Effects of Board Density and Resin Content on the Strength and Dimensional Properties of Particleboard from Kelempayan (*Anthocephalus Chinensis*)

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ABSTRACT

Kelempayan was successfully used in the manufacturing of urea formaldehyde particleboard at varying target board densities (525 kg/m^3, 575 kg/m^3 and 665 kg/m^3), resin content (6%, 8% and 10%) with a board thickness of 12 mm. Increasing densities increases all the board properties significantly in a linear fashion except for internal bond. An increase in resin content results in a significant effect on all the board properties. Modulus of rupture (MOR) increases in a definite trend, internal bond and screw withdrawal (SW) shows no trend while thickness swelling (TS) decreases. Boards with density of over 600 kg/m^3 and a resin content of 10% meets the minimum requirements for the strength properties as stipulated in the BS Standards (BS 5669). However, all boards fail in the thickness swelling.

Keywords: *board density, Kelempayan, resin content, strength and dimensional properties*

Introduction

In Malaysia, there are over 3000 timber size species belonging to over 90 families (Wong, 1982). *Anthocephalus* is a genus of medium-sized tree belonging to the family of *Rubiaceae*. In Malaysia, only the *anthocephalus chinensis* species is found. The standard Malaysian name for the timber is Laran. Vernicular names are Entipong (Sarawak), Kelempayan (Sarawak, Sabah and Peninsular Malaysia) and Limpoh (Sabah).

The timber is soft and light and the sapwood is not differentiated from the heartwood, ranging from white to creamy yellow in colour. It is easy to saw and planing produces smooth surface. The timber also seasons fairly rapid with slight end-checks and splitting. It is prone to insect attack and sap stains. It is suitable for plywood manufacture, packing cases, wooden sandals, and disposable chopsticks and as a source of short fibre pulp (Wong, 1976). This paper discusses the possibility of producing urea formaldehyde (UF) particleboard from kelempayan.

Materials and Methods

Sample Preparation

Three Kelempayan trees were felled from the riverbank of Sungei Klang at Section 24, Shah Alam. The average diameter at breast height was 45 cm, an average height of 45 feet and the trees were about 10 to 12 years old. The merchantable logs measuring 18 feet were first cut into six feet billets and, then, sawn lengthwise into 2" x 3" x 6' and fed into a Taihei wood chipper to produce chips. The chips were further processed in a Pallman Knife-ring flaker set at 0.6 mm to produce wood particles. The particles were, then, screened into various sizes and dried at 60ºC in an oven until it reached an average moisture content of about 5%. Particle size analysis was also carried out on the dried particles.

Board Preparation

Single layer urea formaldehyde particleboard of 12 mm thickness at varying target board densities (525 kg/m^3, 575 kg/m^3 and 665 kg/m^3) and resin content (RC) of 6%, 8% and 10% were produced. A measured quantity of particles was sprayed in Drais mixer with a resin mix containing urea formaldehyde, hardener and water. The sprayed particles were, then, laid in a wooden mould and pre-pressed at 3.5 kg/m^3. The consolidated mat was finally pressed in Taihei hot-press at 160°C for 6 minutes. The cooled board was, then, conditioned in a conditioned room at 20°C and 65% relative humidity. The board was, then, cut into the desired sizes according to the British Standards BS 5669 (BSI, 1989) for strength and dimensional stability tests.

Results and Discussion

Particle Size Analysis

Moslemi (1974) stated that particle geometery is a prime factor affecting the board properties and, furthermore, it helps in controlling dimensional stability. Longer and thinner particles will produce a board with higher modulus of rupture (MOR) with better dimensional stability while shorter and thicker particles produces a board with lower MOR and lower water absorption but with a higher internal bond (IB). Shaikh (1991) found that thicker particles will increase the IB values while thinner particles will decrease the water absorption due to better compaction ratio during board forming. The particle size analysis of Kelempayan particles are shown in Table 1. The particles (82%) are mainly distributed between the mesh sieve of 0.25 to 2.00 mm. The particle thickness is between 0.3 to 0.6 mm (78.3%) with an average thickness of 0.50 mm. The average particle length is 18.9 mm and accounting for nearly 78.0% of the total particle measured.

Table 1: Particle Size Analysis of Kelempayan (*Anthocephalus chinensis*)

Sieve size (mm)	Weight (%)	Thickness (mm)	(%)	Length (mm)	(%)
<0.25	8.58	0.1	-	0	-
0.25	12.00	0.2	4.61	5	-
0.50	24.86	0.3	15.80	10	8.05
1.00	18.26	0.4	28.95	15	40.37
1.40	16.00	0.5	19.74	20	37.50
2.00	10.80	0.6	13.82	25	9.21
2.80	3.59	0.7	7.89	30	2.01
3.35	5.91	0.8	4.61	35	2.01
		0.9	1.31		
		1.0	3.29		

Values are averages of 3 determinations.

Strength and Dimensional Properties

The strength and dimensional properties of UF particleboard manufactured from Kelempayan are shown in Table 2. The data were further analysed for the analysis of variance (ANOVA) and Duncan Multiple Range-T-tests for the effects of board density and resin content on the board properties.

Table 2: Strength and Physical Properties of Kelempayan Particleboards

Density (kg/m³)	Resin content (%)	MOR (MPa)	IB (MPa)	SW (N)	TS (%)
525	6	9.49	0.59	503	12.17
	8	9.07	0.74	537	8.83
	10	9.69	0.89	498	5.51
575	6	10.69	0.57	668	16.01
	8	13.43	0.79	693	11.16
	10	14.45	1.09	723	8.11
665	6	11.05	0.39	692	19.69
	8	15.83	0.72	836	13.60
	10	15.56	0.85	924	9.07
BS 5669		>13.8	>0.34	>360	<8.00

Note; MOR - modulus of rupture, IB - internal bond, SW- screw withdrawal, TS - thickness swelling. Values are averages of six test replicates

All board irrespective of board densities surpassed the minimum requirements of the BS Standards for internal bond (IB) and screw withdrawal (SW). For modulus of rupture (MOR), only boards having densities of over 575 kg/m^3 and a RC of more than 8% met the requirements of the Standards (Table 2). In general, thickness swelling (TS) decreased with an increase in RC at all densities level. TS were also observed to increase with increasing density. TS can be further reduced with the incorporation of wax during board manufacturing. However, all boards failed to meet the minimum requirements of the BS Standards, especially for thickness swelling properties.

Table 3 indicates that board density had significant effects on all board properties except for IB while resin content affected all board properties significantly. Their interaction also showed significant effects on all board properties.

Table 3: Summary of the Analysis of Variance (ANOVA) on the Board Properties

SOV	df	MOR	IB	TS	SW
Density (D)	2	107.6*	0.11ns	126.1*	424119*
Resin (RC)	2	41.4*	1.97*	318.9*	51673*
D x RC	4	12.6*	0.48*	6.6*	19180*

Note: ns- F-value are not significant at $p < 0.05$, * significant at $p < 0.05$

With an increase in board density, all the board properties show a significant increase in all the strength values (except for IB) and TS as shown in Table 4. The higher value of TS is attributed to higher amount of wood particles available in the board. Chew et al. (1992) and Shaikh (1991) found a similar trend. From Table 4, MOR and SW indicate an increasing trend with higher density. Kelempayan has a density of 300 kg/m^3 to 520 kg/m^3 producing particles, which occupies a greater volume than the same weight of dense wood. Thus, greater particle contact promotes better resin efficiency giving higher strength values at higher board density.

Table 4: Summary of Duncan Multiple Range T-tests on the Particleboard Properties

Density (kg/m^3)	MOR (MPa)	IB (MPa)	SW (N)	TS (%)
525	9.42c	0.74a	513c	8.83c
575	12.85b	0.87a	695b	11.76b
665	14.15a	0.88a	818a	14.12a
Resin Content (%)	**MOR (MPa)**	**IB (MPa)**	**SW (N)**	**TS (%)**
6	10.41c	0.51c	621b	15.96a
8	12.78b	0.80b	676ab	11.19b
10	13.23a	1.17a	728a	7.56c

Means having the same letter down the column are not significantly different at $P < 0.05$ probability level

Variation in resin content significantly affected the strength and TS values (Table 4). The MOR, IB and SW values indicate an increasing trend similar to Moslemi's (1974) findings. The higher values were due to the more resin available for bonding the wood particles together. An increase in the resin content was also observed to reduce the thickness swelling of the board.

Conclusion

From the study, the effects of varying board density and resin content on board properties was found to be significant, however, none of the boards produced surpassed the requirements for thickness swelling of less than 8% as stipulated in the BS 5669 Standards. With the addition of wax, the thickness swelling properties of the boards is expected to improve further.

Acknowledgements

The authors would like to thank the Wood Technology Laboratory and FRIM personnels for the assistance rendered during the harvesting of the timbers. To Azhar Ayub and Saimin Basir our greatest appreciation for the assistance offered during board manufacturing, to Institute of Research Development and Consultancy, UiTM for funding the study and to FRIM for the use of laboratory equipment without which this study would not have been possible.

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