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Effects of Varying Resin Content and Wood Species on Particleboard Properties

Nor Faizura Mohd Yassin[1], Jamaludin Kasim[2]*, Wan Mohd Nazri Wan Abd Rahman[3], Nurrohana Ahmad[4], Siti Noorbaini Sarmin[5]

[1-5] Wood Industries Learning Center, Universiti Teknologi MARA Cawangan Pahang
Kampus Jengka, 26400 Bandar Tun Razak Jengka, Pahang, Malaysia
djamal@pahang.uitm.edu.my
*Corresponding Author

Abstract: Petai Belalang (*Leucaena leucocephala*) and Batai (*Paraserianthes falcataria*) chips were used in the manufacture of particleboard. Particleboard made from Batai with 12% resin content had the highest MOR (35.11MPa) and MOE (6334MPa). The board also had the lowest WA (66.96%) and TS value (23.02%). For particleboard made from Petai Belalang with 12% resin content showed the highest value for MOR (26.67MPa) and MOE (5975MPa), WA (61.73%) and TS (18.85%). Increasing the resin content increases the MOR and MOE insignificantly but the increase in IB values is significant. With higher resin content, lower water absorption values was observed. Properties of MOE and IB were not affected by the different species. However for MOR values, batai particles significantly gave better value than petai belalang. The thickness swelling of Petai Belalang (Leucaena leucocephala) is significantly lower than Batai (Paraserianthes falcataria) but their water absorption values does not show any significant difference. All boards made from Batai and Petai Belalang surpassed the standard value of JIS for the mechanical and physical properties except for TS value. Further research is required to improve the thickness swelling and water absorption by the use of water repellant agent such as wax in making board is suggested.

Keywords: Batai, Particleboard, Petai Belalang

1. Introduction

Particleboard is the most popular panel product that used throughout the world for furniture manufacture and house construction, including flooring systems. Recently, the demand for the particleboard continuously increases mainly in the housing construction and furniture manufacturing. The main raw material used in particleboard manufacture comes mostly from the rubberwood plantation. Trees from the forest are also use but have decreased tremendously due to overlogging. The depletion of our tropical rainforest due to excessive logging and clear cut logging which are for plantation crops. The supply of raw materials from both these resources is decreasing at an alarming rate. Therefore the search for other feasible raw material for particleboard manufacture is ongoing.

Batai (*Paraserianthes faicataria)* is one of the fastest growing trees in the world and it is a fuel wood species for the humid tropics. Batai are large deciduous tree with a thin, medium sized tree, has fast growth in the wet forest of Southeast Asia. It is widely planted at the tropical countries and becoming naturalized (Taylor, 1990). Growth records of this tree on good soil and high rainfall are as much as seven meter in height in a year, 13 to 18 meters in three years, 21 meters in four years and 30 meters in 9 to 10 years respectively. The growth rate of the tree slows down to a maximum of 45 m and has a short life of about 25 years. In addition, the most vigorous trees increased in trunk diameter about 5-7 cm per year. A height of 15 m and diameter of 30 cm have been attained after 4 years. The trees coppice vigorously and can be harvested in plantation on an 8 year cycle from coppice. *Falcataria* wood has a density of 336 kg/m^3 and is a fairly large tree and its height can reach up to 40 m tall, bole characteristics is branchless for up to 20 m, grows to 100 cm or sometimes more in diameter, with a spreading flat crown. *P. falcataria* is an important source of veneer and plywood and is very suitable for the manufacture of particleboard, wood wool board and hardboard and has recently been used for block board. Tannin or dyestuff, the bark of *P. falcataria* has tanning properties (Agro Forestry Tree., 2011).

Scientific name for Petai Belalang is *Leucaena leucocephala* is a species of small Mimosoid tree. *Leucaena leucocephala* is family of Leguminoseae and subfamily of Mimosaceae. The specific name is derived from the Greek words meaning "white", and "head", referring to its flowers. *L. leucocephala* is used for a variety of purposes, such as firewood, fiber and livestock fodder (Carl, 2010). Morphological description according to Tropical Forest, 2011 information of Petai Belalang (*Leucaena leucocephala*) is species that has a very fast growth rate, young trees reach a height of more than 20 ft in 2-3 years. The shrub or tree is up until 18m in tall. Fiber values are similar to those of other tropical hardwoods, and it produces paper with good printability but low tearing and folding strength; the wood-pulp strength is greater that wood-pulp from most hardwoods, with almost 50% greater ring crush. Its pulping properties are suitable for both paper and rayon production. Also used for particleboard production. *L. leucocephala* characteristics are porous wood structure, has longer fiber than that of other hardwoods, high holocellulose, a-cellulose and low lignin content with xylan type hemicellulose making it a suitable raw material in pulp and paper industry (Malik *et al.,* 2004). Timber *L. leucocephala* has hard heavy wood (about 800 kg/m^3), with a pale yellow sapwood and light reddish-brown heartwood. The wood is known as a medium density and to dry without splitting or checking. It is strong, medium textured, close grained and easily workable for a wide variety of carpentry purposes. The paper discussed the properties of particleboard from batai and petai belalang and evaluate the effects of varying resin content and wood species on the properties.

2. Materials and Methods

Materials Preparation

Chips were prepared from of Petai Belalang (*Leucaena leucocephala)* and Batai (*Paraserianthes falcataria*) separately. Three Batai trees were collected from Dong Hwa Plantation, Kedah with DBH : 25.0- 28.5 cm and height at 24.0m – 26.0m. Petai Belalang (a total of 10 trees averaging 15cm in DBH and average tree height of 18 feet) were logged from a woody area near Pasar Jerantut, Pahang. All logs were transported back to the Wood Technology workshop. Debarking process were carried manually on all the logs. The logs were then sawn lengthwise into 1 inch by 1 inch by 8 feet planks and sent to the wood chipper. The wood chipper converts all the planks to generate wood chips. The wood chips were then flaked by the knife ring flaker into smaller particles. The particles were then airdried for 1 week and then screened into the required size of 1.0 mm for both species Batai and Petai Belalang. Particles are subsequently ovendry at 80 C to achieve the final level of moisture content of about 5%.

Particleboard Manufacture

A weighted amount of particles are placed in the particle mixer and sprayed with urea formaldehyde resin between 8 to 12%. After mixing the sprayed particles formed manually in wooden mould with dimesions of 35 cm X 35 cm. After mat forming the boards are then cold press to consolidate its thickness. Prepress was conducted at 300 – 500 psi pressure for about 30 seconds. The consolidated mat was then hot pressed in a thermal-oil heated hydraulic hot press at an elevated temperature of 165°C with a three stage of pressure which first pressure stage is 1800 psi at 180 second follow by stage two which is 1200 psi at 160 second and last stage is 800 psi at 60 second. After hot pressing the finished boards are then cooled to room temperature.

The board will cut into the require size which is 350 mm x 350 mm x 12mm. Next, the board will evaluate according the standard for testing (Table 3.1).

Table 3.1 The number and size of sample according to testing

Property	Sample size (mm)	No. test sample/board
Bending Strength	240 x 50	3
Internal Bonding	50 x 50	7
Thickness Swelling	50 x 50	7
Water Absorption	50 x 50	7
Density	100 x 100	1

Particleboard Evaluation

The physical and mechanical properties of the board were tested according to the Static Bending Test (MOR and MOE), Internal Bond Strength, Thickness swelling and Water absorption. Testing process was regarding Japanese Industrial Standard (JIS A 5908:2003) Particleboard. The physical and mechanical data will presented here were analyzed using Analysis of Variance (ANOVA) to determine the significant difference of the variables used on the properties. The means were further analyzed by Least Significance Difference (LSD) to determine the significant level of the variables used in this study.

3. Result and Discussion

Particleboard Properties

Table 1 show the results of mechanical and physical properties of Batai (*Paraserianthes falcataria*) and Petai Belalang (*Leucaena leucocephala*). The result were compared to meet the minimum requirement for strength properties of particleboard panels for general uses and furniture manufacturing were evaluated based on JIS A 5908:2003 Particle Boards.

Table 1. Mechanical and physical properties of particleboard from Batai and Petai Belalang

Species	Resin Content (%)	MOR (MPa)	MOE (MPa)	TS (%)	WA (%)
Batai	8	28.46	5443	42.24	92.00
	10	31.74	5546	32.78	77.71
	12	35.11	6334	23.02	66.96
Petai belalang	8	24.23	5353	33.65	79.20
	10	25.97	5802	26.44	66.75
	12	26.67	5975	18.85	61.73
	JIS A 5908:2003	> 13.00	> 2500	<12.00	

Particleboard made from Batai with 12% resin content had the highest MOR (35.11MPa) and MOE (6334MPa). The board also had the lowest WA (66.96%) and TS (23.02%). For particleboard made from Petai Belalang with 12% resin content showed the highest value for MOR (26.67MPa) and MOE (5975MPa), WA (61.73%) and TS (18.85%). All boards made from Batai and Petai Belalang surpassed the standard value of JIS for the mechanical and physical properties except for TS value.

Table 2 shows the analysis of variance (ANOVA) of the effects of resin content and species on the particleboard properties. SPP was shown to significantly affect the MOR and TS. RC had significant effects only on IB, WA and TS. Their interaction showed significant effect only on WA.

Table 2 Analysis of Variance (ANOVA) of the effect of species and resin content on the particleboard properties

SOV	df	MOR	MOE	IB	TS	WA
SPP	2	7.942*	0.025^{ns}	0.329^{ns}	35.933*	1.874^{ns}
RC	2	1.612^{ns}	1.323^{ns}	8.692*	122.724*	50.412*
SPP X RC	1	0.358^{ns}	0.190^{ns}	0.494^{ns}	2.507^{ns}	3.702*

Effect of Resin Content on Mechanical Properties

Effect of resin content on the mechanical properties is shown in Figure 1. Increasing the resin content increases the MOR and MOE but the increase is not significant. However the increase in IB values with increasing RC is significant. Rahim *et al*, (1992) stated that with higher resin content all the strength properties will also increase. It is well understood that the adhesion of porous materials involves mechanical interlocking, physical attraction and chemical bonding (Wellon, 1980). Nur Farahin et al. (2014) and Nadir, Jin and Tae (2012) reported that with increasing resin content the strength properties of particleboard increases significantly.

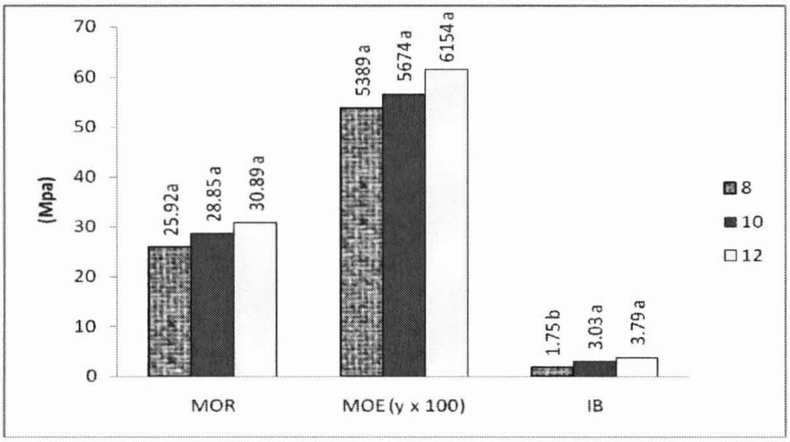

Fig.1 Effect resin content on mechanical properties

Effect of Resin Content on Physical Properties

The four major factors that should be focus on particleboard dimensional properties are board density, particle geometry, resin and wax and pressing condition (Razali, 1985). From Figure 2, increase in RC from 8% to 12% was found to improve the WA and TS properties of all boards by about 29% and 46%, respectively. According to Rahim et al, (1992), increase in resin content will increase in contact areas and these turns contribute to better adhesion between particles. With higher resin content, lower water absorption values will be observed. Nur Farahin et la. (2014) reported at higher resin content better WA and TS values were obtained. Gatchell et al., (1996) state that the factor which affects the thickness stability of particleboard is resin content.

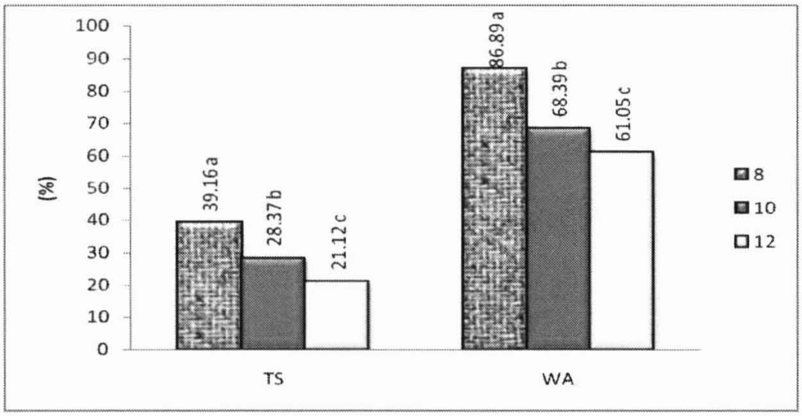

Fig.2 Effect of resin content on thickness swelling and water absorption

Effect of Species on Strength Properties of Particleboard

Figure 3 shows the effect of species on the modulus of rupture, modulus of elasticity and internal bonding. Properties of MOE and IB were not affected by the different species. However for MOR values, batai particles significantly gave a better value than petai belalang. This higher value is probably due to the higher compaction ratio imparted on the batai particles leading to better contact among the particles. This happen because Batai density is about 336 kg/m^3 and Petai Belalang is about 500 kg/m^3 (Agro Forestry Tree, 2011).

Effect of Species on Physical Properties of Particleboard

Yaguang Zhou (2002) reported that the great internal bond strength of the board should lead to small value of thickness swelling. Usually the value of thickness swelling will be more stable if the density of species is high compare to low density of species. Based on the result shown in Figure 4, it shows that thickness swelling of Petai Belalang (Leucaena leucocephala) is lower than Batai (Paraserianthes falcataria). This is due to their difference in density, where Petai Belalang has a higher density of more than 500kgm3 as Batai of only 336kgm3. Whereas for water absorption, there is no significant difference between species of Batai (Paraserianthes falcataria) and Petai Belalang (Leucaena leucocephala).

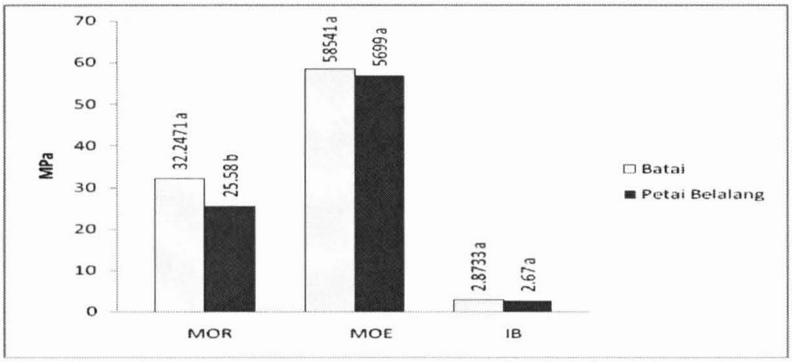

Fig.3 Effect of species on modulus of rupture, modulus of elasticity and internal bonding

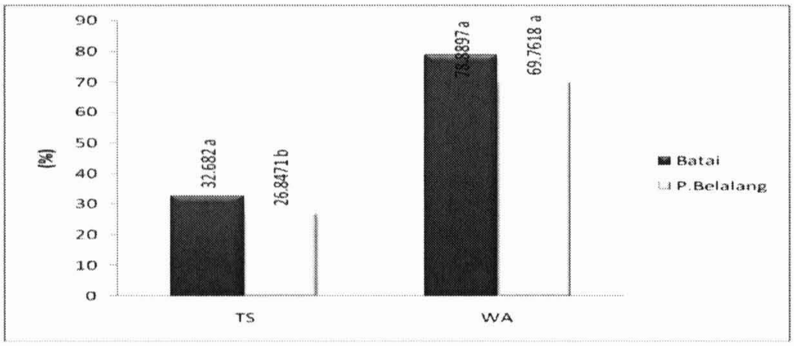

Fig.4 Effect of species on physical properties

4. Conclusions

Batai (*Paraserianthes falcataria*) and Petai Belalang (*Leucaea leucocephala*) were found to be suitable raw materials to produce particleboard and has a potential in furniture manufacturing. The resin content was found to affect the properties of water absorption and thickness swelling. Properties of MOE was not affected by the different species. However for MOR values, batai particles significantly gave a better value than petai belalang. For the effect of species, thickness swelling of Petai Belalang (*Leucaena leucocephala)* is lower than Batai (*Paraserianthes falcataria*). For water absorption, there is no significant difference. All boards made from Batai and Petai Belalang surpassed the standard value of JIS for the mechanical and physical properties except for TS value. As a recommendation, for future research to improve the thickness swelling and water absorption the use of water repellant agent such as wax in making board is suggested.

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