Properties of Particleboard Produced from Admixture of *Acacia mangium* and Sentang

Shuhaila Johar, Wan Mohd Nazri Wan Abdul Rahman and Jamaludin Kasim
Center of Wood Industry, Faculty of Applied Sciences, Universiti Teknologi Mara Pahang

*shuhailajohar@gmail.com

Abstract
This study was conducted in order to find a new alternative of raw materials to substitute rubberwood in Malaysia since the source of this materialwas depleting. This study used fast growing species which were treated i.e: (1) 100% of Acacia mangium spp. (2) 100% of sentang spp and (3) 50% of sentang: 50 % of Acacia mangium spp. For particle size i.e: 1.0mm, 2.0mm and mixed particle size 1.0mm and 2.0mm were used. The objectives of this study were to evaluate and compares the properties of particleboard from single and mixed wood species and from different particle size of particleboard. The results showed that properties of particleboard increased as increase in wood density. Results from treatment of single species perform better strength properties as compared to mixed species of particleboard. Properties of particleboard also can be affected by particle size where the particleboard with larger particle size gives more strength properties.

Keywords: Particleboard; *Acacia mangium;* sentang; Particle size

INTRODUCTION

Particleboard has widely used in furniture manufacturing in order to decrease cost and reduce the usage of sawn timber. In Malaysia, Rubberwood (*Hevea brasiliensis*) is commonly used in manufactured the particleboard due to its favourable medium-density hardwood (Balsiger et al., 2008). Recently, the Rubberwood supply has been decreasing. This means, the demand of the Rubberwood is more than the supply of the Rubberwood. This situation leads to the increment cost in manufacturing particleboard made from Rubberwood (Norini, 2001). Due to the shortage of the Rubberwood and increment in cost, the new alternatives which is utilizing the fast growing species of wood such as *Acacia Mangim* and 'multi-purpose' wood which is sentang (*Azadiractha excelsa*) can help in overcome the problem of shortage of Rubberwood. In addition, the usage of particle size also can help in maximizing the usage of the wood as particleboard raw materials.

The application of mixed production of particleboard also not common in Malaysia. Due to the different wood density between wood species, the weak of particleboard maybe can be minimizing. This is because the density variation between two wood species has influenced binder consumption and the bulk of particles to be consolidated. As such, the strength and the smooth surface of the board will be influenced.

Acacia mangium used for this study because of these species is widely available and it has a potential in furniture industry. In brief, *A.mangium* wood is one of the fast growing species that easy to grow in Malaysia. This wood species is abundance in Malaysia and has in a large amount of quantity. This means, *A.mangium* can be dependable in particleboard production because of the abundances and commercially available at the moment.

The availability source of raw material is one of the factors of using sentang in this study. In Malaysia, sentang plantation is relatively new where it is can be reliable since there is more sentang tree planted in Malaysia. Most of them are located in the states of Kedah, Perak, Negeri Sembilan, Johor and Pahang.

Species of wood gives significant variable in particleboard manufacturing. The lower density of wood species will produce the superior properties compared to higher density of wood species. Lower wood density gives good properties compared to higher wood density because low wood density gives sufficient interparticle contact area during pressing time as the volume of particles for low wood density is higher than volume of particles for high wood density. This will result in increase bending properties (Maloney, 1993). However, wood species with low density will give poor internal bonding properties (Ashori and Noutbakhsh, 2008).

Particle size can affect in internal bond strength of the boards where smaller particle size give better internal bond properties (Ngueho Yemele, 2008). In addition, internal bond properties will decrease as increase in particle size. This is because smaller particle size makes the particle more compressed (Marashdeh et al, 2011).

The objective of this study aimed is to determine the suitability of mixed species of particleboard and analyze the properties of particleboard made from different wood species and particle size.

MATERIALS AND METHODS

Acacia mangium and sentang species chosen for this study was prepared in Bengkel Perkayuan UiTM Pahang. The raw materials were in the form of wood particles. The wood particles size is reduced by using wood flaking machine. Then, wood particles were classified into size required which is 1.0mm and 2.0mm by using screening machine. Urea formaldehyde resin with 64% solid content supplied by Malayan Adhesive and Chemicals Sdn Bhd, Shah Alam, Selangor was used as binding agent. Single-layer boards were made using each species alone and mixture species. The particleboards were made with target density of 700kg/m^{-3}.

The variables were as follows:

1) Wood species: (1)*A.mangium*, (2)sentang (all single species); (3)*A.mangium* mixed with sentang (equal parts for each species).
2) Particle size: 1.0mm; 2.0mm; and 1.0mm mixed with 2.0mm (each of the wood species variables).

For board preparation, wood particles are oven-dried with temperature 90°C to reach moisture content 2 to 6 %. The pre-weighted wood particles consists of *A.mangium* and sentang were blended in the mixer with resin content of 10% resin solid based on oven-dried

weight of wood particles. After blending, the particles were forming evenly into 340mm x 340mm wooden box former using metal caul plate as the base to produce a loose mat. Silicone released agent was sprayed onto caul plate before the particles is formed onto it in order to prevent the board from sticking to the plate during hot pressing. Mat formed particle was initially pre-pressed by using cold press hydraulic machine. Distance bar were placed between the plates in order to get the desired thickness during hot pressing. Then, the mat is hot pressed in a hydraulic hot press. The mat was hot pressed for 6 minutes.

After hot-pressed, the boards are conditioned and then were trimmed. After conditioning process, the boards were cut into test sample and the properties were determined based on EN standards. The properties data were analyzed by using Analysis of Variance (ANOVA) to determined the significant different of the variables used in this study.

RESULTS AND DISCUSSIONS

Table 1 showed the average values of mechanical properties of modulus of rupture (MOR), modulus of elasticity (MOE), internal bonding (IB), screw withdrawal (SW) and physical properties of thickness swelling (TS) according to species and particle size. Based on EN Standard, all the strength properties of the particleboard in this study meet the minimum requirement of the standard.

Table 1: Physical and mechanical properties

Species	PS [mm]	MOR	MOE	IB	SW	TS [%]
A.mangium	1.0	23.22	2747.09	1.72	1.36	15.15
	2	23.57	3360.14	1.41	1.43	17.19
	1.0+2.0	25.27	3277.09	0.97	1.43	17.13
Sentang	1	21.09	2752.59	1.41	1.42	26.87
	2	23.97	3118.25	1.23	1.48	26.09
	1.0+2.0	21.04	3858.77	1.24	1.58	23.14
A.mangium + Sentang	1	22.48	2842.39	1.52	1.6	22.19
	2	22.49	3067.05	1.35	1.27	24.98
	1.0+2.0	24.69	3223.65	1.33	1.4	25.98

The thickness swelling of particleboards in this study is ranging from 16% to 26% respectively. Particleboard made from *A.mangium* had the best dimensional stability compared to other particleboard. The worst thickness swelling was observed for particleboard made from sentang species.

Effect of Wood Species

Table 2 showed the effects of wood species and particle sizes on the mechanical and thickness swelling properties of particleboard made from admixture of acacia mangium and sentang.

Table 2: Effects of wood species and particle size on the mechanical and physical properties

Variables		MOR [MPa]	MOE [MPa]	IB [MPa]	SW [MPa]	TS [%]
Wood species	*A.mangium*	26.53b	3445.71b	1.37a	1.41a	16.49a
	Sentang	24.56ab	3157.93a	1.40a	1.42a	25.36b
	A.mangium + Sentang	23.64a	3108.83a	1.29a	1.49a	24.38b
Particle size	1.0mm	24.16a	3058.14a	1.55b	1.46a	21.41a
	2.0mm	25.28a	3374.79b	1.33a	1.39a	22.08a
	1.0 + 2.0mm	25.27a	3279.53ab	1.18a	1.47a	22.75a

Different letters in each column represent statistical significant

Particleboard made from wood species A.mangium has the highest MOR and MOE strength. This study also showed that particleboard made from single wood species has higher MOR and MOE strength compared to the mixed species. For single wood species particleboard, Wong et al. (1999) stated, with an average board density, strength properties of particleboard decrease as raw material density decreased. For mixed species, there are some disadvantages of mixing wood species where it relate to the variation of density that can affects the resin uptake during mixing process. Lighter density of wood species have tendency to absorb more resin than high density wood species. This may lead to poor adhesion interference between heavy and lighter particle after formed into particleboard which can affect the board properties (Xu and Suchsland, 1999).

As shown in Table 2, wood species made from sentang and A.mangium has high internal bond strength compared to mixed species of particleboard which give poor and lower internal bond strength. Therefore, internal bond increased when particleboards are made from either A.mangium or sentang alone species. Loh (2010) stated internal bond strength decreases as the mixing of different wood species density. For internal bond strength related with particle size, there is significant difference between them. In this study, internal bond strength increased when particleboard made smaller particle size. This can be supported by theory of smaller particle size gave better internal bond strength properties to particleboard. This is because, when particle size decreased, there is less number of voids between particles. Therefore, smaller particle leads to smaller overlapping areas, thinner the void between particles and more chance to form uniform density distribution which can increase the strength properties.

Effects of Particle Size

For particle size variable, particleboard made from 2.0mm particle size has the highest bending properties for MOR and MOE. The particleboard made from 1.0mm gives the lowest bending properties. Therefore, the particleboard made from mixed particle size was higher compared with 1.0mm size. According to Nazerian et al. (2011) coarser particle will give better strength properties since there are the large bond areas between particles that may form larger contact surface area. In addition, the best bending properties strength can be produced when longer particle are used.

For screw withdrawal, there is no significant different between the wood species and particle size in particleboard properties of this study. The mixed species and particle size both gives better screw withdrawal strength. This is may be caused by smaller particle filling up the void between the larger particle which more overlapping between the particle fiber and this can contribute to the higher screw withdrawal strength.

Effects of Particle Size

Thickness swelling increased as increased in wood density, as Benedito (1974) stated, an increase in raw material density gives low thickness swelling properties of particleboard which can higher the thickness swelling percentage. While particleboard made from single particle size give low TS compared to mixed particle size which contributed higher value of TS in this study. Based on EN Standards, particleboard should have maximum 15% TS value and all the TS value is not meet the standard requirement.

CONCLUSIONS

In conclusion, the results of this study showed the possibility of mixing wood species in particleboard manufacturing with acceptable properties. Wood species and particle size found to have an effect on the properties of particleboard made from single and mixed species and particle size. The suitable wood species must be concerned in order to produce a quality particleboard such as wood species that have the same wood density. The appropriate particle size also should be considered in order to produce high strength properties for particleboard. Therefore, the mixing particleboard and the usage of fast-growing wood species can be a new alternative in order to overcome the timber shortage in the wood and furniture industry.

REFERENCES

Ashori, A. and A, Nourbakhsh, 2008. Effect of press cycle time and resin content on physical and mechanical properties of particleboard panels made from the underutilized low-quality raw materials. *Ind. Crops Prod.*, 28:225-230.

Balsiger, J., Bahdin J. and Whiteman A., 2008. Asia Pacific Forestry Sector Outlook Study: The Utilization, Processing and Demand for Rubberwood as a Source of Wood Supply. FAO, Bangkok.

Kimoto, R., Ishimoir E., Sasaki H., and Maku T., 1 9 6 4. Studies on particleboards. Effects of resin content and particle dimension on the physical and mechanical properties of low-density particleboards. Wood Res. Kyoto U. 32:1-14

Loh Y.W., H'ng P.S., Lee S.H., Lum and Tan C.K., 2010. Properties of particleboard from admixture of Rubberwood and Mahang species. *Asian Journal of Applied Science* 3(5):310-316, 2010.

Maloney T. M, 1993. Modern particle board and dry-process fibre board manufacturing. Miller Freeman Inc., San Francisco. 688p.

Marashdeh, 2011. Effect of particle size on the characterization of binderless particleboard made from Rhizophora spp. mangrove wood for use as phantom material. *BioResources* 6(4), 4028-4044.

Nazerian, 2011. Properties of three-layer particleboard made from wood of Athel (*Tamarix aphylla*) and pruning particle of Almond (*Amugdalus communis*) and Pistachio (*Pistacia vera*). *J. Basic Appl. Sci. Res.*, 1(8): 837-843, 2011.

Norini, H., 2001. Supply and demand of timber for the wood-based panel industries in Malaysia. Proceedings of the 3rd National Seminar: Wood-Based Panel Products, July 10-11, Kuala Lumpur, Forest Research Institute Malaysia, ISBN:983-2192-31-3, pp: 1-7.

Wong E.D., Zhang M., Wang Q. and Kawai S., 1999. Formation of density profile and its effects on the properties of particleboard. *Wood Sci. Technol.*, 33:327-340.

Xu, W. and Suchsland O., 1999. Within-panel variability and selected property relationships of particleboard from single and mixed species processes. *Forest Prod. J.*, 49: 36-40.