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The characteristics, properties and uses of plantation timbers – rubberwood and *Acacia mangium*

by

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Introduction

Rubber trees (*Hevea brasiliensis*), which were introduced into Malaysia more than a century ago, have contributed tremendously to the social and economic well being of the country. Generally, the rubber trees start to decline in the latex production after 25 to 30 years of age. At 25 years, rubber trees normally have a clear bole of 3 to 10 m depending on the clones and the location of growth. The diameter of rubber trees could reach 50 cm at breast height. For logistic and ease of extraction, rubberwood logs are in short length of about 1.8 m.

Rubber tree plantations (Figure 1) have a striking appearance in that the trees are mostly leaning and sometimes haphazardly in all possible directions giving rise to rather unbalanced crown structure, with few branches and bent in order to get to the maximum sunlight. The genetic, environmental conditions and the nature of growth are likely to cause the occurrences of tension wood and growth stresses, which in turn, affect the wood quality, characteristics, utilisation and recovery.

Acacia mangium, a species of the family Leguminosae, was first introduced into Sabah in 1967 as fire-break species. It was subsequently introduced into Peninsular Malaysia via the Compensatory Forest Plantation Programme (CFPP) in 1982. To date, a total of 51,768 ha of *Acacia mangium* had been planted in Peninsular Malaysia, mainly in the states of Johore, Negeri Sembilan, Pahang, and Selangor (Ho *et al.* 1999). *Acacia* species normally demand full light for good development and may be stunted when grow in shade. Generally, *Acacia* trees are renowned for their robustness and adaptability, which makes them good plantation species. As *Acacia mangium* has a strong tendency to produce multiple leaders from the base, 'singling' should be carried out during the early stage of growth. Regular pruning of branches is only necessary where the objective is to produce quality saw or veneer logs (Arentz *et al.* 1995).

Characteristics of rubberwood and *Acacia mangium*

Rubberwood

As the trees normally have low branching, it is not possible to obtain rubber logs with long length (Figure 2). Sapwood is not distinct from the heartwood. The wood is white to pale cream, weathering to light straw or light brown. Planed surface not particularly lustrous. Growth rings figure on tangential surface simulated by the banded wood parenchyma. Texture is moderately coarse to coarse. Grain straight to interlocked. Characteristic smell of latex on freshly sawn material. Very often, sawn rubberwood may contain a layer of bark or bark pocket as a result of poor tapping practice where the cambium cells had been damaged or completely removed. Tension wood is commonly present in the rubberwood (Lim & Ani 1999).

Figure 1 A typical rubber plantation

Figure 2 Rubber logs

Acacia mangium

The logs of *Acacia mangium* when taken from well-pruned trees can be quite straight making processing easy (Figure 3). Sapwood is pale yellow to straw-coloured and distinct from the heartwood which is light to dark brown. Planed surface not particularly lustrous. Growth rings indistinct or absent. Texture fine to moderately coarse and even. Grain usually straight, sometimes interlocked.

Figure 3 *Acacia mangium* logs

Properties

Density

Wood density is by far the most useful parameter for measuring wood quality. It is positively correlated to mechanical strength and shrinkage of timber. The density of rubberwood ranges from 480 to 650 kg m^{-3} depending on their age and possibly due to their clonal variation. For *Acacia mangium*, however, the density ranges from 290 kg m^{-3} to as high as 675 kg m^{-3}. Generally, the density of wood tends to increase with age for both the rubberwood and *Acacia mangium* (Table 1).

Table 1 Density of rubberwood and *Acacia mangium*

Rubberwood			*Acacia mangium*		
Age	Clone	Density (kg m^{-3})	Age	Source/Site	Density (kg m^{-3})
n.a.	n.a.	640	2	FRIM	421
n.a.	n.a.	560-640	5	Batu Arang, Selangor	290-500
20	RRIM 623	586-609	6	Ulu Sedili, Johor	340-500
3	PB260	508-547	8	Ulu Sedili, Johor	350-580
8	PB260	526-565	8	Indonesia	530
14	PB260	503-553	9	Sabah	389-535
8	RRIM600	480-603	9	Sabah	420
24	RRIM600	560-625	9	Sabah	483
29	RRIM600	565-650	12	FRIM	570
29	RRIM600 (branch wood)	555-635	14	FRIM	467-675

n. a. - not available

Tension Wood

The occurrence of tension wood (Figure 4) is a common phenomenon in rubberwood. It is commonly found in branches, leaning stem or in consequence of exposure to prevailing wind direction. It is often associated with eccentric pith. Generally, the eccentric pith is nearer to the lower side, with the tension wood occurring above the pith (i.e. on the wider side of the two radii of the cross section of the log). However, observations made on Malaysian rubberwood logs indicated that tension wood may be in the form of concentric or crescent-shaped zones distributed in random throughout the crosssection of the stem.

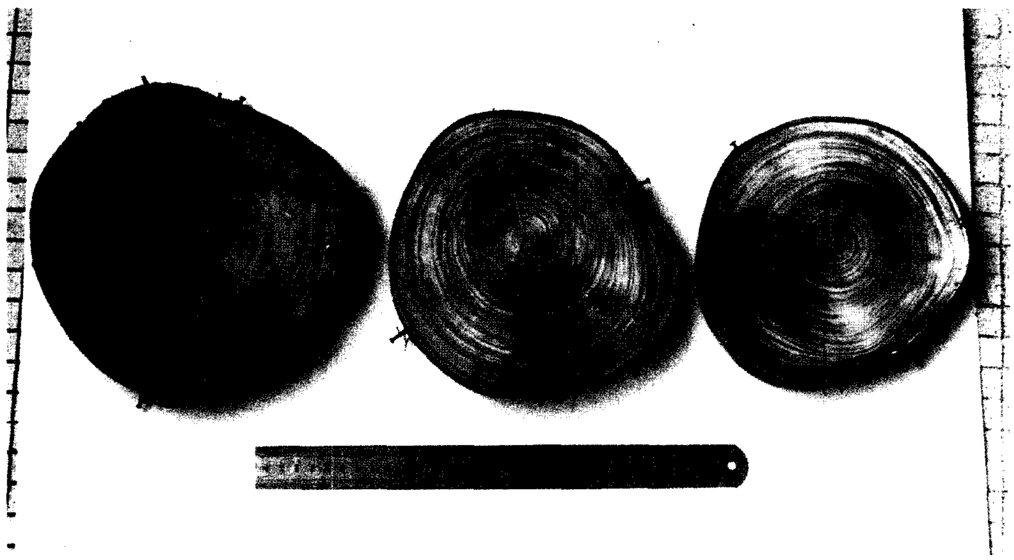

Figure 4 Rubberwood with tension wood (light-coloured zones)

The characteristics of tension wood as compared with normal wood have been summarized by Zobel and Buijtenen (1989) as follows:

- fewer and smaller vessels with slightly longer fibres than normal wood
- lignin content may vary from low to normal, while cellulose content is high
- contains gelatinous-layers (not lignified)
- specific gravity often higher

The occurrence of tension wood in rubberwood has given rise to problems in utilization. Some of the problems are:

- saws and cutter tools get blunted fairly easily
- rough and woolly formation on surface due to partly-torn fibres rather than cut cleanly
- abnormally high longitudinal shrinkage during drying causing distortion in the form of bow, spring or twist
- dried boards may suffer further distortion like splitting because of stresses set up during drying

Generally, the proportion of tension wood varies from tree to tree and possibly from clone to clone. The proportion of tension wood has been recorded by Lim and Ani (1999) as per Table 2.

For clone PB 260, the percentage of tension wood appeared to increase with height whereas for clone RRIM 600, it is just the reverse in most cases. In term of age, high percentage of tension wood (more than 40%) can still be obtained for the 14-year-old rubberwood of clone PB 260. For RRIM 600, on the other hand, tension wood appeared to decrease with the increase in age.

Table 2 Percentage of tension wood in rubberwood at various ages and tree heights

Age	Clone							
	PB 260				RRIM 600			
	B	M	T	Mean	B	M	T	Mean
3	35	40	57	44	-	-	-	-
8	27	29	37	30	42	33	25	33
14	49	36	52	45	-	-	-	-
24	-	-	-	-	39	29	25	30
29	-	-	-	-	25	30	30	28
29*	-	-	-	-	24	24	20	22

B=bottom; M=middle; T= top
* branch wood

The proportion of tension wood in *Acacia mangium* has not been documented. Local millers have yet to encounter processing problems associated with the tension wood which may probably due to the insignificant occurrence of the tissue. However, it has been reported elsewhere that there is a certain degree of tension wood found in all the plantation-grown timber (Zobel & van Buijtenen 1989).

Drying

Rubberwood can be dried fairly easily using the kiln schedules RW1 (Table 3) for board thickness of less than 30 mm as recommended by FRIM. By using this schedule, boards of 30 mm thick take approximately 7–9 days to dry from green or immediately after chemical treatment to final moisture content of between 8 and 10%. For 55 mm thick boards, it takes about 12–15 days, inclusive of miscellaneous kiln treatments. Rubberwood is generally prone to warping during drying but can be minimized by a 'warp-relief treatment' where both the dry-bulb temperature and wet-bulb temperature are raised to 85 $_o$C and maintain for a period of about 8 hours. Shrinkage from green to air dry is quite low with tangential and radial shrinkages average 1.9% and 0.8% respectively. The kiln dried timber has relatively low 'movement' which provides good dimensional stability of finished products. It is recommended that kiln dried dimension stocks should be box-stacked and wrapped with plastic sheets to minimize the re-absorption of moisture due to the 'hygroscopic' nature of the timber. Good drying of rubberwood is governed by (a) proper stacking of the boards (b) the application of weight on the drying stack and (c) follows the recommended drying schedule.

Table 3 Recommended kiln drying schedules for rubberwood (Schedule RW1)

Moisture content at start of step (%)	DBT ($_o$C)	WBT ($_o$C)	EMC (%)
Green	40.5	38	17.5
60	40.5	37	16.0
40	40.5	35.5	13.5
35	43.5	36	11.0
25	51.5	38	7.0
20	60	40.5	5.3
15	65.5	44.5	5.0

DBT – Dry bulb temperature
WBT – Wet bulb temperature
EMC – Equilibrium moisture content

Acacia mangium dries slowly and has the tendency to distort. The schedule below (Table 4) is recommended for boards of dimension around 30 x 110 mm. Owing to its highly refractory nature, application of steaming at 50oC for at least twenty four hours is recommended prior to the kiln drying proper. For pieces containing heart rot, collapse may occur. Thus, it is recommended that an air drying (under shed) period of about 3 weeks should be undertaken before the commencement of actual kiln drying. Other drying defects include spring and bow. Shrinkage is very high with tangential and radial shrinkages average 6.4% and 2.7% respectively. Movement in service is classified as medium.

Table 4 Recommended drying schedule for *Acacia mangium*

Moisture content(%)	DBT ($_o$C)	WBT ($_o$C)	EMC (%)
Green	45	42.5	17.0
90	45	41.5	15.8
80	50	43	11.2
70	50	41	10.0
50	54	42	8.0
40	59	40	5.8
30	65	40	< 5.0

Preservative treatment

Rubberwood: Both rubber logs and sawn rubberwood are extremely susceptible to staining fungi as well as insect attack. Thus, if there is any delay (which should not be more than 2-3 days) in conversion or processing, chemical preservatives containing a fungicide and an insecticide could be applied by spraying or end coating the logs for temporary protection. Another method which protects the rubberwood temporary is by dipping the board in a mixture of fungicide and insecticide. For long term protection, treatment processes such as the conventional Bethell process using borax compound is used.

Acacia mangium: the timber is susceptible to both fungal and insect attack and therefore, needs to be protected to prolong its service life. The timber is reported to be easily treated with preservative. Peh and Khoo (1984) reported that satisfactory loading and penetration of preservative even though the timber contains higher than normal moisture content. Treatment methods use for rubberwood can also be applied in the *Acacia mangium* timber.

Working properties

Rubberwood: Generally, rubberwood has good machining properties and it has been reported to resaw and cross-cut easily. The timber planes easily and the finish is smooth. Due to the presence of tension wood in most rubberwood, woolly surface may be present, particularly on the quarter-sawn material and this can be overcome by optimizing cutter tools angle and for the semi-finished products, by appropriate applications of sanding sealer and finished coatings.

Acacia mangium: The timber has been reported to plane, shape, bore, mortise and turn with excellent surface finish. Trial production of furniture for commercial production has found that planning, turning and spindle moulding are easy with little tearing. Sanding is easy and smooth surface can be achieved. The timber takes stain well with little requirement for filler. The timber can be laminated well.

Mechanical properties

The comparative mechanical properties of both *Acacia mangium* and rubberwood have been evaluated and their results are shown in Table 5.

Table 5 Mechanical properties of *Acacia mangium* and rubberwood

No	Properties	*Acacia mangium*			Rubberwood	
		Tested in FRIM*** Near to (away from) heart rot (16.5 - 17.5 % m.c.)	Green* (118.9% m.c.)	Air-dry* (15.5% m.c.)	Green** (52.0%)	Air-dry** (17.2%)
1	Modulus of rupture (MPa)	117.9 (118.7)	37.8	58.4	58	66
2	Modulus of elasticity (MPa)	12941 (12884)	9579	11671	8800	9240
3	Compression parallel to grain (MPa)	51.8 (51.4)	30.7	43.5	41.7	25.9
4	Side hardness (N)	-	-	-	3030	4320
5	Shear parallel to grain (MPa)	16.4 (16.6)	-	-	9.0	11.0
6	Cleavage (radial)(N/mm)	-	12.02	12.65	60	59
7	Cleavage (tangential)(N/mm)	-	15.05	16.20	84	65

* based on Peh & Khoo (1984)
** based on Lee *et al.* (1979)
*** based on Ho *et al.* (1999)
m.c. – moisture content

Based on the strength data obtained, rubberwood has been classified under strength group SG5 – a group of timber not recommended for structural application. *Acacia mangium*, which has not been classified, can probably be classified under strength group C or SG5 - SG6.

Natural and processing defects

Several defects occur naturally or due to human activities are found in the rubberwood and *Acacia mangium*, they are listed below:

- **Knots**: Knots are actually left over portions of the fallen branches (Figure 5). If the branches are alive at the time of their inclusion their tissues are continuous with those of the main stem and the knots so formed are said to be live or tight knots. When a branch dies a stump remains, which is gradually surrounded by the tissues of the trunk but being dead, its tissues are not connected with enveloping tissues of the main stem, and dead or loose knot results; such knots fall out, either when the timber is converted, or after it is seasoned. Knots in general, have reduced strength and should be used with care. As a general rule, knots should not be concentrated in a particular area. Large knots may pose problems in sawing and woodworking processes. Knots in rubberwood are generally sound and small. For *Acacia mangium*, Ho *et al.* (1999) reported that only 18% of the knots found were sound, 67% unsound (rotten) with the remaining hollows. Only 7 % of the boards studied were free from knots and the others had knots number 1 to 6 over a 2 m length. 35 % of the knots spacing had distance equal or less than 30 cm. The loss in volume due to knots amounted to 5 % of the log volume.

Heart rot: This is particularly serious in the locally grown *Acacia mangium*. Ho *et al.* (1999) reported a loss of volume due to heart rot at about 7.5 % of the total log volume (Figure 6).

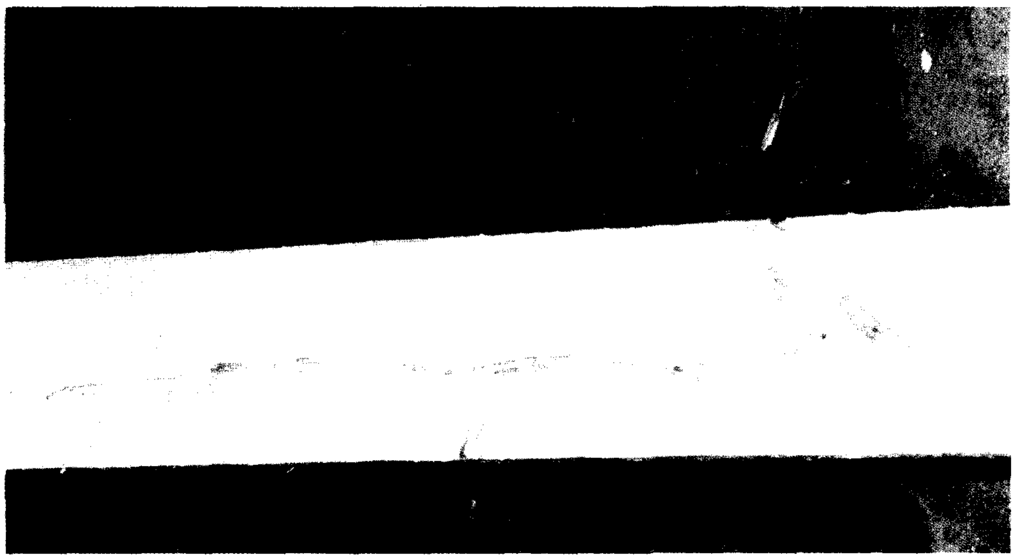

Figure 5 Knots and some associated defects

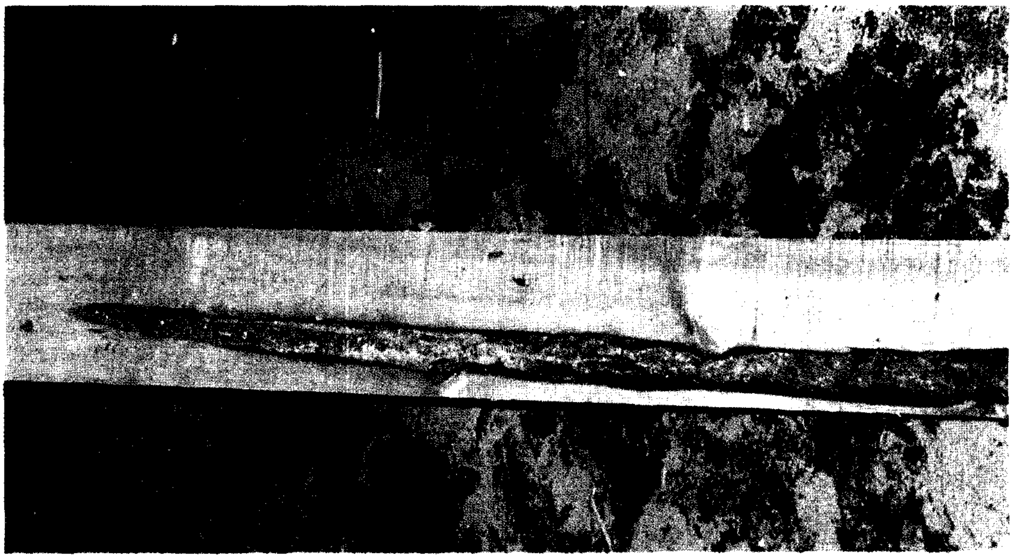

Figure 6 Acacia with a section of hollow core

- **Wane**: Study on *Acacia mangium* indicates that 46 % of the board contained a certain amount of wane and resulted in a loss of 3.8% of the log volume. Depending on the size of the rubber logs, normally, the smaller logs tend to produce more sawn boards with wane than larger logs.

- **Warping**: Warping in the form of bow and spring (Figure 7) after sawing are common in plantation timber due to growth stresses. In *Acacia mangium*, it was found that 13 % of the boards had excessive springs of more than 15 mm. The loss in volume due to warping amounting to 1.9 % of the log volume. For rubberwood, bowing and spring can be quite serious in some instances if the timber are not properly stacked and weighted down during drying.

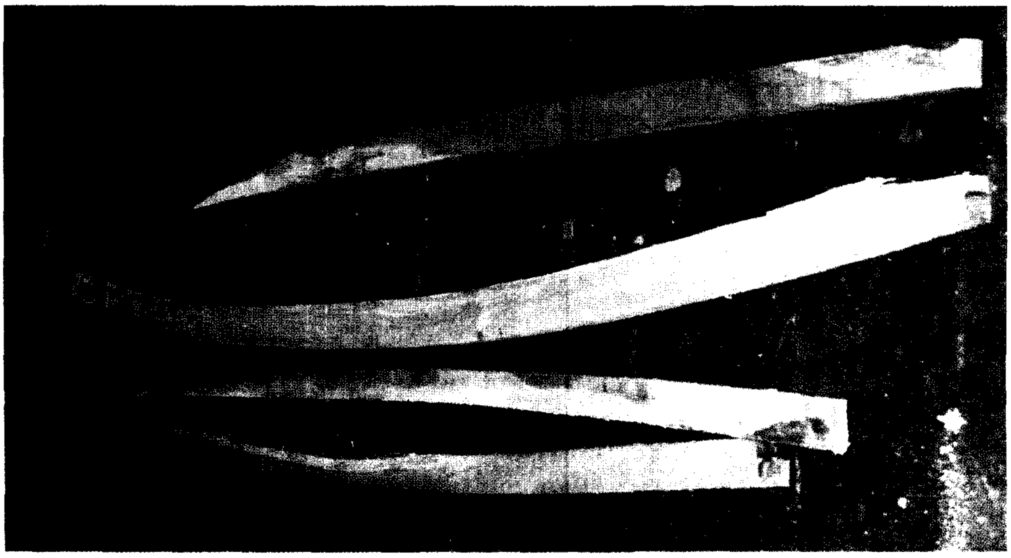

Figure 7 The occurrence of spring in Acacia wood after drying

- **Tapping panel defect**: This particular defect is confined only to the rubberwood. The formation of the tapping panel defects is the result of poor tapping of the rubber tree for latex especially by the smallholdings managed by pioneer land scheme settlers. When tapping is carried out, three types of wounding can occur, they are: (1) Wounding during normal tapping in which the cambium is not injured. (2) Wounding in which the cambium is partly removed and is capable of bark regeneration and (3) Wounding resulting in the complete removal of the cambium. The healing of the wound results in callous formation. It is the second and third types of wounding that will cause a lot of damage to the proper formation of the wood in rubber trees. In this case, regeneration takes place around the edges of the injured area. As the stem expand in size, the callous formation with the inclusion of a thin layer of bark will be enclosed by the normal wood formation. The presence of the thin bark that appears as a dark-coloured stripe is known as tapping panel defect in the trade. The presence of tapping panel defect will invariably lower the value of the rubberwood sawn timber. A study conducted from two clones of rubber trees of two different ages showed about 9 to 17 % of the boards contained tapping defects (Hong & Sim 1999).

- **Grain deviation**: In small diameter logs processing, there is a high possibility that the sawn boards may not contain straight but diagonal or oblique grain. Timber with such a deviation in the grain direction is weaker in strength than timber cut with straight grain. In order to obtain boards with fairly straight grain, further conversion is necessary resulting in the lower recovery of the timber.

The advantages of using rubberwood and *Acacia mangium*

There are several advantages of using rubberwood and *Acacia mangium*, they are listed below:

- Sustainable and issues related to environment: As the timber is obtained from the plantation, it is regarded as sustainable and will alleviate the issue related to environment.
- Availability: Rubber trees are normally fell for replanting after about 25 years. With the large hectarages of rubber plantations in the country, the supply of rubberwood is almost assured. *Acacia mangium*, on the other hand, was mainly planted by the government in the early 1980s and most of the stock is ready for harvesting now.
- Density: Both timbers are light hardwood - rubberwood with a density of 480 to 650 kg m^{-3} and *Acacia mangium* with a density of 467 to 675 kg m^{-3} (based on 14-year-old trees) at 15% moisture content. This makes the woods suitable for a wide range of products, especially furniture production. The timbers are also a good source of fibres for medium density fibreboard (MDF) production.
- Colour: The white to pale cream colour of rubberwood as well as the growth rings figure due to parenchyma bands is rather attractive especially for the manufacture of furniture and interior fittings, domestic flooring, staircase components and kitchen utensils. *Acacia mangium*, with its 'walnut' colour, can also be quite attractive. However, the sapwood and heartwood of *Acacia mangium* is rather distinct and the inclusion of sapwood of *Acacia mangium* in usage cannot be avoided.
- Machining and woodworking properties: both rubberwood and *Acacia mangium* have good machining and working properties and therefore, can be easily worked with consequent increased productivity.
- Seasoning properties: Rubberwood can dry fairly quickly and easily provided good drying procedures are followed. Boards of 30 mm thick can be kiln-dried to a moisture content of 8-10 % in 7-9 days. Drying of *Acacia mangium* may be slightly difficult, but if precautionary steps mentioned earlier on are taken, it can be dried within acceptable quality and with minimal defects.
- Preservative treatment: both rubberwood and *Acacia mangium* have been reported to treat easily and well with preservatives and therefore can be easily protected against infestation by biodeteriorating agents.
- Jointing and lamination: both rubberwood and *Acacia mangium* can be finger-joint and glue-laminated easily.

Uses

Rubberwood is one of the most popular timbers used for the manufacture of furniture. It is also the main source of fibre for the manufacture of particle board and medium density fibreboard (MDF) in the country. Other uses include interior finishing, wall panelling, office and domestic flooring, kitchen wares, and staircase components. The waste from rubberwood in the form of sawdust is an excellent medium for the growing of mushroom, especially oyster mushroom.

The timber of *Acacia mangium* is suitable for the manufacture of furniture, turnery, wall panelling, veneer and plywood, composite panel products, fibre for medium density fibreboard (MDF) manufacture, tool handles, interior finishing and other general utility purposes. It has been reported that the sawdust of *Acacia* provides a good medium for the production of shitake mushrooms.

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