Mechanical and Physical Properties of Three Layered Particleboard from Kelempayan (*Neolamarckia cadamba*) and Sawmill Sawdust

Diana Julie[1*], Nurrohana Ahmad[2]

Faculty of Applied Science, Universiti Teknologi MARA (Pahang) Malaysia[1,2].
*dianaakjulie@gmail.com**

Abstract

The objective of this study is to determine the physical and mechanical properties of three layered particleboard from Kelempayan (*Neolamarckia cadamba*) and sawmill sawdust as well as to explore the effect of density and resin content on the particleboard. Sawmill sawdust is used for face and back of the particleboard, with the resin contents (8 %, 10% and 12%) and densities (500 kg/m^3, 600 kg/m^3 and 700 kg/m^3), while Kelempayan is used as the core with consistent of resin content (Urea-Formaldehyde) (10%). The optimum conditions for making the particleboard was found, where mechanical properties revealed that board with higher density, 700 kg/m^3 and resin content, 10%, showed the value for MOR (12.9 MPa), MOE (2001 MPa), IB (0.20 MPa) which surpassed the minimum standard for JIS A 5908:2003 for board Type 13. For the physical properties, it is not pass the minimum standard because this particleboard is only suitable for interior products.

Keywords: Kelempayan (*Neolamarckia cadamba*), sawmill sawdust, Urea-Formaldehyde, mechanical properties, physical properties.

1. INTRODUCTION

Recently, fast growing tree species were planted in large area. Some of them are Acacia species, Kelempayan, Petai Belalang and Rubber trees. According to Ishak, Karim and Samsi, (2013) these fast growing trees were used as an alternative raw material in the production of particleboard, medium-density board and chipboard manufacturing. The forest plantation was developed as it can increase support for the wood industry and at the same time can improve the economic growth of the country.

Kelempayan is a lightweight hardwood with poor durability. According to Lim, Gan and Thi (2005) Kelempayan timber is soft, light-coloured and white with coarse surfaces due to the presence of large vessels. Sapwood from Kelempayan log is not well defined from the heartwood, which is white and will turn to yellow on exposure. The timber is used for plywood, pulp and paper and furniture components. The wood can be easily impregnated with synthetic resins to increase its density and compressive strength. The wood has density of 290-560kgm^{-3}, at the 15% moisture content, low luster, can get the straight grain and a fine to medium texture (Ishak et al., 2013)..

Increasing number of sawmills has created high amount of sawmill sawdust waste. This sawmill sawdust waste pollutes the environment as the sawdust waste are burned off and dumped in the landfill. According to Fuwape, Fabiyi & Osuntuyi, (2007) burning the sawdust in the open air can pollute the environment as carbon dioxide (CO_2) and carbon-monoxide (CO) are released into atmosphere as a result, insufficient oxygen in the heap of the sawdust. This activity can change the climate of the world via global warming.

The aim of this paper is to see the performance of three layered particleboard made from Kelempayan particle with sawmill sawdust by using Urea formaldehyde.

2. MATERIALS AND METHODS

The Kelempayan tree (*Noelamarckia cadamba*) was harvested from UiTM Pahang Forest reserved. The tree age is approximately 15 years old with average diameter at breast height 40 cm and high 25 m. The trees were cut to 1.5 m length logs and transferred to the UiTM wood industry workshop. Sawmill sawdust was used from wood shaving, wood sawing and wood cutting that from surface planning machine, thickness planning and straight line ripe saw. The resin used was a commercial Urea Formaldehyde (UF), with solid content at 50 % and hardener solution 3% from Ammonium chloride (NH_4Cl). The plank were chipped using a wood chipper, followed by disintegration in a knife ring flakers. The flaking turned particles into common reduction units. The particles were screened through the 5.0 mm and 0.5 mm screening metal plates and classified into coarse and fine particles. Kelempayan particles are air-dried in large area first, for duration 7-14 days and oven-dried 24 hours at 80°C to achieve the final level of moisture content of below 5 %.

Three layered particleboard (340 mm x 340 mm x 12 mm) were manufactured with a target density 500 kg/m^3, 600 kg/m^3 and 700 kg/m^3. The particles were sprayed separately with UF resin in a particleboard mixer, at resin 8%, 10%, and 12% for sawmill sawdust and 10% for Kelempayan particles. All formulations had 3% hardener added. Air pressure of 0.4 MPa helped the resin to go through the tube into mixer. The blender will rotate until the resin has been completely blended. Hands forming were used to form the particle in a forming box and pre-press at pressure 300-500 psi for 30 seconds before being the hot pressed for 6 minutes at 165°C. All boards were conditioned in a conditioning room maintained at 20 ± 2°C and the relative humidity (65 ± 5) %.

The test pieces were prepared according to the procedure of JIS A 5908:2003 in order to determine the modulus of rupture (MOR), modulus of elasticity (MOE), internal bonding (IB) and thickness swelling (TS). The effect of the variables on the properties of the board was assessed by Analysis of Variance (ANOVA) and Duncan Multiple Range test (DMR) was used for comparison of the average values.

3. RESULTS AND DISCUSSION

Physical and mechanical properties of particleboard made from three layered particleboard from Kelempayan and sawmill sawdust are presented in Table 1:

Table 1: Summaries of physical and mechanical properties of three layered particleboard from Kelempayan and sawmill sawdust

Density (Kg/m3)	RC (%)	MOR (MPa)	MOE (MPa)	IB (MPa)	TS (%)	WA (%)
500	8	3.3	647	0.15	15	115
500	10	3.7	656	0.18	12	114
500	12	4.6	844	0.19	11	107
600	8	4.8	973	0.16	20	100
600	10	5.6	1040	0.17	16	99
600	12	7.0	1165	0.19	11	91
700	8	8.0	1440	0.19	19	95
700	10	12.9	2001	0.20	16	77
700	12	14.4	2136	0.28	15	67
JIS A 5908:2003 Type 13		13.0 min	2000 min	0.2 min	12 max	n.a

Based on JIS A 5908: 2003 standard, board made from a density higher than 700 kg/m³ with resin content ≥10% achieved the MOR, MOE and IB, while for TS densities 500 and 600 kg/m³ with (10 + 12) % and 12% resin content respectively had surpassed the minimum standard for JIS A 5908:2003 for board Type 13. Mostly physical properties mean results showed it is not pass the minimum standard.

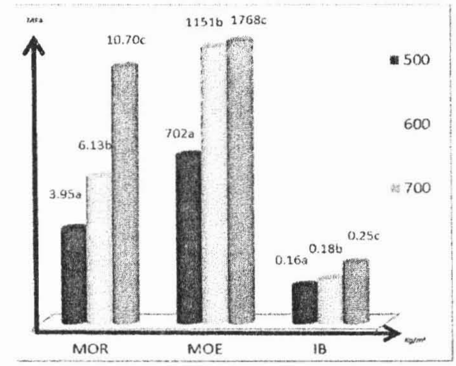

Figure 1: Effect of Board Density on Mechanical Properties

As shown in Fig 1, it is clear that the lowest MOR value (3.95 MPa) was obtained from board with lowest density (500 kg/m³), MOE (702 MPa) and IB (0.16 MPa). As for density (600 kg/m³), the MOR value is (6.13 MPa), MOE (1151 MPa) and IB (0.18 MPa). The highest MOR value (10.70 MPa) was obtained from board with highest density (700 kg/m³), MOE (1768 MPa) and IB (0.25 MPa). The effect of board on mechanical properties that present MOR, MOE and IB has significant between the difference densities. The strength of bending is depended on the density of the particleboard, particle configuration, orientation, species and pressing condition (Rachtanapun, Sattayarak and Ketsamak, 2012).

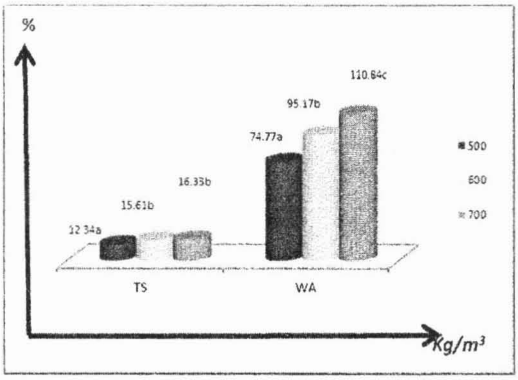

Figure: 2 Effect of board density on physical properties

From the Figure 2 it can be seen that the TS from 500 kg/m³ to 700 kg/m³ are not significant. The highest board density (700 kg/m³), get the larger value for TS (16.33%), whiles the lowest density (500 kg/m³), get the decreased value of TS (12.34%). While, the water absorbed (WA) from 700 kg/m³ board density is higher (110.84%) than following by 600 kg/m³ and 500 kg/m³ board density (95.17% and 74.77%) respectively. Increasing board density has significantly influenced on the WA value. Benedito, Lehmann and William, (1974) stated that high densities are not common to get lowest swelling values.

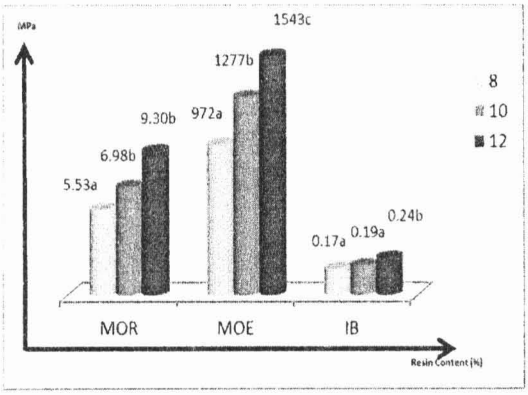

Figure 3: Effect of Resin Content on Mechanical Properties

Figure 3 presents the effect of resin content on the mechanical properties. MOR increased significantly with the increase of resin content. Boards with 12 % resin content have higher MOR (9.30 MPa). The board with 12% resin content has 68% higher strength compared to the one with 8% of resin content. Based on the JIS A-5908:2003, only boards with 12% resin content fulfilled the minimum standard. As the resin content increased, the MOE also increased by 59% when resin content increases from 8% to 12%. The highest value for MOE (12%) resin content is (1543 MPa). The MOE has also increased significantly with the increase of resin content. The highest percentage of resin content has not fulfilled the JIS A-5908:2003 standard for MOE. This may be caused by the particle size of face and back from sawmill sawdust mixture. While for internal bonding increased by (41%) from 8% to 12% resin content. Internal bonding for resin content from 8% to 12% also is not significantly different. According to Rofii et al., (2014) the shape of the particles and its size can affect the particleboard performance. While Hegazy and Aref, (2010) stated if surface layer density is decreased and IB strength can improve because of the increase in core layer density.

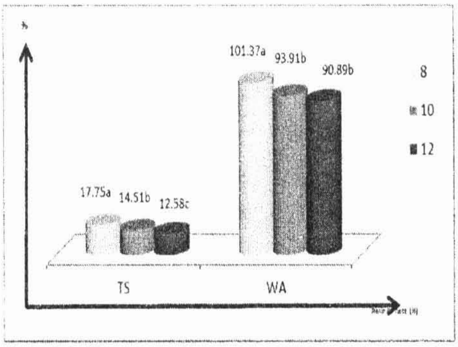

Figure 4: Effect of resin content on physical properties

Figure 4 show the TS and WA properties improves the board when resin content increase from 8% into 12%. The resistance to TS improved by 41%, as the resin content increase from 8% to 12%. The resin content increased, and it also produced the improve water absorption properties. Besides that, for the water absorption (WA) the percentages of WA improved resistance by 16% when resin content increase from 8% to 12%. It shows that, the value of percentage for TS and WA is lower percentages. The water absorption of the 8% and 10% resin content has significant results. As proven by the Ayrilmis, Kwon & Han, (2012) when they found that as the content of resin was increased from 8% to 10%, the WA values of the samples had also decreased.

4. CONCLUSIONS

From this study, boards with high density give more strength in the mechanical properties. Mechanical properties for MOR increased about 171%, MOE increased 152% and IB 51% when the board density is increased from 500 kg/m^3 to 700 kg/m^3. Increased board density has more percentages of TS (33%) and WA (48%) which is from 500 kg/m^3 to 700 kg/m^3. The result shows TS is not significant, while the WA has significantly difference results.

Resin content had also affected the mechanical properties and physical properties of particleboard. Board with higher resin content gave more strength in the mechanical and physical properties test. The percentages from resin content 8% to 12% that is (68%) for MOR. The MOE has also increased with 59% and IB 41% when the resin content increased. For the physical properties, TS was improved by 41% and resistance towards WA increase about 16% when resin content 8% to 12%. This resin content gives effect to mechanical and physical properties of particleboard. From the result, TS is not significant and WA has significant when board density increased. Board made from density 700 kg/m3 with resin higher resin content that is ≥10% were able to satisfy the minimum JIS requirement standard. Mostly physical properties is not exceeded the minimum standard because this particleboard suitable for interior products.

It is suggested that, future study of particleboard using Kelempayan and sawmill sawdust should be continued. One should explore making the particleboard using 100% Kelempayan or sawmill sawdust using different particle sizes, ratios and difference types of resin.

Acknowledgements

I would to thank my parents Mr Julie anak Niyat and Mdm Yer anak Sanum, Lecturer from Academy of Language Studies Mdm Suzaini Harmiruslin Supian, UiTM Jengka staff Mr Mohd Sharil Izanie Abdullah, Mr Khairilanuar Zainol and Mr Nazrie Mustfha to helping harvested and cutting the Kelempayan tree and Mdm Suzaini Harmiruslin Supian.

REFERENCES

Ayrilmis, N., Kwon, J. H., & Han, T. H. (2012). Effect of resin type and content on properties of composite particleboard made of a mixture of wood and rice husk. *International Journal of Adhesion and Adhesives, 38*, Pp79–83.

Benedito, V. R., Lehmann F. William, B. S. R. (1974). How Species and Board Densities Affect Properties Of Exotic Hardwood Particleboards. *Forest Products Journal, 24*(12), Pp37–45.

Fuwape, J. A., Fabiyi, J. S., & Osuntuyi, E. O. (2007). Technical assessment of three layered cement-bonded boards produced from wastepaper and sawdust. *Waste Management (New York, N.Y.), 27*(11), Pp1611–6.

Hegazy S. Said, A. M. I. (2010). Suitability of Some Fast-Growing Trees and Date Palm Fronds for Particleboard Production. *Forest Products Journal, 60*(10), Pp599–604

Ishak, A., A. Karim, S. R., & Samsi, H. W. (2013). Mechanical and Physical Properties of Particle Board Made from Silaned and NaOH Modified Kelampayan (*Neolamarckia cadamba*) Particles. *Advanced Materials Research, 812*, Pp169–174.

Japanese Industrial Standard (JIS A 5908:2003), Particleboards, Japanese Standard Association/ 4-1-24, Akasaka, Minato- Ku, Tokyo, 107-8440 Japan

Lim, S., Gan, K., & Thi, B. (2005). Identification and utilization of lesser known commercial timbers in Peninsular Malaysia. 4. Kelempayan, Melembu, Membuloh and Mempari. *Timber Tech. Bull*, (Figure 1).

Rachtanapun, P., Sattayarak, T., & Ketsamak, N. (2012). Correlation of density and properties of particleboard from coffee waste with urea-formaldehyde and polymeric methylene diphenyl diisocyanates. *Journal of Composite Materials, 46*(15), Pp1839–1850

Rofii, M. N., Yumigeta, S., Kojima, Y., & Suzuki, S. (2014). Utilization of High-density Raw Materials for PanelProduction and its Performance. *Procedia Environmental Sciences, 20*, Pp315–320