Leucaena Particleboard: A Commercial Trial

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In Malaysia, the depletion of raw materials has begun to impact mills, as their production could decrease or cease. This will impact the Malaysian wood-based economy, both locally and globally. Usage of trees with fast-growing characteristics is essential to add feedstock sources to mills. This study investigated the mechanical properties (MOR, MOR, IB, and screw withdrawal) of particleboard (density = 660 kg/m^3) made of *Leucaena leucocephala*, rubberwood, and mixed tropical trees with different species ratios. The wood species ratios for the particleboards were 100% *Leucaena*, 50% *Leucaena* and 50% rubberwood, and 50% rubberwood and 50% mixed tropical wood. Boards with the dimensions 3680 mm × 2465 mm × 25 mm were produced. The results showed that all of the species ratios passed the minimum requirements for commercial use. The performance of the *Leucaena* particleboard was 17.40 MPa (MOR), 2654 MPa (MOE), 0.68 MPa (IB) and 623 N (Screw withdrawal). The *Leucaena* board performance matched that of the board made from the current raw materials used commercially (mixed tropical wood and rubberwood).

Keywords: Particleboard; Leucaena leucocephala; Mechanical properties; Rubberwood

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INTRODUCTION

Wood composites are described as any material that contains wood that is bonded by an adhesive to produce a product, such as particleboard, plywood, oriented strand board, fiberboard, and other boards (Bal and Bektas 2014). Particleboard is a wood composite that consists of various shapes and sizes of lignocellulosic material bonded together with an adhesive. During manufacturing, a loose mat is consolidated with pressure and heated into a panel (Sarmin *et al.* 2013). Particleboard is also manufactured by utilizing low-grade logs, twisted logs, slabs, cracked logs, and other similar materials. The utilization of these types of source materials can minimize waste from log mill manufacturing (Abdolzadeh and Doosthoseini 2009).

Malaysia is one of the largest global exporters of timber and wood composite products, including furniture, plywood, sawn timber, particleboard, and other products (Malaysian Timber Industry Board 2015). However, the increase in wood consumption has strained the forest reserve, thus causing a yearly decline in resources. These issues have led to some particleboard manufacturers utilizing waste residues from other mills. Another option to meet the demand is to study fast-growing species. *Leucaena leucocephala* is a fast-growing species with short rotation cycles of approximately 2 years (Rahman *et al.* 2017). This tree species can be used for particleboard, pulp, and as a biomass source. It can be used as an alternative wood source in the wood industry (mainly for particleboard) because of the decrease in the rubberwood supply. *Leucaena leucocephala* is similarly bright and creamy in color, and the wood density is higher than that of rubberwood. Earlier research on *L. leucocephala* in particleboard was promising (Rahman *et al.* 2018). Conversion from a laboratory scale to a commercial trial of *L. leucocephala* will help validate the performance of new products and identify the needs of further study into the processing parameters. This will help to decide whether to launch new products, guide production plans, and estimate optimum stock levels. New products, such as *L. leucocephala* boards, will encourage sales and retailer support, which provide benchmarks for sales targets (Wright and Stern 2015). This study investigates a commercial trial on the suitability of producing particleboard from *Leucaena leucocephala* wood with parameters defined by the industry standards.

EXPERIMENTAL

Materials

Leucaena logs were obtained from roadside, residential, and abandoned areas in the municipality of Kuantan, Malaysia. Meanwhile, the rubberwood was obtained from smallholders, and the mixed tropical wood was sourced from sawmill waste generated from the current commercial raw material used in mills. The diameter of the *Leucaena* logs was 6 cm to 25 cm, while the rubberwood diameter ranged from 10 cm to 30 cm. The wood material was crushed using a chipper machine, which was followed by flaking to produce wood particles. The particles were dried to a moisture content of less than 2%.

Methods

Manufacturing process

During particleboard production, the *Leucaena* wood boards were compared with the current commercial materials. The wood species ratios for the particleboards were 100% *Leucaena* (L), 50% *Leucaena* and 50% rubberwood (LR), and 50% rubberwood and 50% mixed tropical wood (RMT). The boards were prepared with the dimensions 3680 mm × 2465 mm × 25 mm. Each board contained three layers. The face and back layers consisted of smaller particles than in the core layer. The particleboard density was 660 kg/m^3, which was based on the commercial industry standard. The particles were mixed with urea formaldehyde resin at 9% for face layer and 6% for core layer. The mixed particles were placed in a mat forming press for three-layer formation, and then were pre-pressed and hot pressed on contentious press for 45 seconds to 55 seconds with ranging temperature of 175 °C to 215 °C. After that, the boards were trimmed and allowed to cool. A total of 280 m^3 boards were produced for 6 hours operation. A ready board was trimmed to 1820 mm × 2430 mm and sanded to a 25-mm thickness (Fig. 1).

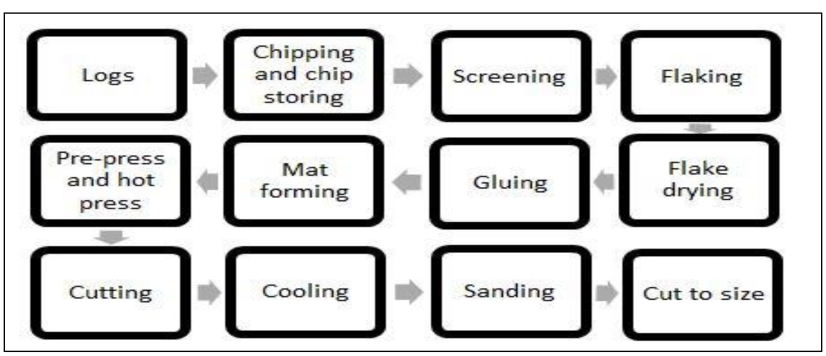

Fig. 1. Process of manufacturing particleboard

Samples for testing

The particleboards were cut to specific sizes for the modulus of rupture (MOR), modulus of elasticity (MOE), internal bond (IB), and wood screw holding tests, which were conducted according to European standards (EN 310 1993; EN 319 1993). The samples were cut to the dimensions 30 cm × 5 cm × 2.5 cm for the bending test, and the dimensions 5 cm × 5 cm × 2.5 cm for the IB and screw withdrawal tests. The factors affecting particleboard manufacturing were analysed with an analysis of variance (ANOVA) and Duncan's multiple range test (DMRT) using the IBM Statistical Package (Armonk, NY, USA) to determine their influence.

RESULTS AND DISCUSSION

Mechanical Properties

Table 1 shows the mean values of the MOR, MOE, IB, and screw withdrawal of the different species ratios. The particleboard with the L ratio exhibited the highest MOR (17.40 MPa) and MOE (2654 MPa). The lowest average bending strength was demonstrated by the RMT-containing combination, with a MOR of 11.20 MPa and MOE of 2256 MPa. Meanwhile, the L ratio had the highest IB (0.68 MPa) with a screw withdrawal value of 623 N, while the RMT combination had the lowest IB of 0.39 MPa and a screw withdrawal value of 534 N.

Table 1. Mechanical Properties of the Particleboards

Species Ratio	Bending Strength (MPa)		IB (MPa)	Screw Withdrawal (N)
	MOR	MOE		
L	17.40 a	2654 a	0.68 a	623 a
LR	16.10 a	2568 ab	0.60 b	560 ab
RMT	11.20 b	2256 b	0.39 c	534 b
EN Standard	**11**	**2300**	**0.40**	**-**

Means with the same letter are not significantly different.

Statistical Significance

The ANOVA results for the effect of the species ratio on the mechanical properties are shown in Table 2. The species ratio was found to significantly affect the MOR, MOE, IB, and screw withdrawal.

Table 2. Summary of the ANOVA of the Mechanical Properties

SOV	Df	Bending Strength		IB (MPa)	Screw Withdrawal (N)
		MOR (MPa)	MOE (MPa)		
Species Ratio	2	14.61**	4.20**	70.04**	4.40**

SOV = Source of variance; Df = Degree of freedom; and ** = Highly significant

Effects of the Species Ratio

The MOR and MOE are important for determining the particleboard strength. The DMRT results showed that the MOR values of the L and LR ratios were significantly different from that of the RMT ratio (Fig. 2). This might have been because of the higher wood density of *Leucaena*. A higher density tends to influence the packing factor during board formation. A better packing normally translates to better contact between the particles. Thus, the wood density contributed to the board strength (Babatunde *et al.* 2008).

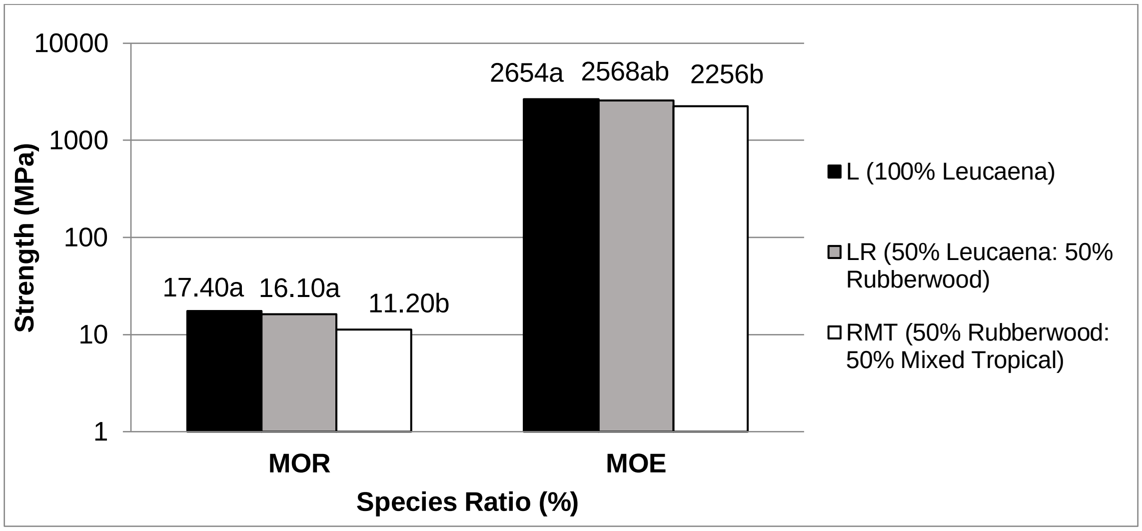

Fig. 2. DMRT results of the bending of the MOR and MOE for the different particleboard species ratios

Figure 3 shows the effect of the species ratio on the IB of the boards. Boards with the L ratio had a higher IB value than the LR and RMT ratios with significant differences in the bonding properties. The R ratio performed better in terms of bonding between the particles, which was ascribed to a good compaction ratio in the board. Boards with good compaction ratios tend to have more closed structures (Iwakiri *et al.* 2014).

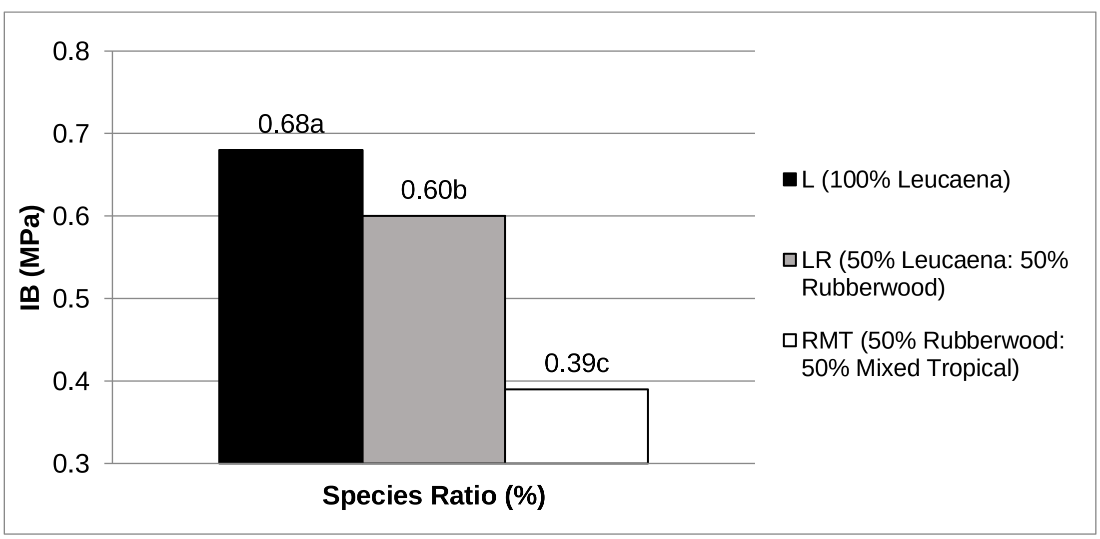

Fig. 3. DMRT results of the internal bond (IB) for the different particleboard species ratio

Figure 4 shows the effects of the species ratios on the screw withdrawal of the boards. It was found that there was no significant difference between the L and LR ratios. However, there was a significant difference between the L and RMT ratios. The 16% improvement in the screw withdrawal for the L ratio compared with the RMT ratio indicated a better board compaction. This was corroborated by the higher IB (Fig. 3).

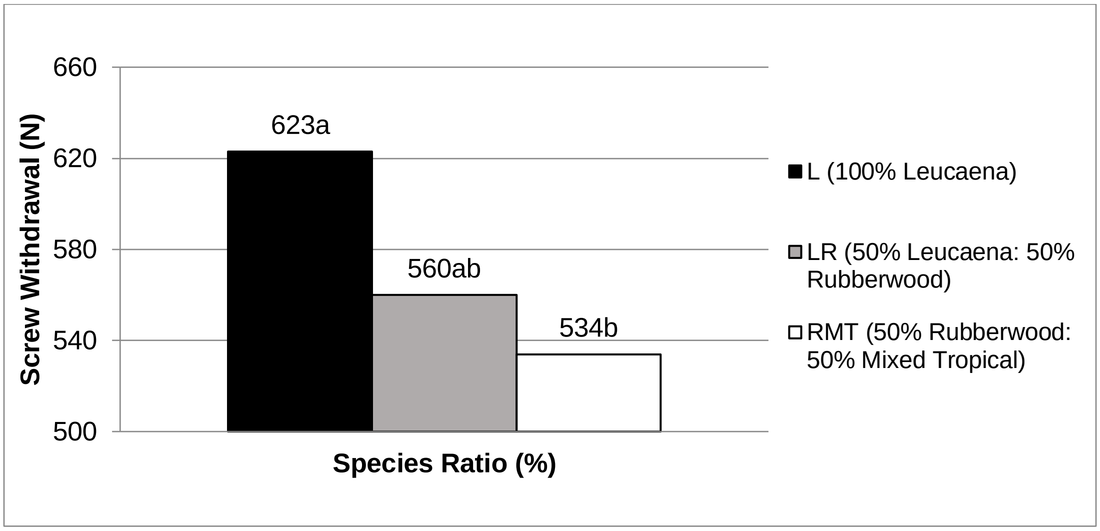

Fig. 4. DMRT results of the screw withdrawal for different particleboard species ratio

CONCLUSIONS

1. The particleboards that utilized *Leucaena* wood at ratios of 100% and 50% had promising results compared with the existing commercial board.
2. The performance of the particleboard made with 50% *Leucaena* met the minimum requirements and surpassed the results of the current commercial product. The results demonstrated that *Leucaena* wood is suitable for use as a raw material in particleboard manufacturing.

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