Effects of Particle Sizes, Resin Content and Board Density on Properties of *Sesendok* Particleboard

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ABSTRACT

Results of the study show that board density, resin content and particle size significantly affect all the board properties. Large particles significantly increase the properties of MOR and MOE while smaller particle sizes give better IB value. With higher board density, all the strength and dimensional properties are significantly improved. However, Sesendok particleboard does not surpass the standard requirement as defined EN 312/3, especially for thickness swelling.

Keywords: *board density, particleboard, particle size, resin content, Sesendok*

Introduction

At present, rubberwood is the main raw material for the manufacture of particleboard. It is expected that in the future, the supply of rubberwood will not be able to meet the demand of the industry. Now, rubberwood is getting costly and limited in resource. Thus, new alternatives have to be identified to support the wood industry, particularly, the particleboard industry. In this study, Sesendok was assessed to determine its suitability as a raw material in the manufacture of particleboards.

Sesendok is a lightweight, comparatively soft and weak wood. The heartwood is yellowish white to bright yellow, with greenish tinge when freshly cut, weathering to straw-coloured, not distinctly demarcated from sapwood. The density is 300-650 kg/m^3 at 12% moisture content. Sesendok can be used for a variety of purposes where lightweight, comparatively soft and light-coloured hardwood is required. The wood is non-durable when used in contact with the ground. Hence, all applications should be under cover. The wood is favoured for match boxes and splints and recommended for chopsticks, popsicle sticks, medical sticks (spatula), ice-cream spoons, toothpicks, carvings and handicrafts. It is also suitable for pattern making, drawing boards, pencil slats, block boards, trays, furniture parts, picture frames, plywood chests, packing cases and crates and buoys and floats. Sesendok also supplies suitable materials for toys and indoor laminated wood, paneling and moulding. It is also favoured for soles and clogs.

The objectives of this study were to determine the strength and dimensional properties of particleboards made from Sesendok (*Endospermum Malaccense*), and to determine the effects of particle size, resin content and board density on particleboard properties.

Materials and Methods

Field Procedure, Material Preparation and Board Evaluation

Three Sesendok trees with a diameter at breast height (dbh) of more than 20 cm were harvested from the UiTM Pahang Forest Reserve. The felled trees were then cross-cut into eight-foot bolts. The logs were sawn into planks of about 1" × 1" x log length and fed into the wood chipper to produce chips. The chips were then passed into a knife ring flaker to obtain smaller particles. The particles were then air dried for a week in a shaded area. After air drying, the particles were then screened into 2.00 mm, 1.00 mm and 0.5 mm using a vibrating screener. The screened particles were then oven dried at 60°C for 24 hours to reduce the moisture content to less than 5%.

Particleboards were fabricated at three density levels – 500, 600 and 700 kgm^{-3}. Urea Formaldehyde resin was used at 8%, 10% and 12%. The particles used were 2.00 mm, 1.00 mm and 0.5 mm. During particleboard making, a known quantity of particles was placed in the particleboard mixer, where resin and hardener were then sprayed onto the particles. After blending with resin, the particles were manually distributed into a wooden mould to form a particleboard mat. The mat was cold-pressed at 1000 psi for about one minute to consolidate it before hot pressing. The mat was then hot pressed with heat and pressure to cure the resin. The hot press was set at three different pressures. The particleboard mat was first pressed at 1800 psi for 180 seconds, followed by a pressure of 1200 psi for 120 seconds and, lastly, 800 psi for 60 seconds. After pressing, the board was trimmed to obtain the desired length and width and to square the edges.

The conditioned boards were cut into specific dimensions for evaluation of various properties. The properties were;

i. Flexural strength (MOR)
ii. Internal Bending (IB)
iii. Water Absorption (WA) and Thickness Swelling (TS)

Results and Discussion

Mechanical and Physical Properties

Table 1 shows the mechanical and physical properties of the particleboard from Sesendok according to particle size, resin content and board density. The table shows that particleboard made with 12% of resin content is higher in MOR, MOE, IB and better in TS and WA compared to particleboard made with 8% resin content. Resin content influences the dimensional stability and strength of particleboard. Particleboard with a density of 700 kg/m^3 shows higher MOR, MOE, IB but lowest in TS and WA.

Statistical Analysis

Table 2 shows the ANOVA on the effect of particle size, resin content and board density on the particleboard properties. Particle size (PS) shows significant effects on all the board properties except on MOE. Resin content (RC) also shows significant effects on all the board properties except IB. Board density (BDEN) significantly affects all board properties. Their interaction (PS $\times$ RC $\times$ BDEN) shows significant effects on all the board properties.

Table 1: Strength and Dimensional Properties of the Particleboard from Sesendok

Particle Size (mm)	Resin Content (%)	Density (Kg/m^3)	MOR	MOE	IB	WA	TS
2	8	500	9.79	1281	0.23	130.59	17.53
2	10	500	10.66	1443	0.29	123.08	15.80
2	12	500	15.69	2412	0.13	72.23	19.41
2	8	600	6.94	1334	0.24	91.16	42.03
2	10	600	14.84	2021	0.43	93.09	22.33
2	12	600	16.14	2192	0.65	89.52	18.98
2	8	700	18.95	2579	0.27	65.89	14.43
2	10	700	19.77	2984	0.45	65.94	11.98
2	12	700	17.36	2704	0.61	65.99	9.89
1.0	8	500	5.71	933	0.41	161.73	26.63
1.0	10	500	9.44	1306	0.28	129.04	15.53
1.0	12	500	9.52	1286	0.55	118.59	14.41
1.0	8	600	12.87	1710	0.45	99.65	25.76
1.0	10	600	10.47	1414	0.44	105.48	24.05
1.0	12	600	14.99	1930	0.55	88.30	18.90
1.0	8	700	17.41	2441	0.57	80.52	12.44
1.0	10	700	20.73	2942	0.55	61.16	11.22
1.0	12	700	19.02	2715	0.60	57.21	23.74
0.5	8	500	5.39	797	0.15	146.68	19.64
0.5	10	500	6.00	864	0.33	141.65	14.39
0.5	12	500	8.63	1131	0.39	121.44	13.07
0.5	8	600	14.51	1881	0.45	98.06	24.56
0.5	10	600	12.38	1622	0.39	106.30	21.43
0.5	12	600	16.70	2026	0.67	90.36	15.57
0.5	8	700	18.17	2363	0.35	71.72	11.82
0.5	10	700	20.43	2762	0.37	54.01	11.80
0.5	12	700	20.53	2741	0.31	54.69	10.08

Notes:
MOR – Modulus of Elasticity, MOE – Modulus of Rupture, IB – Internal Bonding
TS – Thickness Swelling and WA – Water Absorption

Table 2: Analysis of Variance on the Effect of Particle Size, Resin Content and Board Density on the Particleboard Properties

Source of Variance	DF	MOR	MOE	IB	WA	TS
PS	2	2.66*	12.50	6.90*	7.55*	2.36*
RC	2	20.54*	20.98*	24.64	79.97*	6.16*
BDEN	2	208.15*	240.35*	33.84*	510.17*	18.23*
PS × RC	4	1.76ns	2.60*	0.88ns	3.22*	0.78ns
PS × BDEN	4	10.71*	7.17*	3.85*	20.20*	1.14ns
RC × BDEN	4	4.89*	4.51*	1.78ns	11.86*	2.86*
PS × RC × BDEN	8	4.53*	3.12*	5.34*	8.70*	1.96*

Notes: * F-values are significant at $p < 0.05$, ns – not significant
DF – Degree of Freedom, MOR – Modulus of Elasticity, MOE – Modulus of Rupture, IB – Internal Bonding
TS – Thickness Swelling and WA – Water Absorption

Effect of Particle Size

Figure 1 shows the effect of particle size on the mechanical properties of Sesendok particleboards. The MOR and MOE of particleboard were observed to increase with an increase in particle size. Higher MOR with larger particle size can be explained by the higher amount of resin available per unit area due to lower surface area per unit (Jamaludin et al., 2001). Large surface area of particle gives better stress distribution than smaller particle.

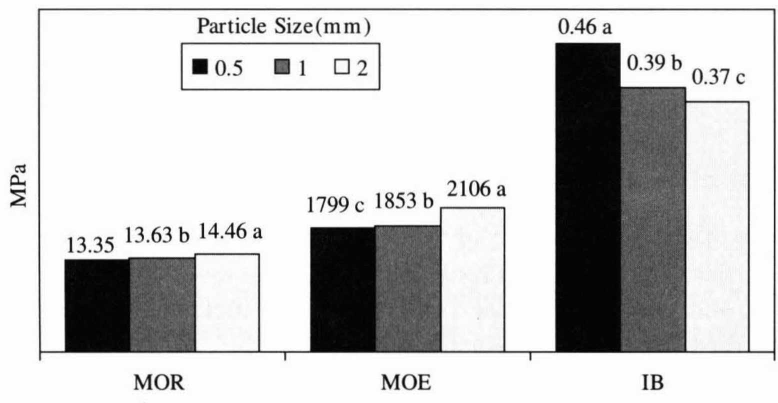

Figure 1: Effects of Particle Size on Strength Properties

Internal bond decreases with an increase in particle size. The higher IB with smaller particle size is due to the ability of smaller particles to generate gap-free surface area that gives rise to good bonding between the particles. Brumbaugh (1960) stated that a greater degree of discontinuous factor of smaller particles gives the higher IB values. Increase in particle size can reduce their bonding ability because of more gaps between particles.

Figure 2 shows the effects of PS on water absorption (WA) and thickness swelling (TS) behaviour of Sesendok particleboard. Particle size is an important parameter in controlling the board response to water absorption and thickness swelling. Water absorption and thickness swelling value increase as the particle size is increased. The lower WA and TS exhibited by smaller particle size is due to their ability to resist the uptake of water. Smaller particle sizes have the ability to create gap-free area during board processing while larger particle size tends to have more voids.

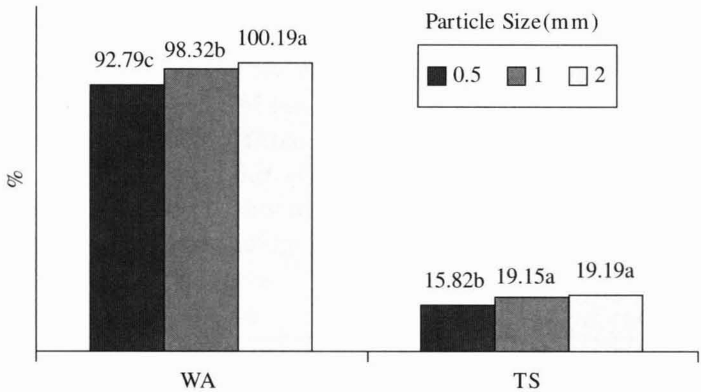

Figure 2: Physical Properties of Particleboard

Effect of Resin Content

Figure 3 shows the effect of varying resin content on the strength properties. The increase in resin content leads to the increase in MOR, MOE and IB. The increase in resin content increases the strength properties through better bonding of the particles.

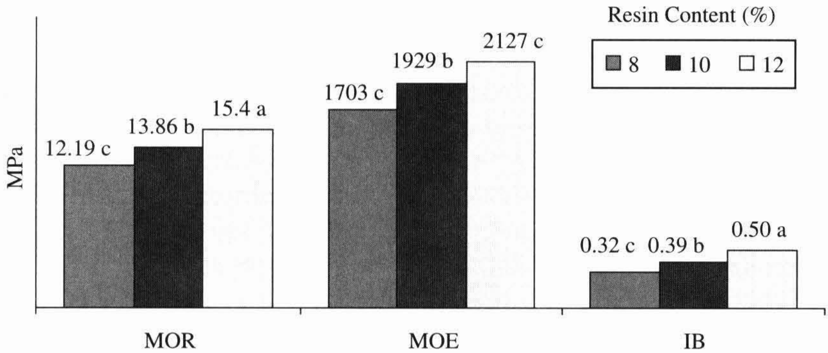

Figure 3: Mechanical Properties of Particleboard Based on Resin Content

The effects of RC on the dimensional properties of the boards are shown in Figure 4. The WA and TS values decrease as the resin content increases. This indicates that the board with greater resin coverage on the particle increases the contact areas and this, in turn, contributes to better adhesion between particles.

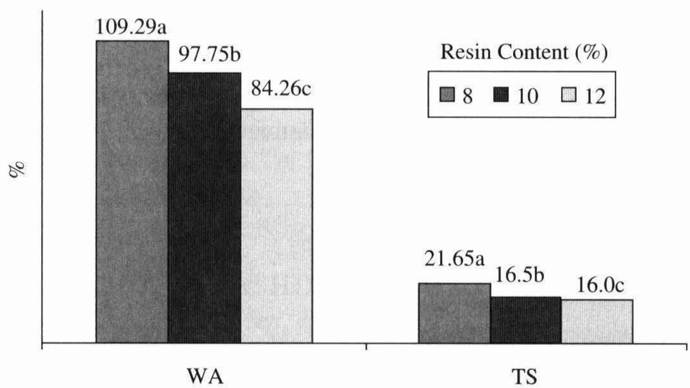

Figure 4: Physical Properties of Particleboard Based on Resin Content

Effect of Board Density

According to Moslemi (1974), particleboard properties are directly influenced by board density. This is true since higher density is usually associated with higher strength properties. Figure 5 exhibits the effects of BDEN on the strength properties. Particleboard with higher BDEN shows significantly higher MOR, MOE and IB compared to lower

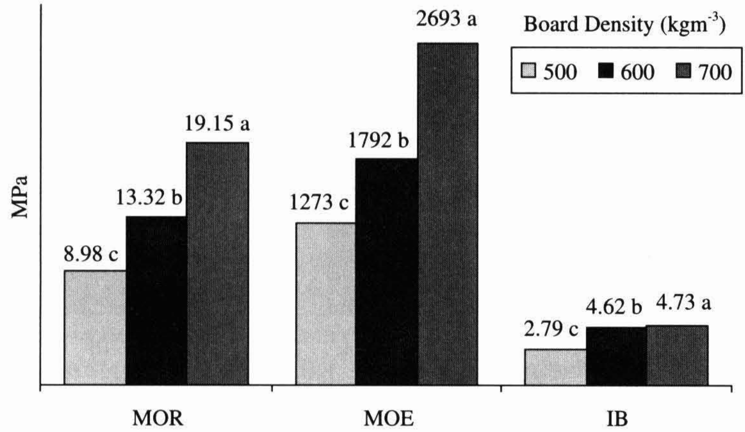

Figure 5: Mechanical Properties of Particleboard Based on Density

particleboard BDEN. The increase in strength properties could probably be due to the higher compaction ratio at higher density.

Figure 6 shows the effect of BDEN on the dimensional properties of the boards. The WA and TS decrease as the density of particleboard increases. The better dimensional properties of higher density particleboards are due to the higher compaction ratio and less voids created during board manufacture. Thus, higher density species will be more stable in WA and TS than lower density boards.

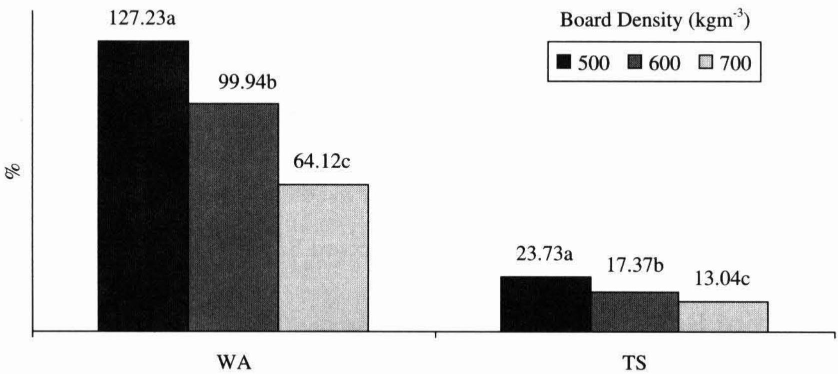

Figure 6: Effects of Board Density on Dimensional Properties

Conclusion

The board density, resin content and particle size are found to greatly influence the overall board properties. Large particles significantly increase the properties of MOR and MOE while smaller particle sizes give better IB value. Mechanical and physical properties are significantly improved. However, Sesendok particleboard does not surpass the standard requirement as defined EN 312/3, especially for thickness swelling.

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