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A Study to Ascertain the Identity of Commercially Available Timbers Sold in South Karnataka through their Diagnostic and Anatomical features

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Abstract

Forensic Botany traditionally deals with leaves, pollen, seeds and wood as evidence in investigations. However, the notion of identifying wood when encountered at a scene is still rare. Wood is the hard layer that comprises most trees, bushes and shrubs. Chemically, it consists of carbohydrates: Cellulose, Hemi-cellulose and Lignin, Pectins and other inorganics. The present study was conducted to ascertain the authenticity of some commercially available timbers in south Karnataka using simple techniques like physical analysis and microscopy. The 29 samples collected were from 8 different locations in south Karnataka. The samples were of six different species of economic importance, namely Teak, Honne, White Sal, Red Sal, Neem and Acacia, were studied. The study samples showed positive identification for Teak, Red Sal, Neem and Acacia species while the samples of White Sal were found identified to be other than that claimed in the market. The Honne samples however did not yield any confirmatory results.

Keywords: Forensic Botany, Wood, Identification, Timber, Anatomy.

Introduction

Forensic Botanists apply the fundamental principles of botany to aid in criminal investigations. They widely focus on botanical evidences like leaves, pollen, seeds and in rare cases, wood. In a forensic context, the 1932 Lindbergh baby kidnapping case was the first instance wherein wood became the prime evidence in rendering a solution to the case[1]. Wood is the hard substrate that comprises most trees, bushes and shrubs. Chemically, it consists of carbohydrates: Cellulose, Hemi-cellulose and Lignin, Pectins and other inorganics[2,3]. Timber identification is a highly specialized and fascinating field of study which uses a natural resource efficiently when economics play a vital role. Timber or "wood of commercial importance", is one of the most valuable and versatile raw materials used by man and has a vital role to play in the economic and industrial development of the nation. As is well-known, wood is of plant origin and cellular in structure, being produced by thousands of different kinds of unique trees like mango (*Magnifera indica*), teak (*Tectona grandis*), rose wood (*Dalbergia latifolia*), etc. Like the trees, the woods produced by them also differ considerably in their appearance, structure and properties[4,5]. In India alone, we have well over 1600 different woods, which show a remarkably wide range of variation in their physical properties such as color, texture, grain, weight, hardness, etc. as well as in their anatomical structure. Timber identification is however, not always an easy matter, especially as one has to deal with a large number of species. In recent times, the use of important imported timbers is passed or sold in the name of local timber species containing the name of the importing country as a prefix. Consequently, there is often a high risk of inferior or even totally unsuitable woods being supplied. The use of wrong timber arising out of such mistakes or fraud may sometimes lead to a serious loss of money, material resources and even human life, which can be easily avoided if correct identification of timber is heeded[5]. The appearance of a timber, which depends on general properties like color, luster, grain, texture and figure, is no doubt suggestive and often gives a clue to its probable identity. Similarly the weight, hardness, odor and feel may also be of some help when we have to deal with only few timbers. Therefore, the only method which is reliable and at the same time, simple and easy enough to be of common application both on field and in the laboratory is one based on the anatomical structure of wood. The wood structure is different in different species, depending on the proportions, size and distribution of various cell types like vessels, fibres, parenchyma, rays and special characteristics like gum canals, ripple marks etc. "No two woods have exactly the same structure" and thus, the structural patterns seen on the end surface or in cross section constitute, as it were, the "fingerprints" of wood by which the identity of any timber can be established[4-6]. Though detailed study of the microscopic structure of wood from specially prepared slides is possible only in a well-equipped laboratory, the main structural patterns which are of diagnostic value can be made out without much difficulty in the field itself and afford an easy and reliable basis for identification[6]. The present study was conducted with an objective to ascertain the authenticity of some commercially available timbers sold at different locations in and around Bangalore. A total of 29 samples were studied which comprised of six different species i.e. nine samples of Teak, eight of Honne, three of White Sal, four of Red Sal, two of Acacia and three of Neem. The timbers were identified by

observation of diagnostic features and through anatomical observation.

Materials and Methods

Beakers(250ml), Stoppered reagent bottles, Sharp blade or knife, small saw, hammer and chisel, conc.HNO_3, Caustic potash solution (10-20%), distilled water, glycerine, hand magnifying lens (10x), slide and coverslip, low power light microscope. The sampling was done from 8 different locations in South Karnataka, namely Ramnagara, Bidadi, Mandya, Mysore road, J. P. Nagar, Rajankute, Bytaranpura and Chandapura. The samples were collected from the saw mills and their location along with details of the timber samples was noted.

Methodology: Method for the physical examination of wood sample: A rectangular piece 2 to 3sq. cm across the grain and about 5cm in height along the grain was taken. The end or transverse surface was selected in the sample to be examined for identification purpose as it provided end-grain patterns. The surface was prepared for examination under the hand lens by trimming it. The sample was held tightly in the left hand in a vertical position with the end surface facing upwards and the pith side pointing inwards towards the holder and the knife was firmly with the right thumb pressed hard against the inner side of the sample. To make a good clean cut, the blade was slightly tilted downwards at an angle and then drawn inwards, across the grain. A good cut is most important for as even the slightest crushing of tissues resulting from a blunt knife or a bad cut is likely to obliterate some of the structural details so important for correct identification. The exposed area was then examined under a hand held lens. Usually, structural features like rays, soft tissues, and resin canals stood out more clearly when the surface was moistened with water. But in some timbers, the application of water appeared to have an opposite effect making some of the structures less distinct. It is hence advisable to try both methods for accurate results. Besides the structural pattern that can be seen under a lens, certain other features like color, luster, hardness, fluorescence, etc. were also noted.

Method for the chemical examination of wood sample:- This was done in two parts: first with nitric acid and second with a caustic alkali soln. i. Small shavings of wood sample were drawn from the radial side and added to a test tube containing 75%vol. of water and boiled until it became transparent and settled down. This was drained and 30% nitric acid was added to the same test tube with a pinch of potassium chloride and boiled again. Later, it was observed under the microscope. ii. A solution of potassium hydroxide was prepared with a concentration between 10-15%. The timber samples were dipped into the chemical solution in a stoppered reagent bottle and left undisturbed. After a few days duration (approx. a week), the samples were taken out from the alkali solution, washed it with fresh water, sectioned and analysed.

Results and Discussion

The observation and analysis by the physical method was done by visual examination of diagnostic features i.e. color, hardness, texture and grain along with the microscopic examination of the internal anatomy of the sample using a light microscope. Recorded in Table-1.

The anatomical features studied included pore size, growth rings and pore arrangement, inclusions or color deposits, vessel lines, parenchyma, rays and ripple marks were also studied and recorded as Table-2.

From the observations and analysis of the timber samples of the six species taken namely *Pterocarpus marsupium Roxb*. (Honne), *Tectona grandis Linn.* (Teak), *Shorea robusta Gaertn* (Red Sal), *Shorea spp. Parashorea spp.*(White Sal), *Azadirachta indica* (Neem) and *Acacia auriculiformis Cunn.*(Acacia).

In total, the 9 samples of Teak analysed from 8 different locations of showed 100% compliance with standards. In case of the 4 samples of Red Sal, all resembled the standards, thus showing 100% confirmation of identity. Alternatively, the 2 samples of Acacia and 3 samples of Neem studied resembled the standards, hence the positive identity for both timber samples was confirmed at 100% resp. Of the 3 samples of White Sal studied, all 3 did not resemble the standards of *Shorea robusta* but resembled the standards of *Parashorea spp*. or Malaysian *Shorea* and hence, the identity was found to be other than that claimed in the market. However, The 8 samples of Honne which were studied did not yield confirmatory results.

Conclusion

Based on our research, it can be concluded that the timbers namely Teak, Red Sal, Neem, Acacia could be verified with respect to identity whilst Honne could not be conclusively identified since results were inconclusive for this species of timber. Alternatively, it was seen that the samples of *Shorea robusta* were found to be other than those claimed in the market elucidating that a number of species belonging to Balau group Malaysian *Shoreas* were currently being used in place of or as alternative to *S.robusta*.

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Table-1
Diagnostic features

Sample No.	Sample Name	Colour	Hardness	Texture	Grain
No:1	Honne (Australia)	Sapwood distinct from Heartwood, pale yellowish or nearly white. Heartwood golden brown with dark streaks.	Moderately hard to hard	Medium coarse textured	Interlocked grained
No:1	Teak (Burma)	Sapwood white to pale yellowish or greyish white, Heartwood golden brown on exposure.	Moderately hard.	Medium coarse	Uneven textured with straight grain.
No:1	White Sal (Malaysia)	Sapwood and Heartwood indistinct, yellow-white to straw yellow. Sapwood cannot always be reliably identified by colour difference.	Moderately hard.	Moderately coarse textured	_____
No:2	Honne (Indonesia)	Sapwood distinct from Heartwood, pale yellowish or nearly white. Heartwood golden brown with dark streaks.	Moderately hard to hard	Medium coarse textured	Interlocked grained
No:2	Teak (Burma)	Sapwood white to pale yellowish or greyish white, Heartwood golden brown on exposure.	Moderately hard	Medium coarse	Uneven textured with straight grain.
No:2	Red Sal (Malaysia)	Sapwood distinct from Heartwood, pale greyish or brownish white. Heartwood brown or reddish brown on exposure.	Hard to very hard	Coarse textured	Interlocked grain.
No:3	Honne (Australian)	Sapwood distinct from Heartwood, pale yellowish or nearly white. Heartwood golden brown with dark streaks.	Moderately hard to hard	Medium coarse textured	Interlocked grained
No:3	Teak (Burma)	Sapwood white to pale yellowish or greyish white, Heartwood golden brown on exposure.	Moderately hard	Medium coarse	Uneven textured with straight grain.
No:3	Red Sal (Malaysia)	Sapwood distinct from Heartwood, pale greyish or brownish white. Heartwood brown or reddish brown on exposure.	Hard to very hard.	Coarse textured.	Interlocked grain.
No:4	Honne (Australian)	Sapwood distinct from Heartwood, pale yellowish or nearly white. Heartwood golden brown with dark streaks.	Moderately hard to hard	Medium coarse textured	Interlocked grained
No:4	Teak (African)	Sapwood white to pale yellowish or greyish white, Heartwood golden brown on exposure.	Moderately hard	Medium coarse	Uneven textured with straight grain.
No:5	Honne (Indonesia)	Sapwood distinct from Heartwood, pale yellowish or nearly white. Heartwood golden brown with dark streaks.	Moderately hard to hard.	Medium coarse textured	Interlocked grained
No:5	Teak (Burma)	Sapwood white to pale yellowish or greyish white, Heartwood golden brown on exposure.	Moderately hard	Medium coarse	Uneven textured with straight grain.
No:5	White Sal	Sapwood and Heartwood indistinct, yellow-white to straw yellow. Sapwood cannot always be reliably identified by colour difference.	Moderately hard.	Moderately coarse textured	_____

Sample No.	**Sample Name**	**Colour**	**Hardness**	**Texture**	**Grain**
No:5	Red Sal	Sapwood distinct from Heartwood, pale greyish or brownish white. Heartwood brown or reddish brown on exposure.	Hard to very hard.	Coarse textured.	Interlocked grain.
No:5	Neem	Sapwood-yellow to yellowish grey Heartwood-reddish to reddish brownon exposure.	Hard to very hard.	Medium to coarse textured.	Interlocked grain.
No:6	Honne (Australia)	Sapwood distinct from Heartwood, pale yellowish or nearly white. Heartwood golden brown with dark streaks.	Moderately hard to hard.	Medium coarse textured	Interlocked grained
No:6	Teak (Burma)	Sapwood white to pale yellowish or greyish white, Heartwood golden brown on exposure.	Moderately hard	Medium coarse	Uneven textured with straight grain.
No:6	White Sal (Malaysia)	Sapwood and Heartwood indistinct, yellow-white to straw yellow. Sapwood cannot always be reliably identified by colour difference.	Moderately hard.	Moderately coarse textured	_____
No:6	Red Sal (Indonesia)	Sapwood distinct from Heartwood, pale greyish or brownish white. Heartwood brown or reddish brown on exposure.	Hard to very hard.	Coarse textured.	Interlocked grain.
No:7	Honne (Australian)	Sapwood distinct from Heartwood, pale yellowish or nearly white. Heartwood golden brown with dark streaks.	Moderately hard to hard.	Medium coarse textured	Interlocked grain.
No:7	Teak (Burma)	Sapwood white to pale yellowish or greyish white, Heartwood golden brown on exposure.	Moderately hard	Medium coarse	Uneven textured with straight grain.
No:7	Acacia	Sapwood and Heartwood are distinct. Heartwood is yellowish brown colour.	Moderately hard.	Medium textured	Shallowly interlocked grain.
No:7	Neem	Sapwood-yellow to yellowish grey Heartwood-reddish to reddish brownon exposure.	Hard to very hard.	Medium to coarse textured.	Interlocked grain.
No:8	Honne	Sapwood distinct from Heartwood, pale yellowish or nearly white. Heartwood golden brown with dark streaks.	Moderately hard to hard.	Medium coarse textured	Interlocked grained
No:8	Local Teak	Sapwood white to pale yellowish or greyish white, Heartwood golden brown on exposure.	Moderately hard	Medium coarse	Uneven textured with straight grain.
No:8	Teak (Burma)	Sapwood white to pale yellowish or greyish white, Heartwood golden brown on exposure.	Moderately hard	Medium coarse	Uneven textured with straight grain.
No:8	Acacia	Sapwood and Heartwood are distinct. Heartwood is yellowish brown colour.	Moderately hard.	Medium textured	Shallowly interlocked grain.
No:8	Neem	Sapwood-yellow to yellowish grey Heartwood-reddish to reddish brown on exposure.	Hard to very hard.	Medium to coarse textured.	Interlocked grain.

Table-2
Anatomical Features

Sample No.	Sample Name	Pore Size	Growth rings. And pore arrangement.	Inclusions or Colour Deposits	Vessels lines	Parenchyma or Soft Tissue	Rays	Ripple marks
No.1	Honne (Australia)	Large to moderately large.	A diffuse porous wood. Growth rings indistinct to distinct. Fairly distinct to the eye, few to moderately few, solitary arrangement or in short radial multiples of 2-4.	Often filled with brownish gummy deposits.	Vessel lines distinct on longitudinal surface.	Narrow, wavy or straight tangential bands touching or partially enclosing pores.	Very fine, not visible to the eye.	Ripple marks visible to the eye.
No.1	Teak (Burma)	The early wood has pores which are large and clearly visible to the eye.	A ring porous wood. Growth rings were distinct. Late wood pores moderately large to small, mostly solitary in short radial multiples.	Pores are partly filled with tylosesand sometimes yellowish – white deposits.	Vessel lines distinct on longitudinal surfaces.	Vasicentric, forming a thin sheath round the pores and also delimiting growth rings.	Rays moderately broad, visible to the naked eye.	No ripple marks.
No.1	White Sal (Malaysia)	Vessels are moderately large	Growth rings are absent.	Tyloses present, vessel deposits are absent.		Parenchyma paratracheal sometimes incomplete, narrow vasicentric, aliform or occasionally confluent.	Rays. Medium to fine, may be visible without a lens	No ripple marks.
No.2	Honne (Indonesia)	Large to moderately large.	A diffuse porous wood. Growth rings indistinct to distinct. Fairly distinct to the eye, few to moderately few, solitary arrangement or in short radial multiples of 2-4.	Often filled with brownish gummy deposits.	Vessel lines distinct on longitudinal surface.	Narrow, wavy or straight tangential bands touching or partially enclosing pores.	Very fine, not visible to the eye.	Ripple marks visible to the eye.
No.2	Teak (Burma)	Pores in the early wood are found to be large and clearly visible to the eye.	A ring porous wood. Growth rings distinct. Late wood pores moderately large to small, mostly solitary in short radial multiples	Pores are partly filled with tyloses and sometimes yellowish – white deposits.	Vessel lines distinct on longitudinal surfaces.	Vasicentric, forming a thin sheath round the pores and also delimiting growth rings.	Rays moderately broad, visible to the naked eye.	No ripple marks.
No.2	Red Sal (Malaysia)	Pores are large moderately large.	A diffuse porous wood. Growth rings are indistinct. Pores mostly arranged solitary and in short multiples of 2-3.	Heavily plugged with tyloses.	Vessel lines dinstinct on longitudinal surface.	Soft tissues rather scanty to abundant, just visible to the eye.	Rays finely moderately broad.	No ripple marks.

Sample No.	**Sample Name**	**Pore Size**	**Growth rings. And pore arrangement.**	**Inclusions or Colour Deposits**	**Vessels lines**	**Parenchyma or Soft Tissue**	**Rays**	**Ripple marks**
No:3	Honne (Australia)	Large to moderately large**.**	A diffuse porous wood. Growth rings indistinct to distinct. Fairly distinct to the eye, few to moderately few, solitary arrangement or in short radial multiples of 2-4.	Often filled with brownish gummy deposits.	Vessel lines distinct on longitudinal surface.	Narrow, wavy or straight tangential bands touching or partially enclosing pores.	Very fine, not visible to the eye.	Ripple marks visible to the eye.
No:3	Teak (Burma)	Pores in the early wood are found to be large and clearly visible to the eye.	A ring porous wood. Growth rings distinct. Late wood pores moderately large to small, mostly solitary in short radial multiples	Pores are partly filled with tyloses and sometimes yellowish – white deposits.	Vessel lines distinct on longitudinal surfaces.	Vasicentric, forming a thin sheath round the pores and also delimiting growth rings.	Rays moderately broad, visible to the naked eye.	No ripple marks
No:3	Red Sal (Malaysia)	Pores are large moderately large	A diffuse porous wood. Growth rings are indistinct. Pores mostly arranged solitary and in short multiples of 2-3.	Heavily plugged with tyloses.	Vessel lines dinstinct on longitudinal surface.	Soft tissues rather scanty to abundant, just visible to the eye.	Rays finely moderately broad.	No ripple marks
No:4	Honne (Australia)	Large to moderately large**.**	A diffuse porous wood. Growth rings indistinct to distinct. Fairly distinct to the eye, few to moderately few, solitary arrangement or in short radial multiples of 2-4.	Often filled with brownish gummy deposits.	Vessel lines distinct on longitudinal surface.	Narrow, wavy or straight tangential bands touching or partially enclosing pores.	Very fine, not visible to the eye.	Ripple marks visible to the eye.
No:4	Teak (African)	Pores in the early wood are found to be large and clearly visible to the eye.	A ring porous wood. Growth rings distinct. Late wood pores moderately large to small, mostly solitary in short radial multiples	Pores are partly filled with tyloses and sometimes yellowish – white deposits.	Vessel lines distinct on longitudinal surfaces	Vasicentric, forming a thin sheath round the pores and also delimiting growth rings.	Rays moderately broad, visible to the naked eye.	No ripple marks
No:5	Honne (Indonesia)	Large to moderately large**.**	A diffuse porous wood. Growth rings indistinct to distinct. Fairly distinct to the eye, few to moderately few, solitary arrangement or in short radial multiples of 2-4.	Often filled with brownish gummy deposits.	Vessel lines distinct on longitudinal surface.	Narrow, wavy or straight tangential bands touching or partially enclosing pores.	Very fine, not visible to the eye.	Ripple marks visible to the eye.

Sample No.	**Sample Name**	**Pore Size**	**Growth rings. And pore arrangement.**	**Inclusions or Colour Deposits**	**Vessels lines**	**Parenchyma or Soft Tissue**	**Rays**	**Ripple marks**
No:5	Teak (Burma)	Pores in the early wood are found to be large and clearly visible to the eye.	A ring porous wood. Growth rings distinct. Late wood pores moderately large to small, mostly solitary in short radial multiples	Pores are partly filled with tylosesand sometimes yellowish – white deposits.	Vessel lines distinct on longitudinal surfaces.	Vasicentric, forming a thin sheath round the pores and also delimiting growth rings.	Rays moderately broad, visible to the naked eye.	No ripple marks.
No:5	White Sal	Vessels are moderately large	Growth rings are absent.	Tyloses present, vessel deposits are absent.	_____	Parenchyma paratracheal sometimes incomplete, narrow vasicentric, aliform or occasionally confluent.	Rays. Medium to fine, may be visible without a lens	No ripple marks
No:5	Red Sal	Pores are large moderately large	A diffuse porous wood. Growth rings are indistinct. Pores mostly arranged solitary and in short multiples of 2-3.	Heavily plugged with tyloses.	Vessel lines dinstinct on longitudinal surface.	Soft tissues rather scanty to abundant, just visible to the eye.	Rays finely moderately broad.	No ripple marks.
No:5	Neem	Pores are moderately large, visible to the eye.	A diffuse porous wood. Growth rings distinct.	Vessels filled with brownish gum.	_____	Concentric lines of parenchyma which are distributed irregularly.	Rays just visible to the eye, fine to moderately board.	No ripple mark.
No:6	Honne (Australia)	Large to moderately large**.**	A diffuse porous wood. Growth rings indistinct to distinct. Fairly distinct to the eye, few to moderately few, solitary arrangement or in short radial multiples of 2-4.	Often filled with brownish gummy deposits.	Vessel lines distinct on longitudinal surface.	Narrow, wavy or straight tangential bands touching or partially enclosing pores.	Very fine, not visible to the eye.	Ripple marks visible to the eye.
No:6	Teak (Burma)	Pores in the early wood are found to be large and clearly visible to the eye.	A ring porous wood. Growth rings distinct. Late wood pores moderately large to small, mostly solitary in short radial multiples	Pores are partly filled with tyloses and sometimes yellowish – white deposits.	Vessel lines distinct on longitudinal surfaces.	Vasicentric, forming a thin sheath round the pores and also delimiting growth rings.	Rays moderately broad, visible to the naked eye.	No ripple marks

Sample No.	**Sample Name**	**Pore Size**	**Growth rings. And pore arrangement.**	**Inclusions or Colour Deposits**	**Vessels lines**	**Parenchyma or Soft Tissue**	**Rays**	**Ripple marks**
No:6	White Sal (Malaysia)	Vessels are moderately large	Growth rings are absent.	Tyloses present, vessel deposits are absent.	_____	Parenchyma paratracheal sometimes incomplete, narrow vasicentric, aliform or occasionally confluent.	Rays. Medium to fine, may be visible without a lens	No ripple marks.
No:6	Red Sal (Indonesia)	Pores are large moderately large.	A diffuse porous wood. Growth rings are indistinct. Pores mostly arranged solitary and in short multiples of 2-3.	Heavily plugged with tyloses.	Vessel lines dinstinct on longitudinal surface.	Soft tissues rather scanty to abundant, just visible to the eye.	Rays finely moderately broad.	No ripple marks.
No:7	Honne (Australia)	Large to moderately large**.**	A diffuse porous wood. Growth rings indistinct to distinct. Fairly distinct to the eye, few to moderately few, solitary arrangement or in short radial multiples of 2-4.	Often filled with brownish gummy deposits.	Vessel lines distinct on longitudinal surface.	Narrow, wavy or straight tangential bands touching or partially enclosing pores.	Very fine, not visible to the eye.	Ripple marks visible to the eye.
No:7	Teak (Burma)	Pores in the early wood are found to be large and clearly visible to the eye.	A ring porous wood. Growth rings distinct. Late wood pores moderately large to small, mostly solitary in short radial multiples	Pores are partly filled with tyloses and sometimes yellowish – white deposits.	Vessel lines distinct on longitudinal surfaces.	Vasicentric, forming a thin sheath round the pores and also delimiting growth rings.	Rays moderately broad, visible to the naked eye.	No ripple marks
No:7	Acacia	Pores are moderately large.	A diffuse porous wood. Growth rings are indistinct. Vessels arranged solitary and radially in multiples of 2-5.	_____	_____	Parenchvma vasicentric	Rays fine, closely spaced.	No ripple marks.
No:7	Neem	Pores are moderately large, visible to the eye.	A diffuse porous wood. Growth rings distinct. Solitary or in radial multiples of 2 to 3.	Vessels filled with brownish gum.	_____	Concentric lines of parenchyma which are distributed irregularly.	Rays just visible to the eye, fine to moderately board.	No ripple mark.

Sample No.	Sample Name	Pore Size	Growth rings. And pore arrangement.	Inclusions or Colour Deposits	Vessels lines	Parenchyma or Soft Tissue	Rays	Ripple marks
No:8	Honne	Large to moderately large**.**	A diffuse porous wood. Growth rings indistinct to distinct. Fairly distinct to the eye, few to moderately few, solitary arrangement or in short radial multiples of 2-4.	Often filled with brownish gummy deposits.	Vessel lines distinct on longitudinal surface.	Narrow, wavy or straight tangential bands touching or partially enclosing pores.	Very fine, not visible to the eye.	Ripple marks visible to the eye.
No:8	Local Teak	Pores in the early wood are found to be large and clearly visible to the eye.	A ring porous wood. Growth rings distinct. Late wood pores moderately large to small, mostly solitary in short radial multiples	Pores are partly filled with tylosesand sometimes yellowish – white deposits.	Vessel lines distinct on longitudinal surfaces.	Vasicentric, forming a thin sheath round the pores and also delimiting growth rings.	Rays moderately broad, visible to the naked eye.	No ripple marks
No:8	Teak (Burma)	Pores in the early wood are found to be large and clearly visible to the eye.	A ring porous wood. Growth rings distinct. Late wood pores moderately large to small, mostly solitary in short radial multiples	Pores are partly filled with tyloses and sometimes yellowish – white deposits.	Vessel lines distinct on longitudinal surfaces.	Vasicentric, forming a thin sheath round the pores and also delimiting growth rings.	Rays moderately broad, visible to the naked eye.	No ripple marks
No:8	Acacia	Pores are moderately large.	A diffuse porous wood. Growth rings are indistinct. Vessels arranged solitary and radially in multiples of 2-5.	_____	_____	Parenchvma vasicentric.	Rays are fine, closely spaced.	No ripple marks.
No:8	Neem	Pores are moderately large, visible to the eye.	A diffuse porous wood. Growth rings distinct. Solitary or in radial multiples of 2 to 3.	Vessels filled with brownish gum.	_____	Concentric lines of parenchyma which are distributed irregularly.	Rays just visible to the eye, fine to moderately board.	No ripple mark.

References

1. Rosen P. (2004). The Great Trials of the Twentieth Century, The Lindberg baby Kidnapping Trial. First edition. NY: Rosen Publishing Group.

2. Institute of Wood Science and Technology (2012). A manual for field identification of important timbers, wood properties and engineered wood division. Mysuru, Karnataka.

3. James Stuart H. and Nordby Jon J. (2005). Forensic Science: An Introduction To Scientific And Investigative Techniques. Second edition, CRC Press.

4. Core H.A., Côte W.A. and Day A.C. (1979). Wood structure and identification. 2nd ed. Syracuse, NY: Syracuse University Press.

5. Desch H.E. and Dinwoodie J.M. (1996). Timber structure, properties, conversion and use. 7th ed. London, UK: Macmillan Press.

6. Hoadley R.B. (1990). Identifying wood: accurate results with simple tools. Newtown, CT: Taunton Press.

7. Schweingruber F. (1978). Microscopic wood anatomy. Birmensdorf: Swiss Federal Institute for Foreign Research.

8. Schweingruber F.H. (1978). Preparation of Wood and Herb Samples for Microscopic Analysis. *Wood structure and environment*, (XII), 279.

9. Rumana Rana (2008). Correlation between anatomical/chemical wood properties and genetic markers as a means of wood certification. Forest Sciences and Forest Ecology of Georg-August University of Goettingen, Germany.

10. Goswami, D. V.; Patil M.J.; Modi, A.; Tiwari, R. (2010). Pharmacognostic and Phytochemical Investigation of Stem Bark of Tectona grandis Linn. *International Journal of Pharma and Bio Sciences*, V1(2).

11. Sinha S.K., Deepak M.S., Rao V.R. and Borgaonkar H.P. (2011). Dendroclimatic analysis of teak (Tectona grandis L. f.) annual rings from two locations of peninsular India. *Current Science,* 100(1)

12. Smith D.M. (1967). Microscopic methods for determining cross-sectional cell dimensions. Forest Service U. S. Department of Agriculture, 79.

13. Kokate C.K., Purohit A.P. and Gokhale S.B. (2007). Textbook of Pharmacognosy. Published by Nirali Prakashan.

14. Fabaceae of North America Update (2011), database, Updated for ITIS by the Flora of North America Expertise Network, in connection with an update for USDA PLANTS (2007-2010), Germplasm Resources Information Network (GRIN), 2007 - 2011.

15. Borgaonkar H.P. (2012). Dendroclimatology and climate change: Indian perspective. *Journal of the Indian Academy of Wood Science.*

16. Kumaran Navnith K.P. *et al*. (2014). Vegetation Response and Landscape Dynamics of Indian Summer Monsoon Variations during Holocene: An Eco-Geomorphological Appraisal of Tropical Evergreen Forest Subfossil Logs.