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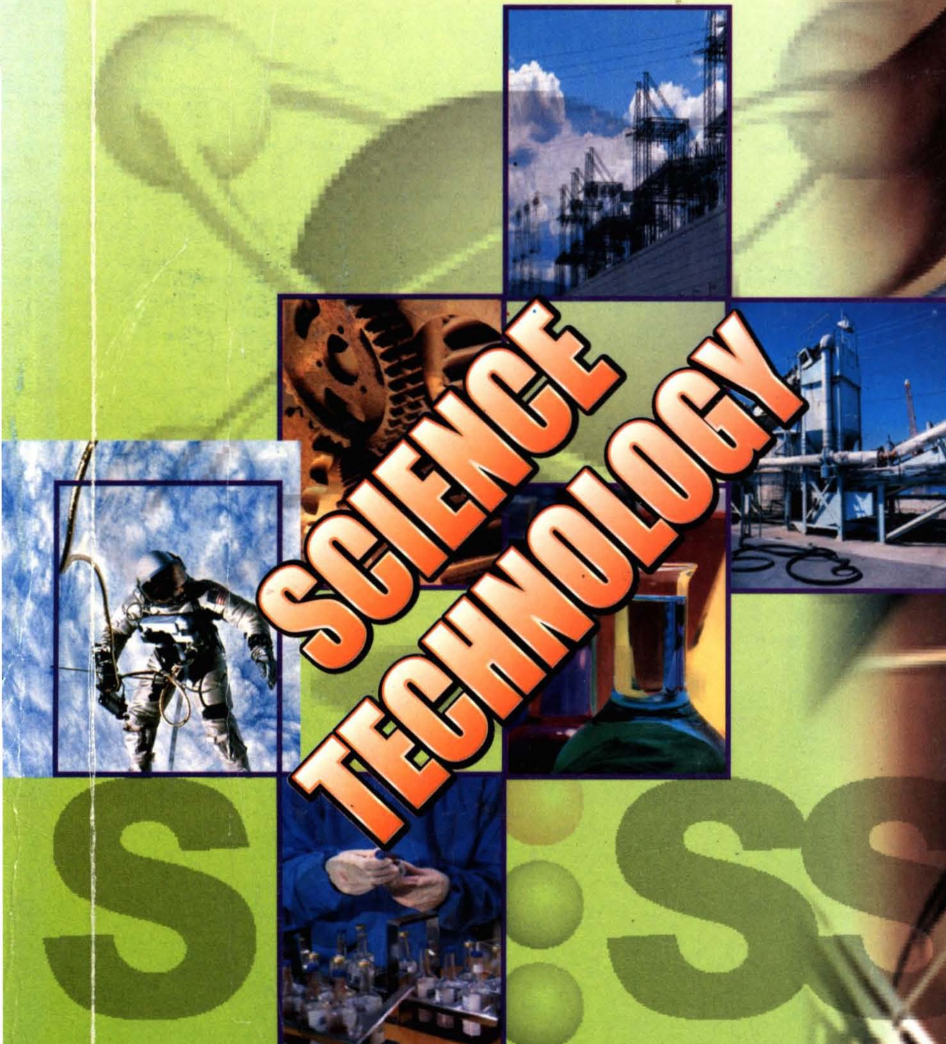

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Properties of Melamine Urea Formaldehyde Particleboard Produced from Buluh Semantan (*Gigantochloa Scortechinii*)

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ABSTRACT

Single-layer melamine urea formaldehyde particleboard was produced using buluh semantan (Gigantochloa scortechinii). Sixty bamboo clums from 1, 2 and 3 year-old bamboo was used in the study. In the manufacture of homogenous board, three different resin contents were applied; 8, 10 and 12% using three different particle sizes of 0.5-1.0, 1.0-2.0 and > 2.0 mm. One percent wax was added while no wax was used for the controlled boards. The results indicate that all the properties tested (except for IB) decrease significantly with age. All the mechanical properties increase, the physical properties is better with increase in the resin content. Particle size influence significantly the mechanical and physical properties of the particleboard produced. Wax addition decreases the mechanical properties but increases the dimensional stability of the particleboard.

Keywords: *Buluh semantan, particleboard, age, resin content, particle size, melamine urea formaldehyde, wax Addition*

Introduction

In Malaysia, particleboard is being manufactured using tropical hardwoods especially rubberwood. At present rubberwood is also sought for by the other wood industries, especially the furniture industry. In order to sustain the operation of the existing particleboard industry it is therefore of utmost importance that alternative raw materials are available.

This paper discusses the particleboard properties of single-layered particleboard produced with melamine urea formaldehyde (MUF) resins. The influences of age, particle size, resin level and wax addition are also included in the discussion.

Materials and Methods

Sixty bamboo clums from three-year-old bamboo (*Gigantochloa scortechinii)* were harvested from managed bamboo clumps in FRIM, cut into 2 m length and splitted longitudinally using a bamboo splitter. The bamboo splits were fed into the Pallmann drum chipper and the chips produced were then flaked in the Pallmann drum flaker. After flaking the particles were air-dried for one week to reduce the moisture content prior to oven-drying and were subsequently placed in an oven at 60 C until the moisture reaches about five percent. The oven-dried particles were then screened into less than 0.5, 0.5-1.0, 1.0-2.0 and more than 2.0 mm sizes using a circular vibrating screen.

In the manufacture of homogenous board, three different resin contents were applied ; 8, 10 and 12% using three different particle sizes of 0.5-1.0, 1.0-2.0 and > 2.0 mm. One percent wax was added while no wax was used for the controlled boards. The melamine urea-formaldehyde resin used in the study had a solid content of 65%. The hardener (ammonium chloride) solution with a concentration of 20% was used. The amount of hardener added was equivalent to 3% of the weight of the resin solution used.

For board manufacture a weighted amount of particles was placed in the Drais glue mixer and sprayed with a resin mix containing resin, hardener, wax and water. The glue mix was sprayed as a fine mist at an air pressure of 0.4 MPa in order to obtain an even distribution of resin over the bamboo particles. After spraying, the sprayed particles were then manually laid in a wooden mould over a caul plate with a dimension of 34 x 34 cm and then pre-pressed with a cold press at 3.5 MPa for 30 seconds. The consolidated mat was then finally pressed to the required thickness of 12 mm at 160°C for 6 minutes with the maximum pressure at the metal stops at 120 kg cm-2. The target density was approximately 721 kgm^{-3}. A total of three boards were produced for each condition.

All the boards produced were cut according to a cutting plan adopted from BS EN 326-1: 1994 (Anonymous 1994) made to obtain a random selection of test samples throughout the board size of 340 x 340 mm. The test samples were tested for its mechanical: modulus of rupture (MOR), modulus of elasticity (MOE) and internal bond (IB), and physical properties: water absorption (WA) and thickness swelling (TS) according to British Standard BS EN: 1993 (Anonymous, 1993). Screw withdrawal (SWE & SWS) tests were conducted according to BS 5669 (Anonymous 1989). All the mechanical tests were conducted using an Instron Universal Testing Machine Model 4204.

Results and Discussions

Statistical significance

The analysis of variance on the board properties is given in Table 4. In general, all the mechanical and physical properties varied significantly with age (except for IB), resin content, PS and wax (except for MOR). These imply that the variations in all the mechanical and physical properties are significantly influenced by the single factor of age, resin, PS and wax.

Effect of Age

Table 5 gives the effects of age on the physical and mechanical properties of the MUF boards. The results indicate that all the properties tested (except for IB) decrease significantly with age. These are further revealed by the correlation analysis (Table 37), which indicate for MOR ($r = -0.16$), MOE($r = -0.12$), TS24($r = -0.32$), WA1 ($r = -0.22$) and WA24 ($r = -0.20$), respectively. The value of SWE ($R = 0.24$) and SWS ($r=0.04$) however, increased with an increment of age. This could be explain by the higher bulk density of older bamboo which would have better resin efficiency in gluing thus better mechanical properties. Regardless of the effects of other factors, the particles from any age group seem suitable for the manufacture of MUF particleboard.

Table 4 : Summaries of the Analysis of Variance on the Board Properties

SOV	df	MOR	MOE	IB	SWS	SWE	TS1	TS24	WA1	WA24
Age (A)	2	48.11**	7.31E6**	0.02ns	3.65E4**	1.21E5**	1.33**	526.45**	644.36**	2.36E3**
Resin(R)	2	778.26**	8.12E6**	2.39**	7.92E5**	5.36E5**	90.27**	1.51E3**	1.07E3**	6.05E3**
PSize(P)	2	49.22**	4.35E5**	0.54**	3.62E4**	4.02E4**	24.33**	182.00**	526.30**	236.87**
Wax (W)	1	2.50ns	4.58E6**	0.58**	6.70E5**	8.21E5**	283.4**	3.81E3**	1.77E4**	6.80E4**
A R	4	1.71ns	1.03E5*	0.02*	6.87E3ns	1.46E3ns	0.20ns	15.13**	8.24**	30.20*
A P	4	20.93**	1.44E6**	0.05**	5.42E**	3.54E4**	8.94**	26.33**	85.23**	490.35**
R P	4	10.80**	3.67E4*	0.008ns	4.39Ens	1.44E3ns	3.41**	10.46**	23.53**	58.33**
A R P	8	2.86ns	1.29E5**	0.04**	1.12E5**	4.17E3ns	1.45**	2.88**	30.40**	27.06**
A X W	2	14.00**	1.87E6**	0.02*	2.95E5**	2.86E4**	9.45**	183.44**	678.57**	378.06**
R X W	2	0.49ns	8.38E4ns	0.003ns	1.89E4**	1.96E3ns	16.30**	197.21**	428.48**	978.04**
A R W	4	3.79ns	.99E5**	0.002ns	2.00E5**	5.93E3*	0.22ns	4.99**	2.91ns	39.13**
P W	2	1.17ns	4.15E5**	0.03*	1.84E5**	5.80E3ns	14.53**	54.18**	623.28**	245.35**
A P W	4	7.94*	9.72E5**	0.06**	2.11E4**	4.06E4**	2.21**	36.49**	115.73**	154.09**
R P W	4	4.63ns	2.53E4ns	0.01ns	8.56E3*	1.10E3ns	2.74**	3.96*	28.87**	38.14**
A R P W	8	4.26ns	6.27E4ns	0.03**	1.60E3ns	2.1E3**	0.73**	2.75ns	20.80**	14.33ns

Note : ns - not significant at $p < 0.05$, * - significant at $p < 0.05$, ** highly significant at $p < 0.01$

Table 5: Effects of Bamboo Age on the Physical and Mechanical Properties of Single-Layered MUF Particleboards

Age (yrs)	MOR (MPa)	MOE (MPa)	IB (MPa)	SWS (N)	SWE (N)	TS1 (%)	TS24 (%)	WA1 (%)	WA24 (%)
1	26.44a	3810a	0.91a	850b	708 b	3.32b	17.33a	16.92a	47.91a
2	25.13b	3261c	0.93a	890a	772a	3.47a	15.58b	14.38b	47.48a
3	25.23b	3670b	0.91a	863a	771a	3.23b	12.55c	11.56c	38.98b

Note : Means having different letter down the column differ significantly at $p < 0.05$

Effects of Varying Resin Content

The effects of varying resin content on the mechanical and physical properties are shown in Figures 1 and 2, respectively. All the mechanical properties increase with increase in the resin content. By increasing the resin content to 4% (8 to 12%), MOR increases by about 26%, IB by 43% and SWS by 24%. The correlation analysis (Table 6) further revealed that the mechanical properties of MOR (r =0.77), MOE (r = 0.52), IB (r = 0.72), SWS (r = 0.64) and SWE (r = 0.58) increased with the increasing levels of resin content. This is obvious since at higher resin content more resin are available for inter-particle bonding thus increase the mechanical properties.

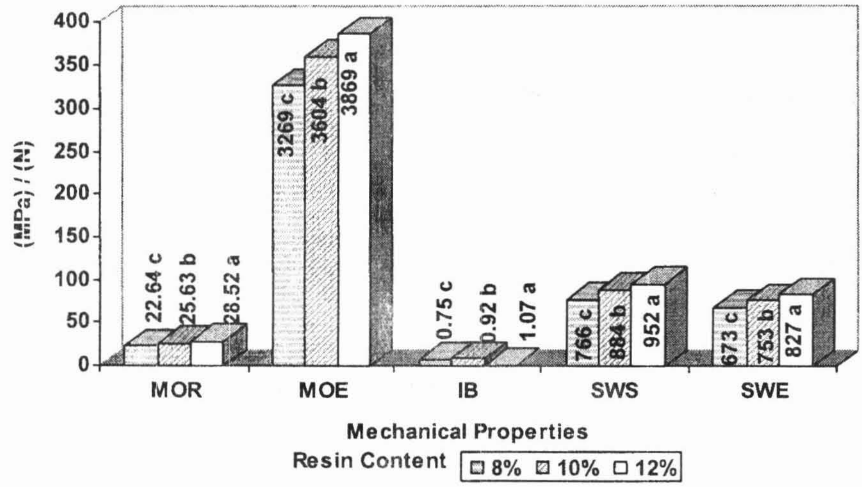

Fig. 1: Effects of Resin Content on the Mechanical Properties

Figure 2 shows that with an increase in resin content all the physical properties (water absorption and thickness swelling) decreased significantly. The correlation analysis further show that with the increase of resin content, the TS1 (r = -0.50), TS24 (r = -0.55), WA1 (r = -0.28) and WA24 (r = -0.36) decreased (Table 37). This could be explain in the sense that with the increase in resin content, more particles surface are covered by resin thus give rise to more bonding sites that hinders penetration of water and helps slowing down the thickness swelling of the boards.

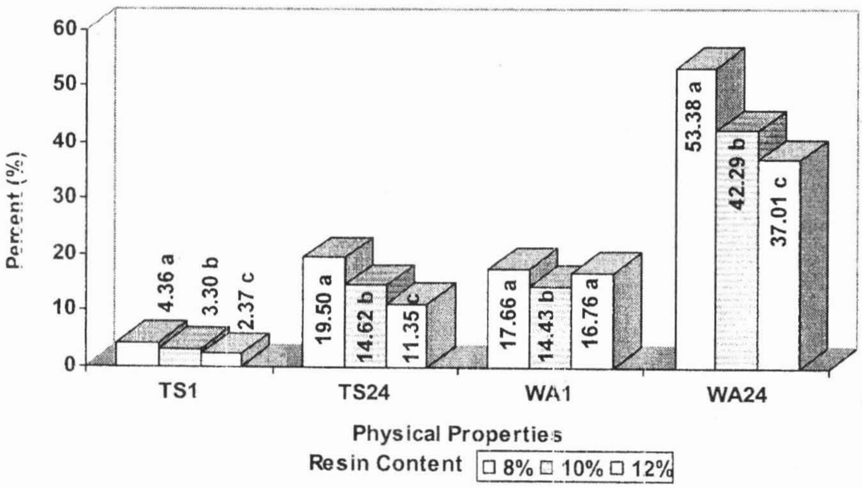

Fig. 2: Effects of Resin Contents on the Physical Properties

Effects of Particle Size

Figure 3 and 4 gives the effects of particle size on the mechanical and physical properties of the boards, respectively. An increase in PS is shown to cause a significant increase in the MOR and MOE values. The correlation analysis (Table. 6) further showed that MOR correlated significantly with PS (r=0.14). MOE on the other hand, tended to increase with larger PS (r=0.11). Higher MOR with larger PS could be attributed to the ability of larger PS to distribute stress over a larger surface area per unit weight and the increase in total glue bonded area. Internal bond, SWS and SWE, on the contrary decrease with the increment of PS (r =-0.34, -0.05 and -0.04). The higher IB and SW values of boards made with smaller PS can be due to the fact that they can intermesh well and well-bonded to give gap free boards. The internal discontinuity factor also gives the boards higher IB and SW values.

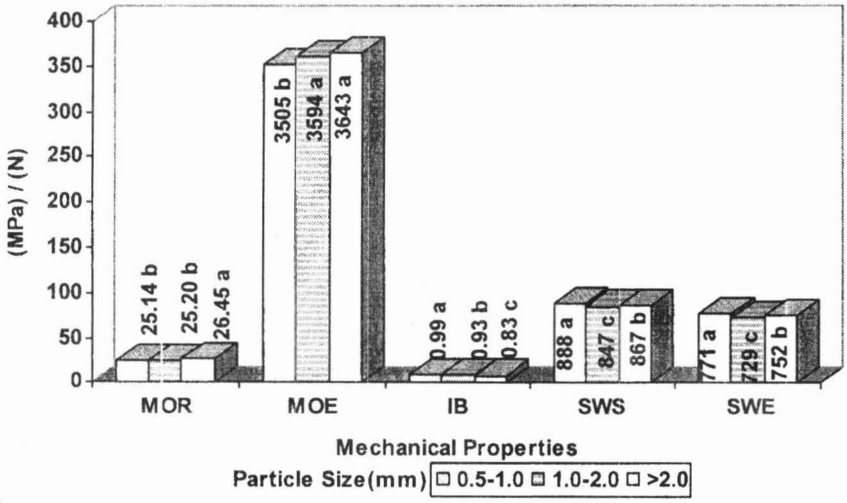

Fig. 3: Effect of Particle Sizes on the Mechanical Properties

Particle size is an important parameter in controlling the boards response to water absorption and thickness swell. Figure 4 shows the effects of particle size on this property. The PS shows a significant effect on the water absorption and thickness swelling property at $p < 0.05$. However, the correlation analysis in Table 37 showed that the TS1 (r = -0.07) and WA24 (r = 0.06) decreased insignificantly while the TS24 (r = 0.14) and WA1 (r = 0.15) increased significantly with bigger PS. The lower WA and TS values in smaller PS could probably be due to their ability to resist the uptake of water since smaller PS are more pliable and able to generate gap-free boards. With bigger PS the existence of larger voids space because of their inability to fit together as close as in smaller particles leads to easier intake of water into the board. Furthermore, since the bigger PS are higher in bending strength, the stress levels is higher and these stress, once released, would increase the water absorption capability and thus higher thickness swell. Shaikh (1991) also reported similar trends in the WA and TS properties of big particles.

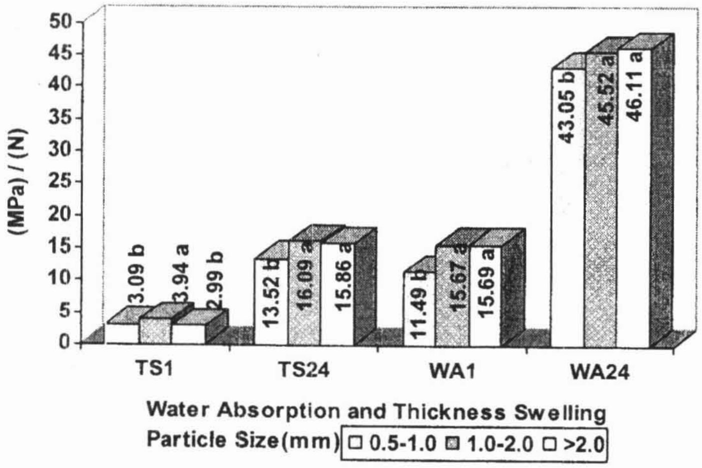

Fig. 4: Effects of Particle Size on the Thickness Swelling and Water Absorption

Effects of Wax Addition

The effects of wax on the board properties are given in Figure 5. In general, the correlation analysis (Table 6) showed that MOR, IB, SWS and SWE decreased with wax addition (r =-0.03, -0.25, -0.42 and -0.51, respectively). An addition of 1% wax was observed to decreased the MOR by 1%, IB (9.4%), SWS (10.8%) and SWE (13.8%) while the TS1 decreased by 47%, TS24 (39.8%), WA1 (72.5%) and WA24 (52.2%).The reduction in mechanical properties is probably due the resistance characteristics of wax which reduced the particles ability to bond intimately. The wax coats the particle surfaces and this greatly reduced the hygroscopic nature of the particles thus increase the WA and TS properties. Since the addition of wax is to increase the boards resistance towards exposure to water, this study shows that the dimensional stability of the boards was significantly enhanced. The reduction of mechanical and physical properties follows the trends set by the UF particleboards as discussed earlier and also follows those reported by Stegmann & Durst (1964).

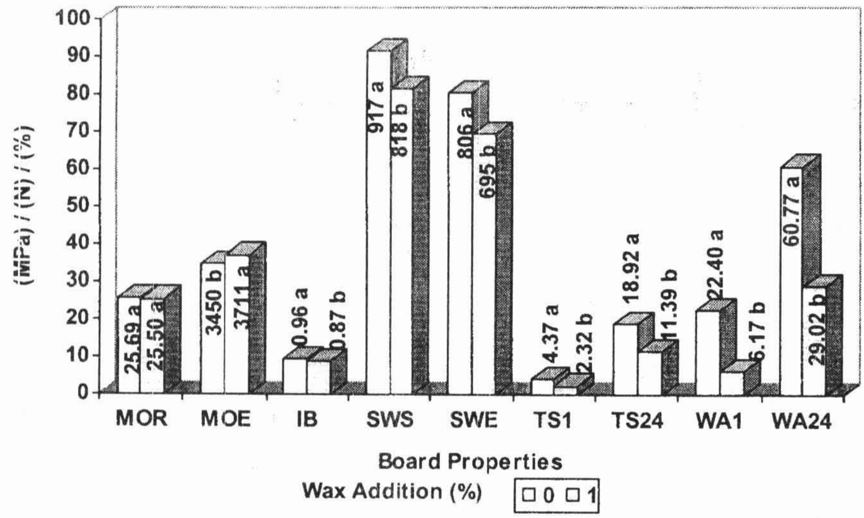

Figure 5. Effects of Wax Addition on the Board Properties.

Table 6: Correlation Coefficients of Board Properties in Relationships with bamboo Age, Particle Size, Resin and Wax Content.

Property	MOR	MOE	IB	SWS	SWE	TS1	TS24	WA1	WA24
Age	-0.16**	-0.12**	-0.01ns	0.04ns	0.23**	-0.02ns	-0.32**	-0.22**	-0.20**
Particle size	0.19**	0.11ns	-0.34**	-0.05ns	-0.04ns	-0.07ns	0.14*	0.15*	0.06ns
Resin	0.77**	0.52**	0.72**	0.64**	0.58**	-0.50**	-0.55**	-0.28**	-0.36**
Wax	-0.03ns	0.27**	-0.25**	-0.42**	-0.51**	-0.63**	-0.62**	-0.80**	-0.85**

Note : ns - not significant , * - significant at $p < 0.05$, ** - highly significant at $p < 0.01$

Conclusion

The study shows that all the board properties vary significantly with age (except for IB), varying resin content, particle sizes and wax addition. All particles from the various bamboo age groups were shown to be suitable for particleboard manufacture. However, particles from one and two year old bamboo is not recommended to be harvested as they are considered to be still juvenile, thus bamboo with the age of three and above are deemed suitable for particleboard manufacture.

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