Properties of Medium Density Fiberboard from Rubberwood and *Leucaena* in Relation to Wood Ratio and Resin Content

Nur Othman Suratman [1*], Wan Mohd Nazri Wan Abdul Rahman [2], Nor Yuziah Mohd Yunus [3], Nur Amalina Razali[4]

Faculty of Applied Sciences, Universiti Teknologi MARA (Pahang) Malaysia[1, 2, 3]
Faculty of Applied Sciences, Universiti Teknologi MARA, Shah Alam, Malaysia [4]
*nurothman@hotmail.com**

Abstract

This study used *Leucaena* and rubberwood species as the raw materials in the manufacture of medium density fiberboard (MDF). The objective were to determine the physical and mechanical properties of MDF using *Leucaena* and rubberwood and evaluate the effect of different wood ratios and resin content on board properties. Urea formaldehyde (UF) was used as a binder and target board density was 700 kg/m3. Medium density fiberboard was assessed for the mechanical (bending and internal bonding) and physical (thickness swelling) properties according to European Standard (EN 622-5:2006). Mechanical properties revealed the highest MOR value of 15.09 MPa with resin content of 12% from wood ratios of 80% Rubberwood and 20% *Leucaena*. However, the highest result for MOE is 2005 MPa and IB is 0.7 MPa obtained from wood ratios of 20% Rubberwood and 80% *Leucaena* with 12% resin content. For the physical properties wood ratio with 80% Rubberwood and 20% *Leucaena* and 12% resin content had the best TS value with 21.59%. The results revealed that wood ratio and resin contents shows significant effect on board mechanical properties of MOR, MOE and TS values. However, IB values shows no not significant effect for wood ratio combination.

Keyword: *Rubberwood-Leucaena-Ratio, Medium Density Fibreboard, Urea Formaldehyde Resin Content*

1. INTRODUCTION

Nowadays the growth of timber sector in Malaysia is slowed. According to Abdul Rahim (2012) from 1990 to 2007, timber production from natural forest in Peninsular Malaysia, Sabah and Sarawak has been decreased and there is stricter law enforcement of forest harvest control imposed by Malaysian government. Besides that, most of the forest plantation area in Malaysia had been turned to agricultural purposes such as oil palm plantation and for construction area (Olaniyi, 2012). This situation had negatively affected many wood-based entrepreneurs in Malaysia. The management of the wood-based production need to have a back-up plan to keep the raw material stable and sustainable. Based on Malaysian Timber Industry Board (2005) eight species had already been identified as potential wood resources. This includes Rubber tree, Binuang tree, Kelempayan tree, Teak tree, Sentang tree, Batai tree, Laran tree and Acacia tree. Target is to ensure that raw materials of timber related production is always sufficient for products manufacture.

In Malaysia, currently Rubberwood is one of the popular species used in the wood industry such as medium density fiberboard (MDF). According to Blasiger (2008) Rubberwood have natural light colour, making it more desirable in making a product. Recently, Rubberwood volume has been decreasing as, upon felling, its' plantation area has been replaced by Oil Palm (Noraini, 2001). A new fast growing species must be discovered to sustain the demand from the wood industry. *Leucaena* or Petai belalang is one of the fast-growing species that has the potential to be one of the raw materials in wood industry (Himli Ab Rahman, 2012). *Leucaena* is a multipurpose species that have potential in the tropic region (Vietmeyer, 1977).

This study resulted from the needs of the wood industry to find alternative material that can help the industry to continue producing products at reasonable cost. Therefore, MDF products from fast growing tree are needed to supplement or reduce impact from shortage of Rubberwood raw material and other solid wood sources. This study aims at determining the physical and mechanical properties of MDF from Rubberwood and *Leucaena*. It also will evaluate the effect of resin content and wood ratio of fiber on MDF properties.

2. MATERIAL AND METHODS

The *Leucaena* tree was harvested from Sabah Softwood Forest reserved. The tree age is approximately 5 years old. The tree were felled, cut to 1.5 m length logs and transferred to the UiTM wood industry workshop. Sawmill sawdust was used from wood shaving, wood sawing and wood cutting, from surface planning machine, thickness planning and straight line ripe saw. Both *Leucaena* and sawmill waste were sent to FRIM for fibre making. The Rubberwood was obtained from Dongwa Merbok Sdn Bhd. The resin used was commercial urea formaldehyde (UF) with ammonium chloride (NH_4Cl) as hardener. The fibres were air-dried for duration of 7-9 days and then oven-dried for 24 hours at 80°C to achieve moisture content of below 5 %. The MDF dimensions were 340 mm x 340 mm x 12 mm with a target density of 700 kg/m^3. The fibres were sprayed with UF resin in a particleboard mixer at three resin dosages of 8%, 10% or 12%. Hardener of 3% was added to all formulations. Air pressure at hydraulic pressure 0.4 MPa atomized the resin into mixer until the fiber was completely blended. Hands forming were used to lay the fibers in a forming box and pre-press done at pressure of 300-500 psi for 30 seconds before being hot pressed for 6 minutes at 165°C. All boards were conditioned in a conditioning room maintained at 20 ± 2°C and relative humidity (65 ± 5) %.

The test pieces were prepared according to EN 622-5:2006 in order to determine the modulus of rupture (MOR), modulus of elasticity (MOE), internal bonding (IB) and thickness swelling (TS). The effect of variables on the properties of the board was assessed by Analysis of Variance (ANOVA) and Duncan Multiple Range test was used for comparison of the average values.

3. RESULTS AND DISCUSSIONS

Summary of physical and mechanical of properties of MDF from *Leucaena* and Rubberwood are presented in Table 1.

Table 1: Mechanical and physical properties of LW and RW MDF

RATIO	RC	MOR (MPa)	MOE (MPa)	IB (MPa)	TS (%)
RW80:LW20	8	14.23	1944	0.31	43.22
RW80:LW20	10	15.05	1976	0.55	23.26
RW80:LW20	12	15.09	1980	0.67	21.59
RW50:LW50	8	8.89	1510	0.28	44.21
RW50:LW50	10	11.97	1908	0.48	30.02
RW50:LW50	12	13.37	1855	0.59	22.93
RW20:LW80	8	6.70	1011	0.39	34.72
RW20:LW80	10	10.84	1531	0.42	34.46
RW20:LW80	12	14.59	2005	0.70	26.88
EN 622-5:2006 GP - dry		22	2500	0.60	<15

Notes: RC: Resin Content, MOR: Modulus of Rupture, MOE:
Modulus of Elasticity, IB: Internal bonding, TS: Thickness swelling, RW: Rubberwood and LW: Leucaena, GP: General Purpose

Apart from the IB value (0.67 MPa) for RW80:LW20 and RW20:LW80 (0.7 MPa) with 12 % resin all other board treatments did not achieve the requirement of MOR, MOE, IB and TS for general purpose, dry EN 622-5 2006. As such further discussions will look at the ratio trends and behavior for the MDFs made. Meanwhile, the interaction between ratio and resin has significant effect.

3.1 Effect of resin content

3.1.1 Mechanical Properties

The comparison for effect of resin contents on MDF panel MOR, MOE and IB on are shown in Figure 1. The results shows that MOR a trend for MDF at 12 % resin content (14.35 MPa) being higher than 10 % resin content (12.62 MPa), and both dosages higher than 8 % resin content (9.94 MPa). The increase of resin content in MDF also increased the MOR significantly. The increase in resin content enable better resin distribution as the glue to substrate contact can be enhanced.

The hybrid MDF with 12 % resin content exhibited highest MOE value of 1946 MPa when compared to hybrid MDF from 10 % resin content (1805 MPa) and 8 % resin content (1488 MPa). All values differences are highly significant.

The IB strength shows MDF with 12% resin exhibit the highest value (0.65 MPa, passed EN general purpose - dry). The results were 35 % and 100 % higher than the 10 % and 8 % resin dosages respectively. The results were significant at P<0.05. This might be due to increase of the resin content in the board which gave more intimate contact for bonding. Nourbakhsh (2008) reported increased MOR, MOE and IB with increasing of resin content. Similarly, Jahanshahi (2011) found that the mechanical properties of panel increase were influenced by the resin content and board has more strength when more resin is added.

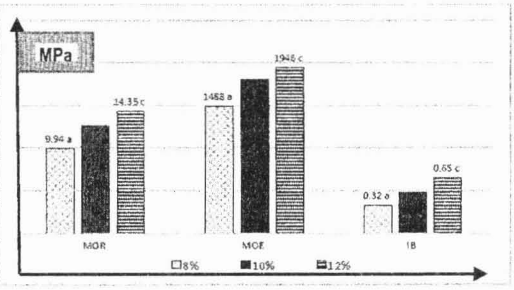

Figure 1: Effect of resin content on mechanical properties

3.1.2 Physical Properties

Value of TS and effect of significant of MDF for resin content is shown in Table 2. The MDF produced with 8 % resin gave the highest TS followed by 10 % and 12 % resin. The relationship of TS to resin content is inversely proportional and is significantly different. This might be due to insufficient UF resin for fiber in the composite. According to Jenkins, (2006), the "spring back" increases when the amount of resin used is not sufficient. "Spring back" occurs either when bonding contact area is low or when raw material used has low density and can lead to expansion of board, thus higher TS.

Table 2: Effect of resin content on physical properties

RESIN CONTENT (%)	TS (%)
8	40.72 b
10	29.24 a
12	23.8 a

Notes: a = lowest significant, b = moderate significant, c = highest significant

3.2. Effect of wood ratio

3.2.1 Mechanical Properties

Figure 2 shows the value of MOR, MOE and IB of hybrid MDF produced from RW80:LW20, RW50:LW50, and RW20:LW80. The value of MOR for MDF from RW80:LW20 (14.79 MPa) is higher than RW50:LW50 and RW20:LW80 (11.41 and 10.71 MPa respectively). While, hybrid MDF from RW80:LW20 exhibit the highest value of MOE (1967 MPa) as compared to hybrid MDF from RW50:LW50 (1758 MPa) and RW20:LW80 (1516 MPa).

The higher MOR and MOE by hybrid MDF produced from RW80:LW20 is due to the sufficient stress transferred from fiber to enable fiber to be ultimately fractured, thus giving higher bending properties. According to Khalil (2010), Rubberwood fibre can withstand heavy load and this lead to higher results for composite with higher Rubberwood ratio. MOR of RW50:LW50 and RW20:LW80 are not significantly different. This might occur due to poor fibre refining quality. According to Mannheim (2013), fibre processed by thermo mechanical pressure give higher potential for bonding between fibre and adhesive.

MDF of RW80:LW20 exhibited the highest value of IB strength (0.51 MPa) when compared to RW50:LW50 (0.45MPa) and RW20:LW80 (0.50 MPa). This might be due to the difference of wood ratio as reported by Paridah, (2000) for fibres from heterogeneous MDF having different properties. The IB results is however not difference significantly..

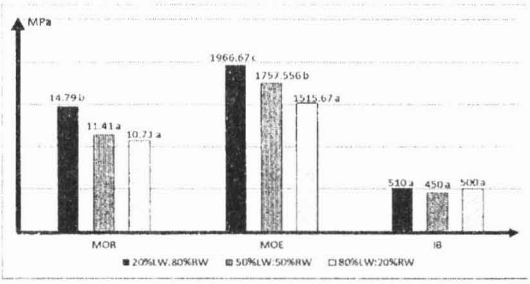

Figure 2: Effect of ratio on mechanical properties

3.2.2 Physical Properties

Effect of TS from the MDF produced from Rubberwood and *Leucaena* is shown in Table 3. Based on the results, MDF produced from RW50:LW50 showed the highest TS compared to the other two combinations. Distribution of UF resin and fiber in the composite which results in the formation of fiber lump may cause this. Besides that, this phenomenon could be due to the properties of rubberwood fiber. According to Khalil (2010), rubberwood fiber had the lower content of the free hydroxyl group in the fibre. Therefore, RW80:LW20 has low TS because Rubberwood fibre is more stable towards water.

Table 3: Effect of ratio on physical properties

RATIO	TS (%)
RW80:LW20	29.35 a
RW20:LW80	32.02 b
RW50:LW50	32.39 b

Notes: a = lowest significant, and b = highest significant

4. CONCLUSIONS AND RECOMMENDATIONS

The mechanical and physical properties of MDF made from Rubberwood and *Leucaena* in at various wood ratios and resin content was studied. MDF panel from Rubberwood and *Leucaena* using 12 % resin content provide higher strength but is still not significantly different from 10 % resin content. Wood ratio of 80 % Rubberwood and 20 % *Leucaena* gives the best properties of MOR (915.09 MPa) and TS (21.59 %). For MOE and IB, the wood ratio of 20% Rubberwood and 80% *Leucaena* obtain the best value of 2005 MPa and 0.70 MPa respectively. Lastly, the effects of resin content and wood ratio for all properties are highly significant except for IB value.

Further work involving resin formulation, optimization of fiber formation and board making parameters are needed for this hybrid MDF before any combination can be recommended.

Acknowledgements

I would to thank my parents Mr Suratman Sukar and Mrs Tiah Ming for their support and UiTM Jengka staffs Mr Mohd Sharil Izanie Abdullah, Mr Khairilanuar Zainol and Mr Nazrie Mustafha for helping in the harvest and cutting the *Leucaena* tree. Special gratitude to Sabah Softwood Bhd and Dongwa Merbok Sdn Bhd.

REFERENCES

Abdul Rahim, A. (2012). Sustainable Forest Management Policy and the Analysis of Convergence Effects on Timber Production. *Forest Policy and Economics*. Pp60-64

Blasiger, J.J. (2008). Asia Pacific Sector: The Utilization Processing and Demand for Rubberwood. Wood Supply FOA Bangkok. Pp 1-14

European Standard EN 622-5 (2006): Fiberboard. General Purpose – Dry

Himli Ab Rahman, W. M. (2012). *Leucaena Luecocephala* a Fast Growing Tree for Malaysian Wood Based Industry. Universiti Teknologi MARA. Pp1-13

Jahanshahi, T. T. (2011). Mechanical and Physical Properties of Wheat Straw Boards Bonded with A Tannin Modified Phenol-Formaldehyde Adhesive. Composites part B. Pp176-180

Jenkins, B.M.(2006). Properties of Medium-density Fibreboard from Saline Anthel Wood. *Industrial Crops and Products*. Pp318-326

Khalil, H. P. (2010). Development and Material Properties of New Hybrid Medium Density Fibreboard from Empty Fruit Bunch and Rubberwood. *Materials and Design*. Pp 4229-4236

Malaysian Timber Industry Board, MTIB (2005). Development of Forest Plantation Programme Malaysia : MTIB

Mannheim, A. S. (2013). Influence of Refinery Fibre Quality. Composite Part A. Pp245-257

Nourbakhsh, A. A. (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. *Industrial Crops and Products*. Pp 225-230

Noraini. (2001). Supply And Demand Of Timber Wood Based Panel Industries In Malaysia . Forest Reseach Institute Malaysia , Pp1-7

Olaniyi, A. A. (2012). Assessment of Drivers of Coastal land use Change in Malaysia. *Ocean & Coastal Management*. Pp113-123

Paridah, T. (2000). Finishing System for Oil Palm EFB Medium Density Fibreboard. *Industrial Crop and Product*, Pp127-132

Vietmeyer, N. C. (1977). Leucaene Promosing Forage And Tree Crop For The Tropics. U.S National Academy Of Science, p80