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Identification of Least Authentic Timber Species by Anatomical Features based on IAWA Classification

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Abstract
Current practice of wood identification is mainly based on expert and personnel skills as there is no proper mechanism to identify timber species in Sri Lanka . In this research, commonly available timber types namely; Jack-Bedidel, Mahogany- Khaya, Mee-Wanamee, Mara-Suriyamara and Mango-Atamba, which are difficult to distinguish and unreliable by the public. Anatomical properties are used to be a precise and accurate wood identification. In addition to the anatomical features as listed in International Association of Wood Anatomists (IAWA), some non- anatomical features were also employed in the identification process. Major objective of this research was to identify least authentic timber species in Sri Lanka. Timber samples were taken from each species (Radial, Tangential and Transverse sections of the wood) were used in microscopic observations. Micrometrics SE Premium 4 software was used to measure and analysis the anatomical properties and features of the timber. Ten timber types were also differentiated using the key identified features. The findings of the present study would have practical significance as consumers and specially researchers would be benefited to proper identification process.

Key words: *Anatomical Features, Authentic, Timber identification*

Introduction

Wood has remained as one of the most valuable and important renewable natural resources available and timber species has unique physical characteristics hence wood have confirmed its suitability as a constructional material (Youngs, 1989). Also timber is valuable and versatile raw material used by man and plays a vital role in the economic and industrial development of the country. In Sri Lankan scenario, some timber merchants sell low grade and low quality timber species which are inaccurate of the authenticity, because the buyers are not skills to identify the timber species by

external features. Therefore they are easily misled on authentic timber species (Muthumala and Amarasekara, 2013; Siriwardana and Muthumala, 2018).

Wood identification is important for controlling international illegal timber trading tasks and enhancement of timber trade regulations. Macroscopic wood identification is the fastest method for the first identification of an unknown timber (Ruffinatto et al, 2020). The microscopic analysis of the wood anatomical features is also time-consuming, and expensive (Newmaster et al. 2006; Nithaniyal et al. 2014). Digital reference databases were used in some researchers for the analysis of wood anatomical characteristics, for the purpose of wood identification (Schmitz, 2020).

Wood identification has never been more important to serve the purpose of global forest protection, by controlling international illegal timber trade and enabling the enforcement of timber trade regulations. International Association of Wood Anatomist (IAWA) is the world's leader in standardizing and summarizing the characters used in microscopic wood identification and it is clear that the IAWA should continue its leadership role in establishing the macroscopic identification (Ruffinatto, Crivellaro and Wiedenhoeft, 2010). Major objective of this research was to identify least authentic timber species; Jack, Bedidel, Mahogany, Khaya, Mee Wanamee, Mara Suriyamara , Mango and Atamba by anatomical observations These timber species which are difficult to distinguish each other.

Materials and Methods

Timber Sample Selection

In this research, ten timber species commonly available in Sri Lanka were selected (Table 1). Heartwood matured timber samples were taken from the tree breast height portion of the tree to prepare specimens. Ten wood sections representing the each timber species (Tangential, Rasdial and Transverse sections) were used to distinguish and identify the microscopic features. All samples were sectioned and macerated by Bass and Zhang (1988) method.

***Table 01**: Local Timber Species*

Number	Common Name	Botanical Name	Family
1	Jack	*Artocarpus heterophyllus*	Moraceae
2	Bedidel	*Artocarpus nobilis*	Moraceae

3	Mahogany	*Swietenia macrophylla*	Meliaceae
4	Khaya	*Khaya senegalensis*	Meliaceae
5	Mee	*Madhuca longifolia*	Sapotaceae
6	Wana mee	*Madhuca fulva*	Sapotaceae
7	Mango	*Mangifera indica*	Anacardiaceae
8	Etamba	*Mangifera zeylanica*	Anacardiaceae
9	Mara	*Albizia saman*	Fabaceae
10	Suriyamara	*Albizia odoratissima*	Fabaceae

Determination of Wood Density

Wood density of all timber species were calculated using following Equation 01. Oven dry weight of the timber piece was kept at 105^0C oven for 48 hours (BSI, 1999).

$$\text{Density} = \frac{\text{Oven dry weight of the wood (kg)}}{\text{Volume of wood (m}^3\text{)}} \quad \textbf{(Eq –1)}$$

Heart wood colour

Heart wood colors were measured according to IAWA (1989) category No 197 to 202 by naked eye.

Preparation of Wood for microscopic examination

First, wood samples were boiled in water periodically for three days until for softening and air space of wood were filled with water. Wood blocks were prepared as the size of 2 cm x 2 cm x 3 cm. Three planes of the sections at the range of 10-15 micrometer thickness were taken from wood samples using a sledge Microtome (Model Leica SM2000 R) (Figure 1). The piece of wood sample were flooded with 30 % ethanol, during the section cutting for facilitate fine sectioning process.

Figure 01: *Slide preparation procedure*

Wood sections were rinsed in alcohol series, stained in Safranin, dehydrated and mounted permanently using Canada balsam. Transverse, Tangential and Radial sections were placed as figure 2.

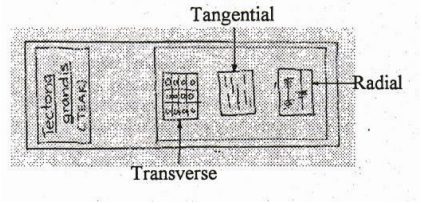


Figure 02*: Model of the slide*

Anatomical observations were made under the light microscope with 4 x 10 magnification. Measurements were obtained using anatomical photographs and used the Micrometrics SE Premium 4 software available at Wood Science Laboratory of the Research division of the State Timber Corporation, Battaramulla, Sri Lanka. Quantitative wood anatomical features: mean vessel diameter, vessels per square millimeter and mean ray heights were measured with referencing the IAWA (1989) classification. Total vessel area per square millimeter of each timber species were taken from the following method showing in equation 01.

Total Vessel area per Square mm = πr^2 x No. of Vessels per sq.mm

=22/7 x (Mean tangential vessel diameter/2) x (Mean tangential vessel diameter/2) x No. of Vessels per sq.mm (Eq-01)

Mean Vessel Diameter

Mean Vessel Diameter (Tangential Diameter) was measured in cross section of each timber species.

Ray Height

Ray height was measured using Tangential section of the timber species.

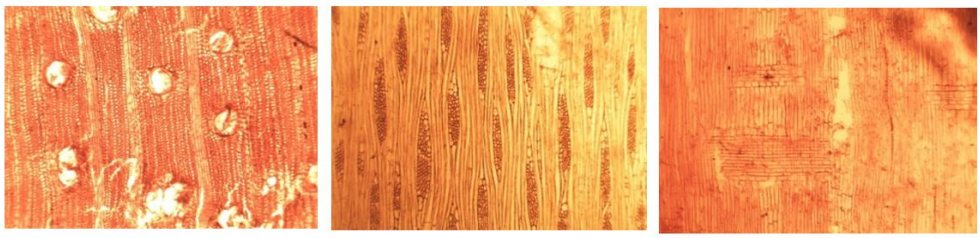
Results and Discussion

Differention of the timbers species using IAWA wood classification

A new IAWA wood classification was prepared based on the modification of the former wood IAWA (1989) classification. A total number of 163 characters have been considered in this classification and further it has been grouped into 46 sub-classes. Wood sections were observed with the light microscope to determine vessels per given area (mm^2).

Photographic representation of anatomical views of timber species

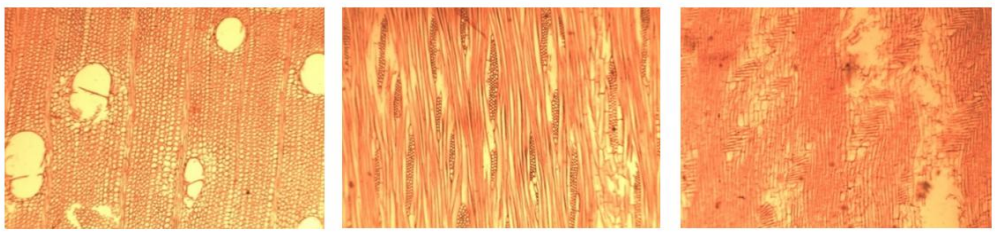
Jack - *Artocarpus heterophyllus*



(a) (b) (c)

Figure 03*: Transverse (T.S.), Tangential (T.L.S.) and Radial (R.L.S.) section of Jack with x 40 magnification*

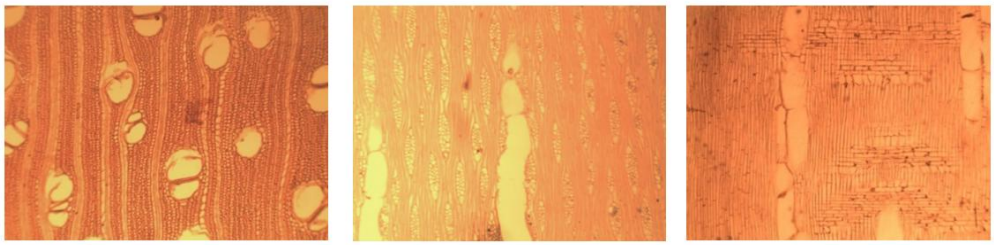
Bedidhel - *Artocarpus nobils*



(a) (b) (c)

Figure 04: Transverse (T.S.), Tangential (T.L.S.) and Radial (R.L.S.) section of Bedidel with x 40 magnification

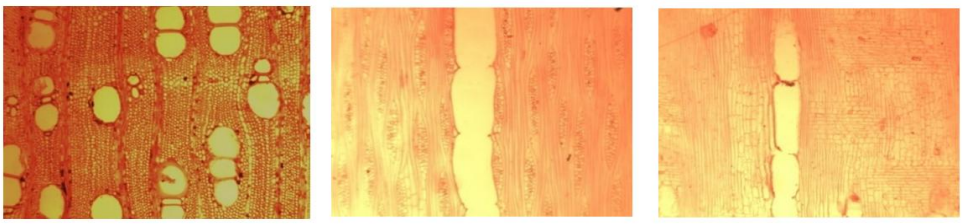
Mahogany - *Swietenia macrophylla*



(a) (b) (c)

Figure 05. Transverse (T.S.), Tangential (T.L.S.) and Radial (R.L.S.) section of Mahogany with x 40 magnification

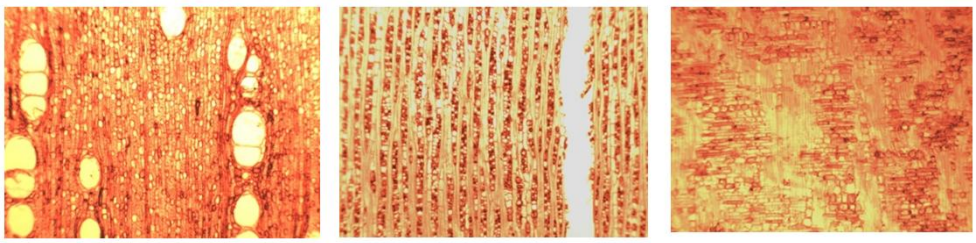
Khaya - *Khaya senegalensis*



(a) (b) (c)

Figure 06*. Transverse (T.S.), Tangential (T.L.S.) and Radial (R.L.S.) section of Khaya with x 40 magnification*

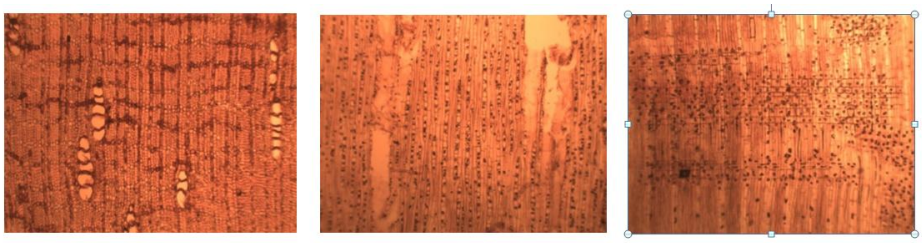
Mee - *Madhuca longifolia*



(a) (b) (c)

Figure 07: *Transverse (T.S.), Tangential (T.L.S.) and Radial (R.L.S.) section of Mee with x 40 magnification*

Wana mee - *Madhuca fulva*



(a) (b) (c)

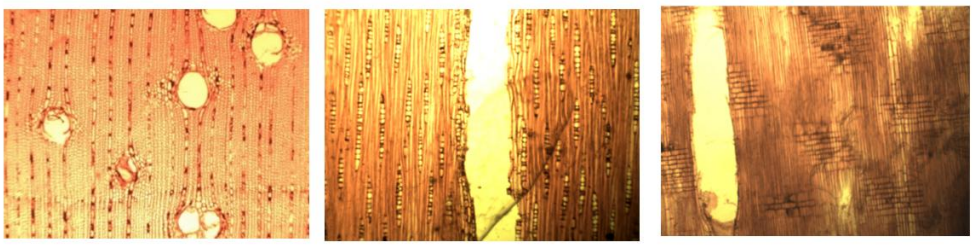
Figure 08*: Transverse (T.S.), Tangential (T.L.S.) and Radial (R.L.S.) section of Wana Mee with x 40 magnification*

Mango - *Mangifera indica*

(a) (b) (c)

Figure 09*: Transverse (T.S.), Tangential (T.L.S.) and Radial (R.L.S.) section of Mango with x 40 magnification*

Etamba - *Mangifera zeylanica*

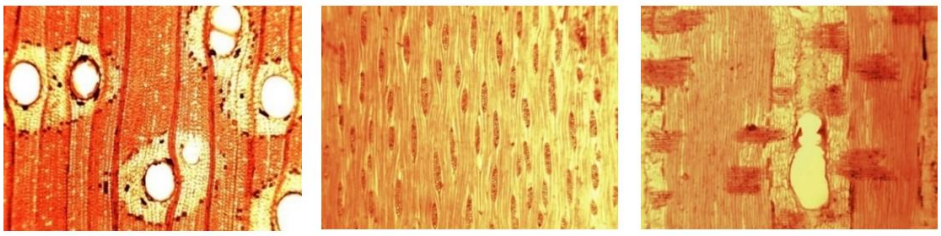


(a) (b)

(c)

Figure 10: *Transverse (T.S.), Tangential (T.L.S.) and Radial (R.L.S.) section of Etamba with x 40 magnification*

Mara - *Albizia saman*



(a) (b) (c)

Figure 11:. *Transverse (T.S.), Tangential (T.L.S.) and Radial (R.L.S.) section of Mara with x 40 magnification*

Suriyamara - *Albizia odoratissima*

(a) (b) (c)

Figure 12*: Transverse (T.S.), Tangential (T.L.S.) and Radial (R.L.S.) section of Suriyamara with x 40 magnification*

Anatomical data and other observations of Rays, Vessels, Parenchyma, wood density, colours and anatomical measurements are shown in Table 2 to Table 7.

Table 02: Anatomical Features of Rays of Selected Timber species

Common name	**RAYS**							
	Visible	Uniseriate	Multi seriate	bi to triseriate	3 to 5 seriate	>5-seriate	Homocellular	Hetero cellular
Jack	*		*		*			*
Bedidel	*		*	*				*
Mahogany	*		*		*			*
Khaya	*		*					*
Mee	*		*	*				*
Wana mee	*	*					*	
Mango	*		*					*
Etamba	*	*						*
Mara	*		*	*	*		*	
Suriyamara	*		*	*				*

***Table 03**: Anatomical Features of Vessels of Selected Timber species*

Common name	**Vessles**							
	Visible	Ring porous	Semi ring porous	Diffuse porous	Exclusively solitary	Radial multiple	Pore chain	Cluster
Jack	*			*	*			
Bedidel	*			*	*			
Mahogany	*			*	*			
Khaya	*			*		*		
Mee	*			*		*		
Wana mee	*		*			*		
Mango	*			*		*		
Etamba	*			*		*		
Mara	*			*	*			
Suriyamara	*			*	*			

Table 04: Anatomical Features of parenchyma of Selected Timber species

Common Name	PARENCHYMA								
	Apo tracheal	Paratracheal					Banded		
	Present	Unila-teral	Scanty	Vasicentric	Aliform	Confluent	Present	>3 cell wide	Narrow band
Jack	*				*				
Bedidel	*		*		*				
Mahogany	*			*			*		
Khaya	*		*	*					
Mee	*						*		
Wana mee	*						*		*
Mango	*								
Etamba	*								*
Mara				*	*				
Suriyamara	*			*	*				

Table 5: Physical features of Rays and vessels of Selected Timber species

Common name	Vessels						
	Vessel diameter(µm)	Mean V. D. (µm)	Vessel/mm^2	Ray width (µm)	Mean RW (µm)	Ray height (µm)	Mean R H (µm)
Jack	160-370	215	3-6	80-91	80.76	452-982	666.4
Bedidel	220-288	254	3	36-62	50.01	316-640	506
Mahogany	90-225	128	11	49-75	68.22	246-335	344.8
Khaya	168-227	119	8	75-98	85.66	458-670	450.8
Mee	140-217	166	14	47-67	54.66	613-1187	868.6
Wana mee	80-106	93	18	26-31	27.75	344-817	549.14
Mango	130-212	161	4	56-72	64.28	437-566	504.4
Etamba	137-225	243	6	26-41	30.8	321-658	433.8
Mara	114-218	175	10	33-55	22	191-263	210
Suriyamara	189-269	219	9	28-57	29	220-321	230

Table 6: Physical and Non Anatomical Features of selected species

Common name	Wood Density at 12 % moisture content	STC timber Classification	Heart wood color					
			Darker than sapwood color	Brown or shade brown	Red or shades red	Yellow or shades yellow	White to Gray	not as above
Jack	645	Luxury	*			*		
Bedidel	560	Class I	*			*		
Mahogany	570	Luxury	*	*	*			
Khaya	600	Class II	*	*	*			
Mee	973	Class I	*	*				
Wana mee	940	Class III	*	*				
Mango	600	C-III					*	
Atamba	580	C-III	*				*	
Mara	660	Class I	*	*				
Suriyamara	840	Sp.upper	*	*				

Table 7: Unique distinguished anatomical properties of selected timber species

Mango	**Atamba**
Biseriate	Uniseriate
Ray width high (64.28 µm)	Ray width small (30.8 µm)
Mara	**Suriyamara**
Prismatic crystal present around the axial paranchyma in cross section	Prismatic crystal not present around the axial paranchyma in cross section
Prismatic crystal in chambered axial parenchyma cells	Prismatic crystal not present in chambered axial parenchyma cells
Mean ray height small (167.446 µm)	Mean ray height high (313.539 µm)
Mee	**Wanamee**
Rays width 1-3 cells (Biseriate to triseriate rays)	Rays exclusively uniseriate
Silica bodies not present in ray cells in tangential longitudinal section	Silica bodies present in ray cells in tangential longitudinal section
Axial parenchyma diffuse in aggregates in cross section	Axial parenchyma in narrow bands or lines up to three cell wide
Vessels partially solitary, partially in radial multiples of 2-4 or very small clusters	Radial multiples of 4 or more common in cross section
Mean vessels diameters 219.44 µm (large vessels)	Mean vessels diameters 99.17 µm (small vessels)
Mahogany	**Kahaya**
Mean fiber length 900 - 1600 µm	Mean fiber length ≥ 1600 µm
Heterogeneous cells in rays	Mostly Homogenous cells in rays
Up right cell shape is oval	Up right cell shape is not oval
Jack	**Bedidel**

Up right cell not oval and not long in T.L.S. Up right cell shape is conical	Up right cell oval and short in T.L.S.
Large rays commonly 4 -6 seriate	Rays commonly 2-4 seriate
Vessels are small (192.3468 µm)	Vessels are large (247.8438 µm)

Conclusion

Morphological features and external appearance of ten described timber species grown in Sri Lanka are almost alike. Therefore accurate wood identification of timber was found to be a hard task. According to the present research findings, IAWA list could be employed much effectively in identifying the significant anatomical characters of timber species enabling consumers and merchants to distinguish closely related timber species. Based on the findings of the present research study, users get higher percentage of authentic timber species using anatomical properties of each wood types.

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