

WOOD PROPERTIES OF SELECTED PLANTATION SPECIES: *KHAYA IVORENSIS* (AFRICAN MAHOGANY), *AZADIRACHTA EXCELSA* (SENTANG), *ENDOSPERMUM MALACCENSE* (SESENDOK) AND *ACACIA MANGIUM*

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Introduction

Malaysia started forest plantation trials in the early 1900s with various indigenous and exotic species. Commercial forest plantations only started in the 1950s with the planting of teak in Kedah (Thai 2000). The importance of forest plantation lies in fulfilling the demand of the wood industries and conserving our natural forests (Haron et al. 1997, Thai 2000). According to Abdul Rasip et al. (2004), species selected for forest plantations must fulfill the criteria of high survival and successful growth after planting, good initial growth (height and girth) to reduce impact of weed competition, being tolerant of some shade and site competitions, natural self pruning with a good natural bole, being generally resistant to insect and fungal attacks, and ability to produce timber of good economic value and of general utility. Fast-growing exotic species like *Acacia mangium*, *Gmelina arborea* and *Paraserianthes falcataria* have been planted in the early 1980s. Among these species, *Acacia mangium* is one of the most widely planted with the objective to produce general utility timber (Abdul Rasip et al. 2004). According to Malaysia Timber Industrial Board (Anon 2007), eight species recommended for plantation in Malaysia are *Azadirachta excelsa* (sentang), *Khaya ivorensis* (African mahogany), *Tectona grandis* (teak), *Acacia* spp., *Hevea brasiliensis* (rubberwood), *Neolamarckia cadamba* (kelempayan/laran), *Paraserianthes falcataria* (batai) and *Octomeles sumatrana* (binuang).

Khaya ivorensis also known as African Mahogany is an exotic species to Malaysia; first introduced during the late 1950s (Lok & Ong 2002). This species belong to the family Meliaceae which in the same family with many other valuable timber trees such as *Toona* spp., *Azadirachta excelsa*, *Chukrasia tabularis*, *Switenia macrophylla* and *Cedrela odorata* (Mabberly & Pannell 2007). The growth rates of these species are comparable to those of other fast growing species such as *Acacia mangium*, *Endospermum malaccense* and *Hopea odorata* (Lok & Ong 2002). Plantation of *K. ivorensis* has been established on about 0.3 ha site with the Rengam soil series in FRIM. In Kedah, about 0.04 and 0.02 ha respectively were established in Jeniang (Gajah Mati soil series) and Kulim (Rengam soil series). Other trial plots established were at Trolak, Perak, Gemencheh, Negeri Sembilan and Mata Ayer, Perlis (Lok & Ong 2002).

Azadirachta excelsa or locally known as sentang is a fast-growing tree and its characteristics are comparable with those of some popular timbers like meranti, keruing, nyatoh and ramin. This species has good potential as a resource for the furniture industry (Ahmad Zuhaidi & Mohd Noor 2002). Sentang has been planted in a 0.45 ha research plot of FRIM in 1953. Since then the Forestry Department of Peninsular Malaysia has established 400 ha of sentang plantation in Selangor, Kelantan and Perak. A few private companies such as Maju Aik Sdn Bhd in Perak, Farmer Organisation Authority, Negeri Sembilan, KETENGAH in

Terengganu and SABAPURI Plantation Sdn Bhd, Tawau have shown keen interest in planting this species on a commercial basis (Ahmad Zuhaidi & Mohd Noor 2002).

Endospermum malaccense (sesendok) belongs to the family Euphorbiaceae has been proposed for plantation in Peninsular Malaysia, a good alternative timber for furniture industry (Ahmad Zuhaidi et al. 2002, Khairul et al. 2010). According to Khairul et al. (2010) sesendok has been discovered as an alternative species to overcome the increasing price of rubberwood. This sesendok is extremely easy to be treated with chemicals (fire retardants or wood preservers); it has excellent working and nailing properties (Lim & Chung 2002). Trial plot of sesendok was established at FRIM Kepong. Other plantation plot of sesendok was established at Sungai Buloh Forest Reserve, Selangor (Ahmad Zuhaidi et al. 2002).

Acacia mangium belongs to the family of Leguminosae and this species does not occur naturally in Malaysia. The timber of this species is commonly known as acacia (Lim & Chung 2002). This species was first introduced into Sabah in 1966 as a fire-break species. *Acacia mangium* has been planted in Peninsular Malaysia since the early 1980s to supplement the demand for timber in the industry. A total of 51 768 ha of *A.mangium* have been planted in Peninsular Malaysia, mainly in the states of Johore, Negeri Sembilan, Pahang and Selangor (Ho et al. 1999). *A.mangium* plantation established in Sabah is used as raw material for pulp and paper industry (Ahmad Zuhaidi 2002).

Properties, durability and uses

General characteristics, anatomical, physical, mechanical, wood working and seasoning properties, durability and the uses of the four plantation species viz *K. ivorensis* (African mahogany), *A. excelsa* (sentang), *E. malaccense* (sesendok) and *Acacia mangium* are presented in Table 1.

Table 1 Timber characteristics and properties of selected plantation species

Parameter	<i>Khaya ivorensis</i> (African mahogany)	<i>Azadirachta excelsa</i> (sentang)	<i>Endospermum malaccense</i> (sesendok)	<i>Acacia mangium</i>
General characteristics				
1. Colour of heartwood	Light pinkish brown turning reddish brown on exposure	Reddish brown	Bright yellow, often with a green tinge and darkens to light brown on exposure	Light brown to golden brown, darkening on exposure
2. Colour of sapwood	Whitish to yellowish	Yellowish white, grayish white or sometimes grey-pink	Sapwood is not differentiated from the heartwood	White
3. Porosity	Diffuse-porous	Usually a distinctly ring-porous structure, though this is not invariably present	Diffuse-porous	Diffuse-porous
4. Growth rings	Growth ring were delineated by several rows of tangential flattened fibers and with poorly defined band of boundary (terminal) parenchyma	No distinct or conspicuous growth rings	Growth rings are absent	Growth rings are absent or vaguely present
5. Grain	Straight or interlocked	Almost straight	Almost straight, shallowly interlocked or slightly wavy	Straight to shallowly interlocked

(continued)

Table 1 (continued)

Parameter	<i>Khaya ivorensis</i> (African ahogany)	<i>Azadirachta excelsa</i> (sentang)	<i>Endospermum malaccense</i> (sesendok)	<i>Acacia mangium</i>
6. Texture	Rather coarse	Slightly coarse and uneven	Rather coarse but even with spiral	Moderately fine and even
Anatomical properties				
1. Vessels				
i. Vessel grouping	Occurred singly or in radial groups	Solitary or in multiples of up to 5 or rarely more, clustering common, up to 4–5 vessels	Solitary, predominantly in radial pairs and multiples of 2 to 7 in a series and occasional clusters	Solitary and in radial multiples of 2–3, seldom more
ii. Vessel arrangement	Tendency to arrange in radial series, circular or slightly oval shaped	Tendency to arrange in tangential and radial series of up to 4 vessels and round to oval shaped	Arrange in radial series	Diffuse, generally oval in shape sometimes round
iii. Vessel contents	Some vessels contained red or dark red-stained resin-like substances	Filled with dark-coloured deposits of dried extractives are present in the heartwood	Tyloses and deposit absent	Tyloses generally absent, dark brown deposits present
2. Wood parenchyma	Axial scanty paratracheal, axial parenchyma vasicentric, axial parenchyma in marginal or in seemingly marginal bands	Apotracheal and paratracheal parenchyma. Apotracheal parenchyma showed 3–6 cells wide, sometimes more and paratracheal parenchyma occurs mainly as incomplete vasicentric	Regularly spaced apotracheal bands	Mainly as scanty paratracheal to very thinly vasicentric,
3. Rays	Multiseriate rays with 3–5 cells, heterocellular	Multiseriate rays mostly 2–3 cells wide, rarely 4, uniseriate present but rare, heterocellular	Uniseriate and multiseriate rays of 2–3 cells wide, heterocellular	Uniseriate and multiseriate mostly 2 cells wide rarely 3, homocellular
Physical properties				
1. Timber classification	Light hardwood	Light hardwood ^d	Light hardwood ^d	Light hardwood ^d
2. Density (kg/m ³)				
i. Commercially supply timber	580 to 690 ^a	550 to 780 ^d	305 to 655 ^d	290 to 580 ^d
ii. Younger timber	(8-year-old) ^b 416 to 512	(8-year-old) ^b 438 to 547	(12-year-old) ^e 313 to 525	(8-year-old) ^d 350 to 580
3. Shrinkage from green to air dry (%)				
i. Commercially supply timber	Tangential - 4.5 ^c Radial - 2.5	Tangential - 1.2 ^d Radial - 0.5	Tangential - 1.3 ^d Radial - 1.2	Tangential - 6.4 ^d Radial - 2.7

(continued)

Table 1 (continued)

Parameter	<i>Khaya ivorensis</i> (African mahogany)	<i>Azadirachta excelsa</i> (sentang)	<i>Endospermum malaccense</i> (sesendok)	<i>Acacia mangium</i>
ii. Younger timber	(8-year-old) ^b Tangential - 3.1 Radial - 2.0	(8-year-old) ^b Tangential - 2.7 Radial - 1.8	(12-year-old) ^c Tangential - 2.5 Radial - 1.8	(9-years-old) ^d Tangential - 4.4 Radial - 2.6
Mechanical properties				
1. Commercially supply timber				
Modulus of rupture (MOR) (N/mm ²)	71–126 ^c	60 ^f	81 ^g	111 ^h
Modulus of elasticity (MOE) (N/mm ²)	8700–10 800 ^c	6770 ^f	10678 ^g	10 764 ^h
Compression (N/mm ²)	37–48 ^c	31 ^f	10 ^g	53 ^h
Shear (N/mm ²)	8–12 ^c	23 ^f	6 ^g	16 ^h
2. Younger timber	(8-year-old)	(8-year-old)	(12-year-old)	(16-year-old)
Modulus of rupture (MOR) (N/mm ²)	77 ^b	81 ^b	48 ^c	97 ^h
Modulus of elasticity (MOE) (N/mm ²)	7667 ^b	7099 ^b	5618 ^c	10 347 ^h
Compression (N/mm ²)	37 ^b	38 ^b	24 ^c	46 ^h
Shear (N/mm ²)	11 ^b	13 ^b	6 ^c	12 ^h
Wood working properties	Easy to saw and work, turning, boring, and sanding are all reported to be satisfactory, wood holds nails and screws well and glues satisfactorily ^c	Generally easy to work, taking a good finish, nailing property is satisfactory, the boring properties are rated as good and planing and shaping as moderately good, glues rather satisfactorily ⁱ	Easy to saw and plane and produces a smooth surface, nailing property is excellent ^d	Easy to work, plain, easy to sand as the surface quality was consistently graded as good to excellent, easy to turn and bore ^m
Seasoning properties	Air dries and kiln dries easily with little degrade, but some warping may occur due to the presence of interlocked grain. Once dry, the wood is fairly stable in service ^c	The timber seasons fairly rapidly, with only slight twisting and end checking as the main sources of degrade. Boards of 13 mm take approximately two months to air dry, while 38 mm boards take four months ^{j,d}	The timber seasons fairly rapidly without serious degrade except for some insect attacks, 13 mm boards take 2 months to air dry, while 38 mm boards take 3 months ^d	Air drying of 30 mm boards took about 150 days from green to air dry moisture content of about 16.5% and could achieve uniform moisture content throughout the board ⁿ
Durability	Rated as durable to moderately durable ^a	Rated as durable to moderately durable ^d	Non-durable but is extremely easy to treat with preservative ^d	Non-durable ^l

(continued)

Table 1 (continued)

Parameter	<i>Khaya ivorensis</i> (African mahogany)	<i>Azadirachta excelsa</i> (sentang)	<i>Endospermum malaccense</i> (sesendok)	<i>Acacia mangium</i>
Uses	Used for high quality furniture, paneling, cabinet making, superior joinery, turnery, canoes and other decorative works ^k . Suitable for light construction, light flooring, ship building, vehicle bodies, handles, ladders, sporting goods, musical instruments, toys, novelties, precision equipment, carving, turnery and pulpwood ^c .	Suitable for high-class joinery works, furniture manufacture, interior finishing for shops, houses and boat, paneling, partitioning, sliced veneers and plywood, particleboard, medium density fibreboard, flooring, carving, fancy articles and turneries ^{j, d} . Suitable for pulp and particleboard ^k .	Is a favoured species for manufacture of match splints and boxes and also suitable for trays, plywood and wooden clogs ^d . Recently, this species has been used as raw material for furniture as an alternative species to overcome the increasing price of rubberwood ^e .	Suitable for light construction work, flooring, linings, mouldings agricultural tool handles, veneer, plywood, furniture, cabinets, joinery, turning, walking sticks and other light utility purposes ^d .

Source: a. Lok & Ong 2002 g. Lee 1979 m. Khairul et al. 2011
b. Ani & Nordahlia 2009 h. Mohammad Omar & Mohd Jamil 2011 n. Gan & Zairul 2011
c. Lemmens 2008 i. Mohd Hamami et al. 1997
d. Lim & Chung 2002 j. Lim et al. 2006
e. Khairul et al. 2010 k. Mohd Nor & Koh 1997
f. Noraini 1997 l. Salmiah et al. 2011

*Khaya ivorensis* wood disc*A. excelsa* wood disc
Source: Nordahlia (2009)*E. malaccense* wood disc
Source: Khairul (2010)*A. mangium* wood disc
Source: Lim & Gan (2011)

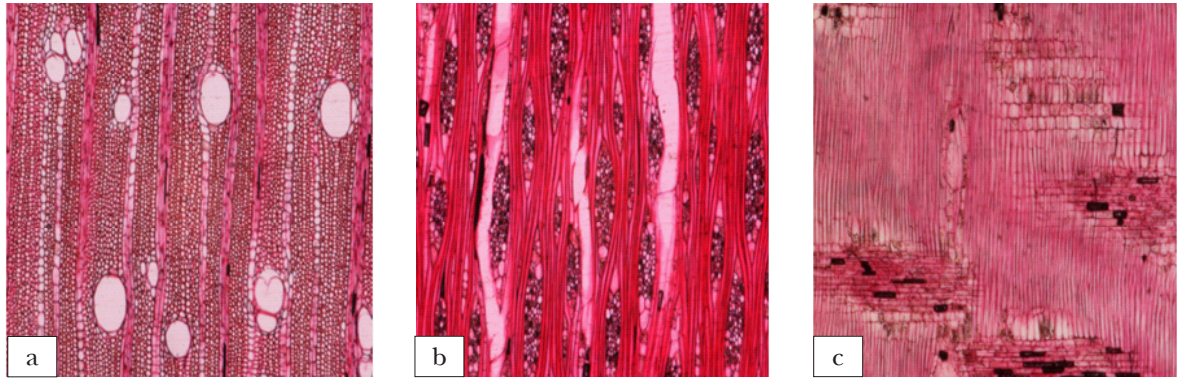


Figure 1 Anatomical structure of *K. ivorensis*: (a)transverse section, (b)tangential section, (c)radial section

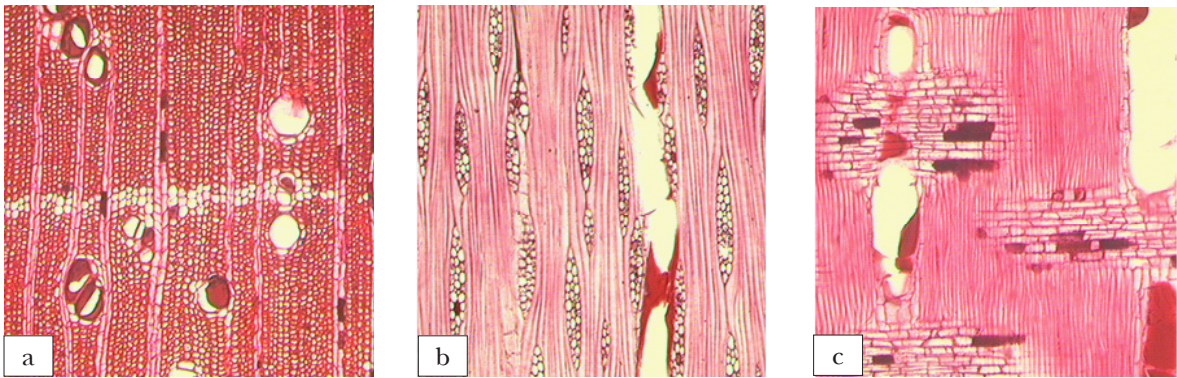


Figure 2 Anatomical structure of *A. excelsa* (sentang): (a)transverse section, (b)tangential section, (c)radial section

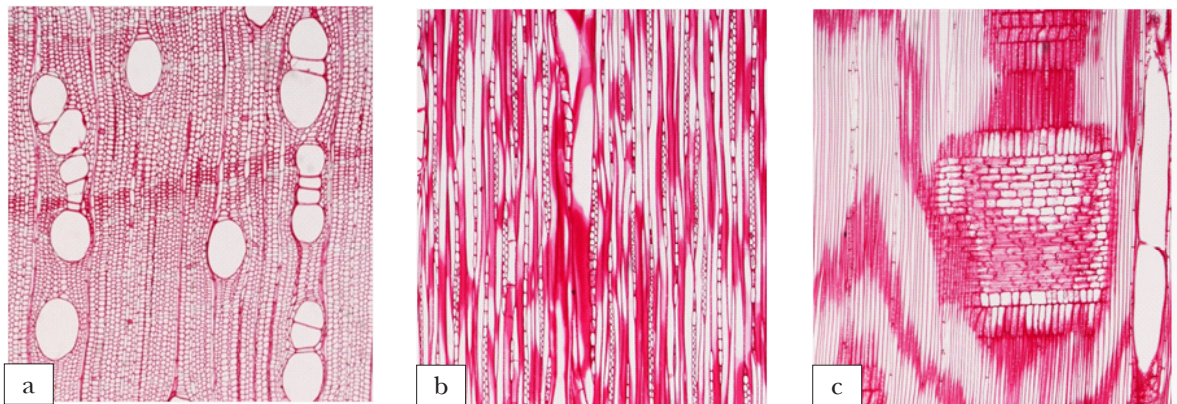


Figure 3 Anatomical structure of *E. malaccense* (sesendok): (a)transverse section, (b)tangential section, (c)radial section

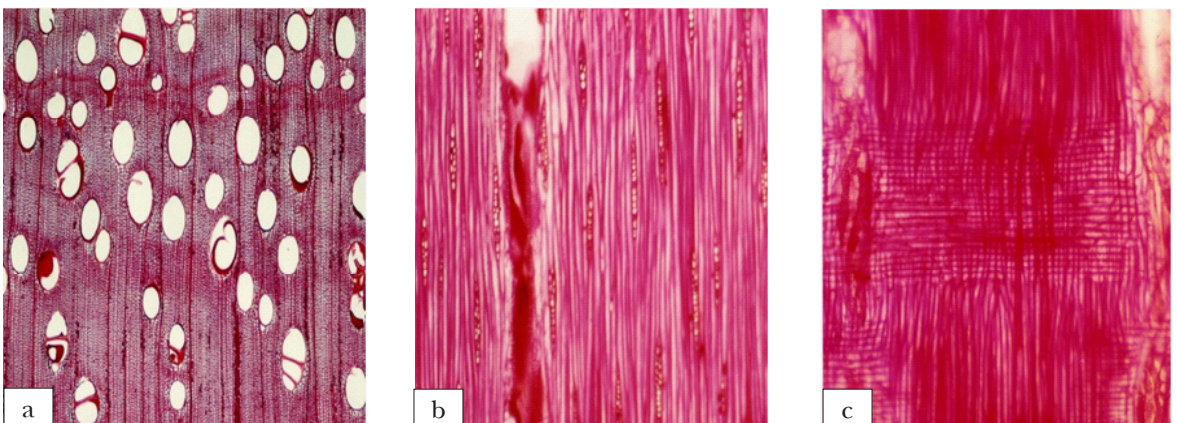


Figure 4 Anatomical structure of *A. mangium*: (a)transverse section, (b)tangential section, (c)radial section

Potential uses of younger plantation species

Based on the density, the 8-year-old *K. ivorensis*, *A. excelsa*, *A. mangium* and 12-year-old *E. malaccense* could be classified as light hardwood. These timbers are suitable for light duty purposes such as furniture component, joinery works, souvenir items and plywood.

References

- ABDUL RASIP AG, AHMAD ZUHAIIDY Y, MOHD ZAKI A, ROSDI K, MOHD NOOR M, MOHD FARID M & MOHD FAUZI MS. 2004. Matrix—Selected Plantation Species. Forest Research Institute Malaysia, Kepong.
- AHMAD ZUHAIIDY Y, ZAKARIA I & ROSDI K. 2002. Species for timber plantations. Pp 13–23 in Krisnapillay B (ed) *A Manual for Forest Plantation Establishment in Malaysia*. Malayan Forest Records No. 45. Forest Research Institute Malaysia, Kepong.
- AHMAD ZUHAIIDY Y & MOHD NOOR M. 2002. Sentang. Pp 199–204 in Krisnapillay B (ed) *A Manual for Forest Plantation Establishment in Malaysia*. Malayan Forest Records No. 45. Forest Research Institute Malaysia, Kepong.
- ANI S & NORDAHLIA AS. 2009. Wood Properties of plantation species from rooted cuttings. Poster presented at 7th Pacific Regional Wood Anatomy Conference. 3–5 August 2009, Kuala Lumpur.
- ANONYMOUS 2007. *Eight Selected Species for Forest Plantation Programme in Malaysia*. Malaysian Timber Industry Board, Kuala Lumpur.
- GAN KS & ZAIRUL AMIN R. 2011. Drying characteristics using the standard test method. Pp 74–82 in Lim et al. (eds) *Properties of Acacia Mangium Planted in Peninsular Malaysia*. ITTO Project on Improving Utilisation and Value Adding of Plantation Timbers from Sustainable Sources in Malaysia Project No. PD 306/04 (1).
- HARON AH, CHIN YM & FAZALI WM. 1997. *Forest Plantations in Asean*. AIFM Technical Report No.32. Asean Institute of Forest Management, Kuala Lumpur.
- HO KS, HAMDAN H, TAN YE & MOHD SHUKARI M. 1999. *Acacia mangium* for timber and case study of utilisation. Paper presented at the Fifth Conference on Forestry and Forest Product, 1999 Series, Utilisation of Plantation Timber: Sentang: Potential Timber for the Future. 20 April 1999, Forest Research Institute Malaysia, Kepong.
- KHAIRUL M, MOHD NOOR M, MOHAMAD OMAR MK, ABDUL HAMID S, MOHD HAFIZ M, KHAIRUL A. & IZBAN K. 2010. Solid wood and veneer study of 12-year-old sesendok clone. *Journal of Modern Applied Science* 4: 1844–1913.
- KHAIRUL M, KHAIRUL A, TENG XY, WONG TC, CHAN CS, IZBAN K & TAN YE. 2011. Sawing and machining properties. Pp 46–55 in Lim et al. (eds) *Properties of Acacia Mangium Planted in Peninsular Malaysia*. ITTO Project on Improving Utilisation and Value adding of Plantation Timbers from Sustainable Sources in Malaysia Project No. PD 306/04 (1).
- LEE YH. 1979. *The Strength Properties of Some Malaysian Timbers*. Forestry Department Peninsular Malaysia, Kuala Lumpur.
- LEMMENS RHMJ. 2008. *Khaya ivorensis* A.Chev. In Louppe D, Oteng-Amoako AA & Brink M (eds) *Prota 7(1): Timbers/Bois d'œuvre 1*. PROTA, Wageningen. (CD)
- LIM SC & CHUNG RCK. 2002. *A Dictionary of Malaysian Timbers*. Malaysian Forest Records No. 30. Forest Research Institute Malaysia, Kepong.
- LIM SC & GAN KS. 2011. Wood anatomy and quality. Pp 7–22 in Lim et al. (eds) *Properties of Acacia Mangium Planted in Peninsular Malaysia*. ITTO Project on Improving Utilisation and Value adding of Plantation Timbers from Sustainable Sources in Malaysia Project No. PD 306/04 (1).
- LIM SC, KS GAN & KHAIRUL A. 2006. *Timber of Sentang*. Timber Technology Bulletin No. 38. Forest Research Institute Malaysia, Kepong.
- LOK EH & ONG TH. 2002. *Khaya ivorensis*. Pp 215–229 in Krisnapillay B (ed) *A Manual For Forest Plantation Establishment in Malaysia*. Malayan Forest Records No. 45. Forest Research Institute Malaysia, Kepong.
- MABBERLY DJ & PANNELL CM. 2007. Meliaceae. Pp 17–218 in Soepadmo E et al. (eds) *Tree Flora of Malaya*. Malayan Forest Records No. 26. Forest Research Institute Malaysia, Kepong.
- MOHAMMAD OMAR K & MOHD JAMIL AW. 2011. Mechanical properties. Pp 23–45 in Lim et al. (eds) *Properties of Acacia Mangium Planted in Peninsular Malaysia*. ITTO Project on Improving Utilisation and Value adding of Plantation Timbers from Sustainable Sources in Malaysia Project No. PD 306/04 (1).
- MOHD NOR Y & KOH MP. 1997. Properties of pulp and paper and particleboard from *Azadirachta excelsa*. Pp 55–57 in Norani A (ed) *Azadirachta excelsa—A Monograph*. Research Pamphlet No. 120. Forest Research Institute Malaysia, Kepong.

- MOHD HAMAMI S, GOH KW & ZAIDON A. 1997. The anatomical features and strength properties of *Azadirachta excelsa* (sentang) from Sabah. Paper presented at the International Tropical Wood Conference on New-Tropical Timber Crops: Challenges in Processing and Utilisation. June 1997, Kuala Lumpur.
- NORAINI A. 1997. *Azadirachta excelsa*: The tree, origin and distribution, nomenclature and biology. Pp 58–61 in Norani A (ed) *Azadirachta excelsa—A Monograph*. Research Pamphlet No. 120. Forest Research Institute Malaysia, Kepong.
- NORDAHLIA AS. 2009. Wood quality of 10-year-old sentang (*Azadirachta excelsa*) grown from seedlings and rooted cuttings. MSc thesis, Universiti Putra Malaysia, Serdang.
- SALMIAH U, BAHARUDIN K & SABRI A. 2011. Assessment of durability using accelerated test. Pp 56–60 in Lim et al. (eds) *Properties of Acacia Mangium Planted in Peninsular Malaysia*. ITTO Project on Improving Utilisation and Value adding of Plantation Timbers from Sustainable Sources in Malaysia Project No. PD 306/04 (1).
- THAI SK. 2000. Forest plantation development in Malaysia and the potential of rubber wood as an important source of timber in the future. *Malaysian Forester* 63: 136–255.

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