INTERNATIONAL JOURNAL OF Electroactive Materials

Int. J. Electroactive Mater. **11 (2023) 60-65**
www.electroactmater.com

RECEIVED
13 05 2023

REVISED
01 06 2023

ACCEPTED FOR PUBLICATION
26 07 2023

PUBLISHED
13 08 2023

Hybrid Particleboard from Kelempayan (*Neolamarckia cadamba*) and Petai Belalang (Leocaena leococephala) Particles: Effects of Resin Content and Board Density on the Properties of the Panels

Nur Sakinah Mohamed Tamat[1,*], Nur Azleen Amarang[1], Andi Hermawan[1], Mohd Ezwan Selamat[1], Nik Alnur Auli Nik Yusuf[1], Wan Mohd Nazri Wan Abdul Rahman[2]

[1]Tropical Wood and Biomass Research Group, Faculty of Bioengineering and Technology, Universiti Malaysia Kelantan, Jeli Campus, 17600, Jeli, Kelantan, MALAYSIA
[2]Faculty of Applied Sciences, Department of Wood Industry, Universiti Teknologi MARA Pahang, 26400, Bandar Tun Abdul Razak, Pahang, MALAYSIA

***E-mail**: nursakinah.mt@umk.edu.my

ABSTRACT: A shortage in the rubberwood supply is becoming a reality in Malaysia. The demand for raw wood materials is increasing and the Malaysian wood-based industries need to find alternative raw materials to produce products so that the supply of wood-based products is always consistent. This research work aims to determine physical and mechanical properties of particleboard made from mixtures of fast-growing species namely Kelempayan (Neolamarckia cadamba) and Petai Belalang (Leocaena leucocephala). This study evaluated the properties of particleboard made with a 50:50 ratio of Kelempayan and Petai Belalang with urea formaldehyde resin at different contents (8%, 10%, and 12%) and board densities (600 kg/m3, 700 kg/m3 and 800 kg/m3. Bending strength, tensile strength and thickness swelling tests were evaluated for particleboard performance. The particleboards were tested according to JIS A 5908:2003. The results showed that the particleboard mechanical properties were significantly improved with increase of the resin content and board density. The thickness swelling value dropped as resin content and board density were increased, showing better stability of the board. Most of the boards surpassed the standard requirement value set by JIS Standard. It can be concluded that fast growing species can be mixed and used as an alternative species to manufacture particleboard to ensure sustainability of raw material.

Keywords: Petai belalang, kelempayan, resin content, thickness swelling

1. Introduction

As the global need for wood and wood-based components continues to rise, one fundamental notion of circular economics is to use wood in a more effective manner to satisfy the demand for the manufacturing of wood-based panels. Due to rising environmental concerns and newly imposed regulatory constraints, the particle board industry is being forced to contend with new challenges.

Rubberwood is one of the most important hardwoods for the forest products industry in tropical areas, especially in Malaysia. Besides, due to decreasing profit margins in the rubber industry as a correlate of low international latex prices, the supply of Malaysian rubber is constrained on a global scale for many different businesses. The success of transforming rubberwood into panels and furniture, along with a decrease in the area where rubber trees are being replanted, has placed a significant demand on the support system for the raw material. This has created a higher demand for rubberwood. This would allow for the establishment of a reliable supply of raw material.

Kelempayan and Petai Belalang are two fast growing species that must be introduced to Malaysia to satisfy the requirements of the country's lumber industry. Kelempayan is a kind of tree that is huge, deciduous, and grows quickly; because of these features, it can produce early economic returns within 8 to 10 years after planting. Within 9 years, it will have grown to a height of 17 metres and a diameter of 25 centimetres at the breast height (dbh) under typical circumstances. A mature tree may grow to a height of 20 to 30 metres and a diameter of 50 to 100 centimetres. The tree has straight trunk and the ability to prune itself. The states of Perak and Pahang in Peninsular Malaysia are where most Kelempayan farms are located [1]. Petai Belalang has a density of roughly 800 kg/m3 and is classified as medium to heavy hardwood. It is a 22-species New World genus in the legume family (Fabaceae), subfamily Mimosoideae. A study was done on the growth performance and potential as a resource material for particleboard. From the first to the fourth month, Petai Belalang trees grew by 44%, and from the 6 to the 12 months, they grew by 43% [2]. Both species can provide fast solutions to the raw material needs in particleboard production.

As fast growing tree species have become a popular plantation forest commodity in Malaysia and other Asian countries, many studies have been conducted to consider their properties and possible utilization. Attempts on particleboard making with fast growing species has been done by Wan Abd Rahman et al. [3] using Kelempayan and Petai Belalang [4]. The use of a fast growing species for wood composite production may have some benefits, such as a faster activation period than with other woody plants.

Therefore, the goal of this research was to determine the mechanical and physical properties of particleboards made from a mixture of Kelempayan and Petai Belalang wood with different board densities and resin contents.

2. Experimental

Kelempayan and Petai Belalang wood were supplied by sawmill in Jeli, Kelantan. The diameters of the Kelempayan and Petai Belalang logs were 35 to 45 cm. The wood was cut and immediately transported to the workshop, chipped, air dried for a week and oven dried to a moisture content below 15%. Particleboard with the dimensions 200 mm × 200 mm × 10 mm were prepared for each density 600 kg/m3, 700 kg/m3 and 800 kg/m3 using 50:50 ratio of Kelempayan and Petai Belalang. The boards were prepared in triplicate. Urea formaldehyde was used at three resin contents 8%, 10, and 12% against the dry biomass amount. The resin was blended with the particles, formed and cold pressed, and finally hot pressed at a temperature 180 °C with a pressure cycle of 1000 psi for 1 to 2 minutes for single-opening presses and up to 5 min for multi-opening presses. The particleboards were conditioned for 24 h at a 65% relative humidity and 20 °C. The mechanical and physical properties of the particleboard specimens were tested in accordance with JIS A 5908:2003. The sample size dimensions were 200 mm × 50 mm × 10 mm for bending strength testing and 50 mm × 50 mm × 10 mm for tensile strength testing and thickness swelling testing. All the boards were analyzed with analysis of variance (ANOVA) using IBM SPSS statistical software.

3. Results and Discussion

3.1 Particleboard properties

Table 1 shows the physical and mechanical properties of the particleboards made from a mixture of Kelempayan and Petai Belalang with three resin contents and three board densities. On the mechanical properties of MOR, density 800 kg/m3 with 10% resin content showed the highest value (17.31 N/mm2) and the lowest value from density 600 kg/m3 of 8% resin content with 6.23 N/mm2. Meanwhile, the best value for MOE from density 800 kg/m3 with 10% resin content. Then, for tensile results show that the highest value from density 800 kg/m3 with 8% resin content and the lowest value from density 600 kg/m3 of 8% resin content. The boards, except for MOR, fulfilled all of the standards for [5] For physical properties, the best value of thickness swelling from density 600 kg/m3 of 10% resin content with value 31% and the worst value from density of 800 kg/m3 and resin content of 8% with value 71%.

Table 1: Physical and mechanical properties of the particleboards made of Kelempayan and Petai Belalang (50:50) with different board densities and resin contents.

Board density (kg/m^3)	Resin content (%)	Modulus of rupture (N/mm^2)	Modulus of elasticity (N/mm^2)	Tensile strength (N/mm^2)	Thickness swelling (%)
600	8	6.23	399.02	0.26	45%
600	10	11.01	582.21	1.00	31%
600	12	9.16	509.33	1.05	33%
700	8	13.90	802.86	1.03	52%
700	10	14.69	867.77	0.80	35%
700	12	12.64	656.62	1.45	37%

800	8	13.32	753.07	1.69	71%
800	10	14.68	952.18	1.35	48%
800	12	17.31	638.03	1.22	40%

3.2 Effects of resin content

According to many researchers, the quantity of resin [6; 7] determines the bonding quality and performance of boards. The modulus of rupture (MOR) and modulus of elasticity (MOE) are shown in Fig. 1, which increased significantly as the resin content increased. The particleboard with resin content 12% had the highest MOR and board with a 10% resin content had the highest MOE. According to [8] when the resin content increases, the MOR and MOE will increase, which is caused by an increase in the particle's surface area. This is because resin coats a greater percentage of the particle surface than would otherwise be the case. For the 8% and 10% resin content comparison, the MOR and MOE also showed significant difference. It is confirmed that bonding between wood particles of 8% was not as strong as 10% and 12% resin, therefore resulted in lower mechanical properties of the samples. High percentage of resin content had better bonding because more resin is available for inter-particle bonding compared to low percentage of resin content.

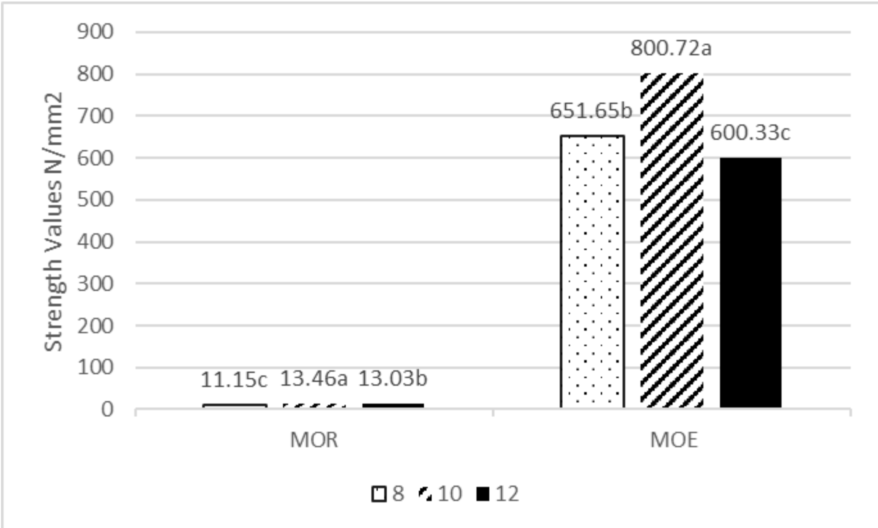

Figure 1: Effects of resin content on modulus of rupture (MOR) and modulus of elasticity (MOE)

The effects of the resin content on the tensile strength of the particleboard are shown in Fig. 2. The particleboard made with 12% resin content had the highest tensile strength (1.24 N/mm2) while 10% resin content resulted in the lowest tensile strength. [9] pointed out that higher amounts of resin encourage stronger interfacial bonding between wood particles and hence improving the ability to withstand the pulling force in the test. This result agrees with the finding of [10].

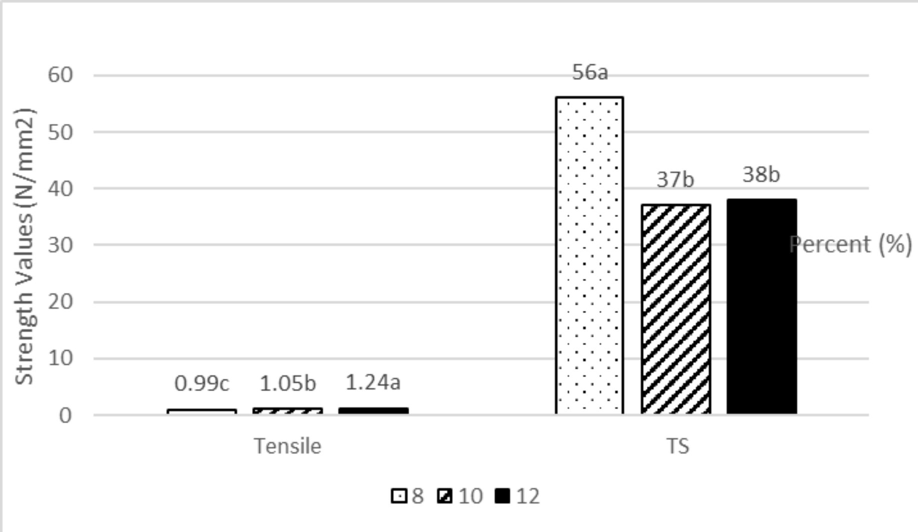

Figure 2: Effects of resin content on tensile strength and thickness swelling (TS)

The thickness swelling of the particleboards showed significant decreasing trends as the resin content increased **(Fig. 2)**. The particleboard with 10% resin content exhibited the highest dimensional stability. It had the lowest thickness swelling value of 37%. There was no significant difference of thickness swelling values between resin content 10% and 12%. Based on the tested ranged, boards of 8% resin content were less dimensional stable compared to the boards manufactured with 10% and 12% resin content. The thickness swelling values were relatively high owing to the porous structure of the lower resin content board, which absorbed more water compared to the porous structure of the lower resin content board. [11] in their study reported that the thickness swelling decreases with an increasing resin content because the resin forms a barrier that helps to minimize the impact of water on particles.

3.3 Effects of the board density

High quality particleboards with a high strength and equal swelling are normally obtained from high density particleboard (Rahman et al. 2019). **Fig. 3** shows that the particleboards made with density 800 kg/mm3 had the highest MOR (15.11 N/mm2) and MOE (781.09 N/mm2). For the MOR and MOE, there was a significant difference between density 600 to 700 kg/mm3. High density particleboard had more compact structure, which contributes to a better interaction between particles and resin and thus stronger bonding [12]. [13] also reported that the MOR and MOE increase with an increasing board density. High density particleboard had more compact structure, thus particles and resin can interact with each other more easily to form stronger bonding compared to low density particleboard.

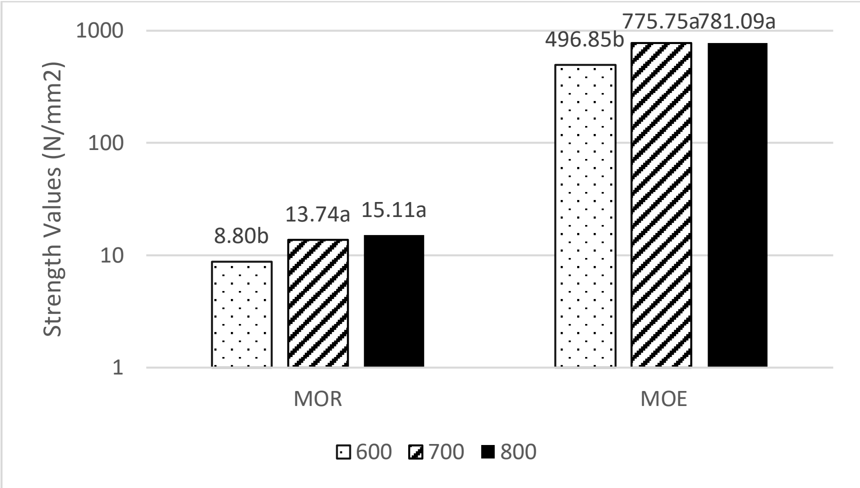

Figure 2: Effects of Effects of board density on modulus of rupture (MOR) and modulus of elasticity (MOE)

Fig. 4 shows the effect of board density on the tensile strength particleboards. There was significant difference between the results for the different board density except for densities 700 and 800 kg/m3. Particleboard has a tensile strength performance that is comparable to other low-density wood-based panels that use resin during the manufacturing process of board. This is because the creation of particleboard involves this resin. This is as a result of the very dense nature of the particleboard. When the density of a material is reduced, its tensile strength characteristics become less impressive. The material's internal structure becomes less dense, making it simpler for the resin to spread throughout the material.

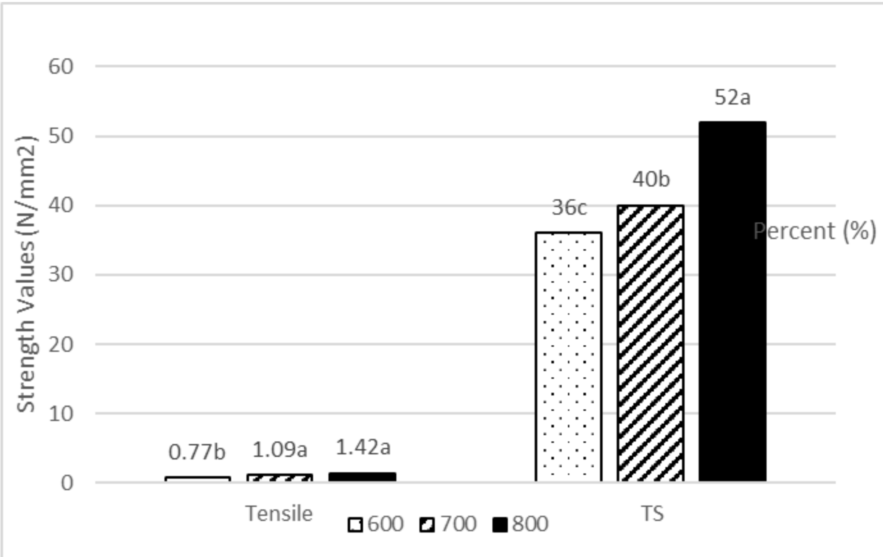

Figure 4: Effects of board density on modulus of rupture (MOR) and modulus of elasticity (MOE)

[14] mentioned that the dimensional stability of particleboards is better when the thickness swelling is lower. The effects of the particle size on the physical properties of the particleboard are shown in **Fig. 4**. The particleboards made with a 800kg/mm^3 board density had the highest thickness swelling value (52%). Thickness swelling trends showed a significant decrease as the board density decreased. This finding was in line with the results of [15]. Larger amount of wood particles in high density particleboards, which could decrease curing performance and thus higher moisture or water penetration into the boards.

4. Conclusions

The potential of the Kelempayan and Petai Belalang mixture in particleboard manufacturing was demonstrated via the performance of in the mechanical properties of the board. The 50:50 mixture achieved the highest performance for the MOE and tensile strength (952.18 N/mm2 and 1.69 N/mm2 respectively) with a 800 kg/m3. The highest value for MOR was 14.69 N/mm2 with the particleboard with the 700 kg/m3 board density and a 10% resin content. Board stability was enhanced by low board density and high resin content. Mixture of Kelempayan and Petai Belalang species were found to be a suitable alternative for particleboard manufacturing. Most of the boards passed JIS A 5908:2003 requirements. It is hoped that the results obtained in this study can provide insight into adopting Kelempayan and Petai Belalang for the wood-based industry in Malaysia.

Acknowledgements

The authors would like to thank Universiti Malaysia Kelantan for the facilities used in study.

Conflict of Interest

The authors declare that they have no conflict of interest.

References

1. Rasat MSM, Razak W, Amran S, Ahmad AMY, Mahani Y, Fatimah SMR, Zulhisyam AK. Journal of Tropical Resources and Sustainable Science, 1, (2013) 42-50.
2. Rahman WAWMN, Johari NAN, Sarmin SN, Yunus MNY, Japarudin Y, Mahmud J, Khairuddin MN. BioResources, 15(4), (2020) 7433-7442.
3. Rahman WAWMN, Yatim MA, Zlan MA, Kasim J, Yunus MNY. BioResources, 14(3), (2019) 6079-6087.
4. Loh YW, H`ng PS, Lee SH, Lum WC, Tan CK. Asian Journal of Applied Sciences, 3, (2010) 310-316.
5. Japanese Industrial Standard (JIS). Japanese Standards Association, Tokyo, (2003).
6. Ashori A, Nourbaksh A. Industrial Crops and Products, 44(2), (2008) 1-9.
7. Kasim J, Yusof MAA, Hashim MNH, Salamat NA. Jurnal Gading, 12(1), (2008) 1-10.
8. Rahman WAWMN, Yatim MAA, Zlan MAA, Kasim J, Yunus MNY. BioResources, 14(3), (2019) 6079-6087.
9. Eslah F, Enayati AA, Tajvidi M, Faezipour MM. Journal of Agricultural Science and Technology, 14(6), (2012) 1321-1329.
10. Colak S, Nemli G, Demirkir C, Aydin I, Demirel S. Journal of Composite Materials, 45, (2011) 29-37.
11. Rachtanapun P, Sattayarak P, Ketsamak N. Journal of Composite Materials, 46(15), (2012) 1839-1850.
12. Nemli G, Yildiz S, Gezer ED. International Biodeterioration and Biodegradation, 56, (2005) 166-172.
13. Zheng Y, Pan Z, Zhang R, Jenkins BM, Blunk S. Bio resource Technology, 98, (2007) 1304-1310.
14. Tahir MP, Halip AJ, Shekeil E, Ali Y, Jawaid M, Alothman Y. Measurement, 56, (2014) 70-80.
15. Amini MHM, Hashim R, Hiziroglu S, Sulaiman O, Sulaiman NS. Composites Part B: Engineering, 50, (2013) 259-264.

e-ISSN: 2289-8360