pp. 3572–3580

Pizzi, (1983). Wood Adhesive, Chemistry and Technology. Marcel Dekkel, Inc. New York.

Pizzi, (1994), Advance wood adhesive technology. Marcel Dekker, inc. New York, Basel and Hong Kong, Pp.67

Zaidon A., Junaidi B., Faridah M.T., & Nor Yuziah M.Y., (2001). Properties and Durability of MUF- Bonded Particleboard Treated with Boron Compound, Sains Malaysiana 30: 177-186.

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