

WOOD STRUCTURE IN RELATION TO PROPERTIES OF LESS IMPORTANT TIMBERS GROWN IN DIFFERENT AREAS

Ghulam Mustafa Nasir¹

ABSTRACT

Neem (*Azadirachta indica*) and Mesquite (*Prosopis juliflora*) grown in Sindh, Sohanjna (*Moringa oleifera*) in Bahawalpur, Kabuli Kekar (*Acacia nilotica subsp cupressiformis*) in D.I. Khan, Beri Patta (*Heterophragma adenophyllum*), Alstonia (*Alstonia scholaris*) and Jacaranda (*Jacaranda ovalifolia*) grown in Peshawar were studied for their basic wood structure to evaluate their wood properties. Cross, radial and tangential sections of each wood were prepared and observed under the microscope for various structural features and data were collected for the frequency and dimensional measurements of different wood elements and wood rays. Results showed that the wood of Neem, Mesquite, Kabuli Kekar and Beri Patta may be stronger or better, Alstonia and Jacaranda medium and that of Sohanjna weak in strength on the basis of fiber morphological characteristics. The wood of all the studied species may be somewhat non-durable because of higher frequency or larger size of wood rays and need chemical treatment before utilization. However, Neem, wood may not require preservation due to its chemical composition. Preservative treatment and seasoning of wood of all the studied species (except Sohanjna) may be slow or somewhat difficult due to medium sized or smaller vessels. In Sohanjna the vessels are very large in diameter and the wood may be easily seasoned and treated with preservative. Furthermore, based on the Runkel ratio, Kabuli keker, Alstonia, Jacaranda, Sohanjna and Mesquite wood may also be used as raw material for pulp and paper manufacture, whereas, Neem and Beri Patta may not be suitable.

INTRODUCTION

Introduction of new wood species in wood and wood based industries for manufacturing of various products need information about their wood properties which can be assessed on the basis of their basic wood structure. Density and strength of hardwoods is generally related to portion of wood volume occupied by fibers as primary function of these cells is mechanical support. As a general rule higher the proportion of thick walled fibers the higher the strength of wood (John & Jim, 1989). Furthermore, dimensional measurements of fibers also provide a clue to predict suitability of any wood species for pulp and paper. Fiber length influences the tearing strength of paper. Fiber lumen width and wall thickness affect the fibers bonding which in turn influences the tensile strength of paper (James, 1980).

Preservation and seasoning behaviour of wood are influenced by vessels that have larger lumen than the other cell types and are specialized cells for water conduction longitudinally in wood as well as laterally to neighboring cells through extensive pitting in the walls (Kollmann and Cote, 1968). Flow of preservative primarily occurs through vessels though tyloses and deposits of gummy substances may increase resistance to flow of vessels (Jhon F. Siau, 1971).

Durability of wood is related with parenchyma (food cells). Sap staining fungi remove the stored plant food material and spoil the appearance of wood. Stained wood exposed to suitable conditions, later on attacked by wood rotting fungi which disintegrate the wood (Dinwoodie, 1983).

1 Logging Officer, Pakistan Forest Institute, Peshawar.

This study was carried out to evaluate the wood properties of seven less important timbers grown in the country on the basis of their wood structure with the objective to find out their better utilization and recommend new raw materials for wood and wood based industries in the country to meet the requirements.

Beri Patta (*Heterophragma adenophyllum*) is a moderate sized deciduous tree 03 to 06m long. This tree is native to Himalayas and planted as an ornamental in the country. Alstonia (*Alstonia scholaris*) is a large evergreen tree with straight but often buttressed trunk. It is planted extensively in Punjab as an avenue tree and in gardens. It is common in Lahore and Kharian Cantonment. Neem (*Azadirachta indica*) is a medium to large usually evergreen tree, 12 to 35m tall and with a diameter of 0.57 to 0.86m. This tree is native to Pakistan and found in Sindh, southern Punjab and lower Balochistan and has been identified as far west as Sarai Alamgir. Mesquite (*Prosopis juliflora*) is an almost evergreen, thorny, shrub or small sized tree, 10m tall. It is found in the dry plains and hills of Sindh, Punjab, Balochistan, and NWFP. Sohanjna (*Moringa oleifera*) is a large deciduous tree, grows well on well drained soils. This tree is native to Pakistan in the sub-Himalayas tract and cultivated in the plains from Rawalpindi east wood. Jacaranda (*Jacaranda ovalifolia*) is a small sized deciduous tree (may appear to be evergreen at lower elevations) having height of 12m. This tree is native to central and South America but has been cultivated in Asia and Africa. In Pakistan it is planted as an ornamental plant (Sheikh, 1993). Kabuli keker (*Acacia nilotica subsp cupressiformis*) is a perennial tree, native to India and Pakistan (wikipedia). In Pakistan it is found in Punjab and Sindh. It has narrow erect crown (<http://www.fao.org>) It has also been planted in D.I. Khan at PFI field station. It grows up to about 15m in height and 1m in girth.

MATERIALS AND METHODS

Wood material of Neem (*Azadirachta indica*) and Mesquite (*Prosopis juliflora*) was collected from Sindh, Sohanjna (*Moringa oleifera*) from Bahawarpur, Kabuli Kekar (*Acacia nilotica subsp cupressiformis*) from D.I. Khan and Beri-patta (*Heterophragma adenophyllum*), Alstonia (*Alstonia scholaris*) and Jacaranda (*Jacaranda ovalifolia*) was collected from Peshawar in log form. In order to study the basic wood structure, the wood samples were collected in the form of disc at a height of 1.2 m (Breast height) from but log of each species. Then the sample blocks of size about 1cm x 1cm x 3cm (at least having one complete growth ring) were removed from the disc of each species and prepared for section cutting by softening. Cross, radial and tangential sections of each species were prepared by standard laboratory procedures (Anon, 1971) and studied under the microscope to observe the structural features and collect data for the frequency and diameter of vessels, frequency and size of wood rays and the fiber diameter and wall thickness in each species.

In order to observe the fiber length, small portion of wood from each species was macerated in 20% Nitric acid and Potassium Chlorate to separate the fibers and measure their length by the process of micrometry. The data collected were analyzed for statistical variables such as mean value, standard deviation and coefficient of variation of each microscopic feature in each species.

Runkel ratio (2X cell wall thickness/ lumen width) was calculated for all the studied species (James, 1980) to assess their suitability for pulp and paper.

Photomicrographs of the cross section of each species were also prepared to show the wood structure.

RESULTS AND DISCUSSION

1- Beri Patta (*Heterophragma adenophyllum*)

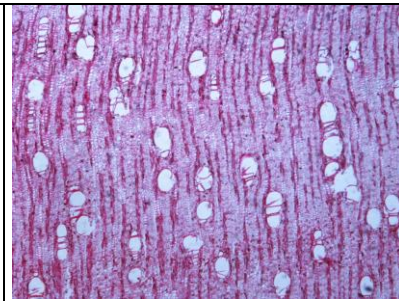
General characteristics of the wood

The wood is reddish-grey, ageing to grayish-brown, heartwood not distinct, without characteristic odour and taste, straight or interlocked grained and medium textured.

Microscopic structure

Growth rings are inconspicuous, delimited by slightly denser fibrous tissues in the outer portion of the ring and are 1.50 rings per cm.

The vessels are medium sized to small or rarely large, 84u - 244u in diameter, the largest are present generally in the central portion of the ring and the smallest in the outer portion, occur mostly solitary or in radial rows of 2-4 (mostly 2-3), quite evenly distributed and 3-13 per mm² in number. Gummy inclusions have not been observed.



Cross section of wood

Wood rays are fine, not visible to the naked eye, normally spaced, 5-7 per mm in cross section and 21-56 per mm² in tangential section. The largest rays are 246u (10 cells) in width and 4030u (121 cells) in height, frequently contiguous to vessels and somewhat darker than the background.

The fibers are semi-libriform to libriform, aligned in radial rows, forming extensive tracts between the vessels, non-gelatinous and occasionally septate. These are 0.88mm-1.43mm long, 9u-26u in diameter and the fiber walls are 3.26u-6.92u in thickness.

Parenchyma is paratracheal, paratracheal-zonate and metatracheal. Paratracheal parenchyma abundant, forming 1-several seriate sheath, paratracheal-zonate parenchyma cross the rays and either ends blindly or unite with extensions from other vessels to form 1-10 seriate bands. Metatracheal parenchyma is sparse to fairly abundant and diffused through the fibrous tracts.

From the average values, it has been observed that Beri-Patta wood may be strong due to longer, thick walled and narrow lumened fibers. It may be non-durable due to higher frequency and large size of wood rays and need preservative treatment before utilization which may be slow as the vessels are medium sized. Similarly drying process of the timber may also be slow.

2- Kabuli Kekar (*Acacia nilotica* subsp *cupressiformis*)

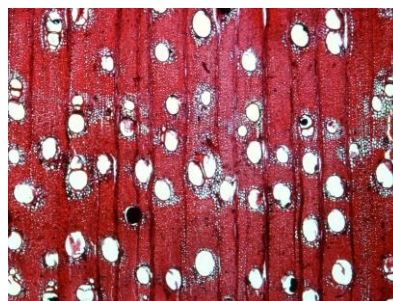
General characteristics of wood

Sapwood is grayish-white, heartwood is red when first exposed fading to reddish-brown, aromatic but without characteristic taste, moderately heavy, interlocked grained and medium to coarse-textured.

Microscopic Structure

Growth rings are distinct, sharply delimited by narrow, brown, concentric lines of terminal parenchyma. The growth rate is 1.38 rings per cm.

The vessels are large to medium-sized or small, 102 μ -220 μ in diameter, oval to elliptical in outline, occur solitary or in radial rows of 2-3 (mostly 2), somewhat unevenly distributed and usually less numerous in the outer portion of the ring and are 3-13 per mm² in number, Deposits of reddish brown gum are frequently present in the vessels.



Cross section of wood

Wood rays are visible to naked eye, medium fine, 5-6 per mm in cross section, 10-31 per mm² in tangential section, 1-5 (mostly 3-4) seriate and heterogeneous. The largest rays are 600 μ (51 cells) in height and 5 cells (55 μ) in width.

Fibers are non-libriform to semi-libriform, rather fine in radial rows, non-septate, very variable in length, 0.86mm-1.71mm, 7.77 μ -20.07 μ in diameter and fiber walls are 1.19 μ -4.29 μ in thickness.

On the basis of average values given in Table.1 Kabuli Kekar wood may be strong due to longer, narrow and reasonably thick walled fibers. It may be quite non-durable because of higher frequency and somewhat larger size of wood rays and need chemical treatment before utilization which may be slow as the vessels are medium sized and filled with deposits. Similarly seasoning process of the wood may also be slow.

3- *Alstonia* (*Alstonia scholaris*)

General characteristics of the wood

Wood is uniformly white when first exposed, turning yellowish-white to pale brown with age, heartwood not distinct, quite lustrous, without characteristic odour, with bitter taste when fresh, light or medium in weight, straight grained and medium textured.

Microscopic Structure

Growth rings are inconspicuous, when present delimited by slightly denser and darker fibrous tissue in the outer portion of the ring. Growth rings are 0.80 per cm.

The vessels are medium sized to small or very small, 65u-158u in diameter, oval to circular in outline, occasionally solitary, for the most part in radial rows of 2-5 (mostly 2-3), quite evenly distributed and are 7-18 per mm² in number. Yellow gummy deposits are occasional.



Cross section of wood

Rays are not visible to the naked eye, fine, fairly close 5–6 per mm, 1-4 seriate, heterogeneous and 7–18 per mm² in tangential section. The largest rays are 70u (4 cells) in width and 412u (19 cells) in height.

Fibers are non-libriform, non-septate and non-gelatinous, aligned in radial rows, 0.62mm-1.87mm long, 17.85u-38.25u in diameter and walls are 2.29u-3.31u in thickness.

Parenchyma is paratracheal, paratracheal-zonate and metatracheal. Paratracheal parenchyma sparse, forming 1-2 (mostly 1) seriate sheath around the vessels, paratracheal-zonate parenchyma very abundant, metatracheal parenchyma extremely sparse, diffused through the fibrous bands.

Based on the average values given in Table.1, *Alstonia* wood may be medium in strength as the fibers are long but thin walled and wide lumened. It may be moderately non-durable because of higher frequency and a bit large size of wood rays and need chemical treatment before utilization. Impregnation of wood with preservative may be to some extent difficult as the vessels are smaller in diameter. However, their frequency is reasonable which may ease the process of preservation and drying of wood.

4- Neem (*Azadirachta indica*)

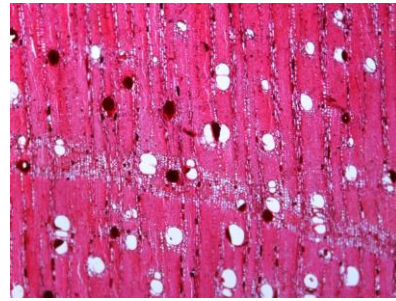
General characteristics of the wood

Sapwood is grayish-white, heartwood is red but fads to reddish brown, aromatic but without characteristics taste, moderately heavy, uneven and interlocked-grained and medium fine textured.

Microscopic Structure

Growth rings are distinct, delimited by narrow brown concentric lines of terminal parenchyma and are 0.86 rings per cm.

The vessels are small to very small, 61u - 138u in diameter, oval to elliptical in outline, occur solitary or in radial rows of 2-3 (mostly 2), contain deposits of reddish-brown gum, unevenly distributed and less numerous in the outer portion of the ring, and are 5-19 per mm² in number.



Cross section of wood

Wood rays are visible to the naked eye, medium fine, 6-7 per mm and 1-7 (mostly 3-4) seriate, homogeneous and reddish-brown spotty infiltrations are present. The largest rays are 571u (19 cells) in height and 94u (7 cells) in width.

Parenchyma is paratracheal, paratracheal-zonate and metatracheal. Terminal parenchyma visible with the naked eye forming light brown lines, paratracheal parenchyma less sparse, forms interrupted sheath around the vessels or vessel groups, paratracheal-zonate parenchyma cells contiguous to vessels, metatracheal parenchyma sparse and diffused.

Fibers are non-libriform to semi-libriform, rather fine, in radial rows, non-septate, very variable 0.78mm-1.3mm in length, 10.67u-25.76u in diameter and the fiber walls are 2.73u-8.02u in thickness.

On the basis of average values shown in Table.1, Neem wood is hard and strong due to thick walled and narrow lumened fibers. Based on the frequency and size of wood rays, the wood may be a bit non durable, however, it may not need preservative treatment due to its chemical composition as reported (www.neeminindia.com). Drying process of the timber may be slow as the vessels are very small in diameter.

5- Mesquite (*Prosopis juliflora*)

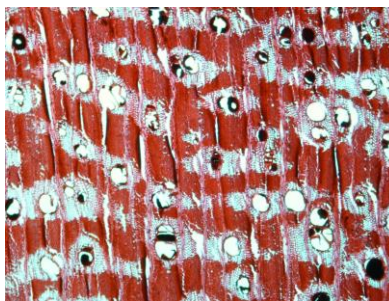
General characteristics of the wood

Sapwood is yellow, heartwood is dark reddish-brown, without any characteristic odour and taste, moderately heavy, spiral grained and medium textured.

Microscopic Structure

Growth rings are distinct delimited by darker band of earlywood and lighter band of late wood in each growth ring. Growth rate is 1.08 rings/ cm.

The vessels are quite variable in size, medium sized to small or very small, 57 μ -202 μ in diameter, circular to oval in outline, distributed throughout the growth ring, occur mostly solitary, occasionally in radial rows of 2-3 or paired tangentially and are 3-17 per mm² in number.



Cross section of wood

The rays are fine to medium sized, placed approximately at equal distance, wavy, 4-5 per mm and wavy in cross section. In tangential section, the rays are observed much variable in size. The largest rays are 5 cells (67 μ) in width and 41 cells (533 μ) in height and are 17-38 per mm² in number.

The fibers are non-libriform and non-septate, angled in cross section, irregularly arranged between the rays, 0.41mm -1.10mm long, 6.86 μ -17 μ in diameter and the fiber walls are 2.02 μ -2.45 μ thick.

Parenchyma is Paratracheal, encircling the vessels forming complete sheath, or irregular shaped projections or patches and sometimes joining two or three vessels tangentially.

From the average values given in Table.1, it has been observed that Mesquite wood may be better in strength as the fibers are very narrow in diameter and lumen width and their percentage per unit area is higher. It may be more or less non-durable because of higher frequency and somewhat larger size of wood rays and chemical treatment of wood may be necessary before its utilization. Impregnation of wood with preservative may be slow because of smaller size of vessels. Similarly drying process of the timber may also be slow.

6- Sohanjna (*Moringa oleifera*)

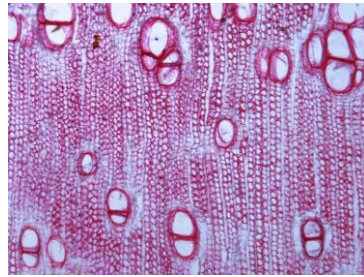
General characteristics of the wood

The wood is soft, spongy and of white colour, weak and light in weight, straight grained and coarse textured. Heartwood is not distinct.

Microscopic Structure

Growth rings are prominent, wide and are 0.38/ cm.

The wood is semi-ring porous, the vessels are medium sized to very large, distributed throughout the growth ring, 147 μ -396 μ in diameter, oval to elliptical in outline, mostly occur solitary, rarely in radial rows of 2-4, and are 2-4 per mm² in number. Tyloses are absent.



Cross section of wood

The wood rays are fine, mostly uni-seriate, wavy, closely spaced, 5-6 per mm in cross and 17-35 per mm² in tangential section. These are heterogeneous and arranged in non-storied arrangement. The largest rays are upto 3 cells (42.5 μ) in width and 243 μ (9 cells) in height.

The fibers are arranged in radial rows between the rays, libriform, non-septate and gelatinous, 0.598mm-1.43mm in length, 36.56 μ -93.47 μ in diameter and the fiber walls are 1.9 μ -8.14 μ in thickness.

Parenchyma is paratracheal forming complete (vesicentric) or incomplete (scanty) sheath around the vessels.

Based on the average values given in Table.1, Sohanjna wood may be very weak in strength because of much larger diameter and very wide lumen width of fibers. The wood may be used for manufacturing of composite wood products such as particle board and plywood etc. It may be to some extent non-durable because of higher frequency of wood rays but very easy to preserve as the vessels are much larger in diameter. Likewise drying process of the timber may also be rapid.

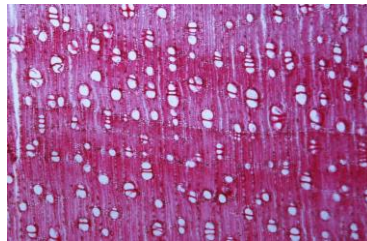
7- *Jacaranda (Jacaranda ovalifolia)*

General characteristics of the wood

The wood is of creamish colour, twisted grained and fine textured.

Microscopic structure

The wood is semi-ring porous, the vessels are small to very small, 36 μ - 92 μ in diameter, circular to oval shaped in outline, occur solitary or in radial rows of 2-4, occasionally paired tangentially or in small groups and are 14-42 per mm² in number. Tyloses are absent.



Cross section of wood

The wood rays are fine, uniseriate or occasionally biseriate, homogeneous, equidistant and straight, closely spaced, 7-8 per mm in cross section, arranged in non-storied arrangement and 49-76 per mm² in number in tangential section. The largest rays are 2 cells (21.25u) in width and 20 cells (276u) in height.

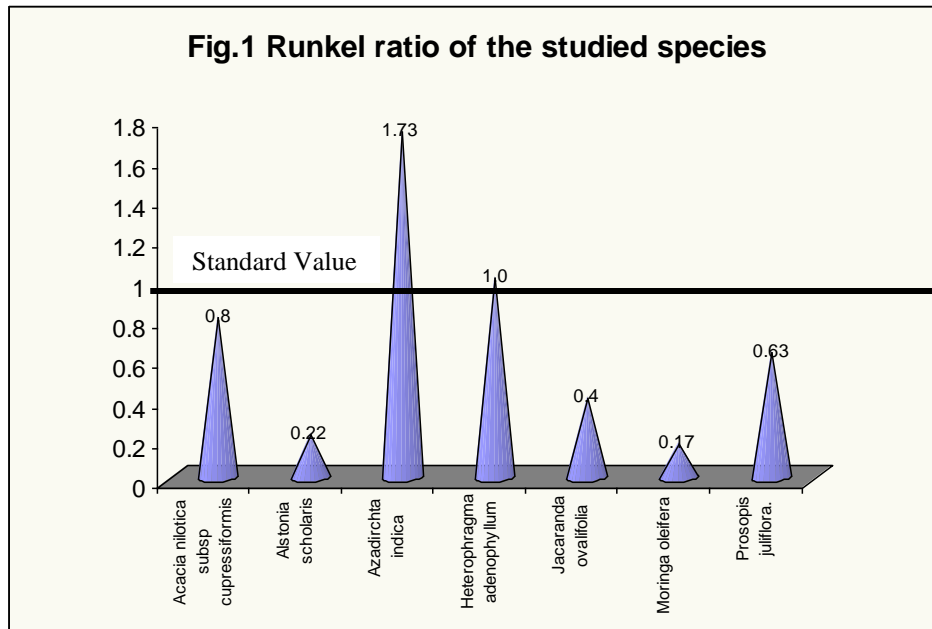
The fibers are squarish to rectangular in outline, arranged in radial rows between the wood rays, libriform, septate, 0.51mm-0.90mm in length, 10.39u-19.57u in diameter and the fiber walls are 1.51u-3u thick.

Parenchyma is terminal, delimiting the growth rings or sometimes forming thin bands joining the vessels in latewood region of the growth ring.

On the basis of average values shown in Table.1, in Jacaranda the fibers are very short, narrow and thin walled but their percentage per unit area is higher and the wood may be medium in strength. It may be non-durable because of very high frequency of wood rays. Chemical treatment of the wood may be difficult because of very small diameter of vessels however, their frequency is sufficient higher which may relieve the process. In the same way seasoning process of the wood may also be slow.

Table1. Frequency and dimensional measurement of different wood elements/ structures in the studied species (Average values)

Microscopic features			<i>Acacia nilotica</i> subsp <i>cupressiformis</i>	<i>Astonia scholaris</i>	<i>Azadirachta</i> <i>indica</i>	<i>Prosopis</i> <i>juliflora.</i>	<i>Moringa</i> <i>oleifera</i>	<i>Jacaranda ovalifolia</i>
Vessel diameter	Microns	151.50	153.99	119.74	95.80	127.82	273.35	72.29
Vessel frequency	/mm ²	7.47	7.24	10.30	10.88	8.34	2.90	31.01
Ray frequency in tangential section	/mm ²	34.37	21.29	30.09	21.52	26.85	24.30	61.11
Ray frequency in cross section	/mm	6.22	5.08	5.96	6.57	4.22	5.87	7.90
Ray width	Cells	3.2	3.12	2.62	4.05	3.22	1.85	1.16
	Microns	62.77	34.71	44.16	56.06	51.58	25.72	15.38
Ray height	Cells	37.47	20.57	10.97	12.2	21.92	6.45	6.83
	Microns	913.33	349.10	299.42	282.84	290.99	196.46	151.13
Fiber length	Mm	1.13	1.36	1.24	1.05	0.805	1.03	0.698
Fiber diameter	Microns	19.07	13.55	28.22	17.22	11.95	57.41	15.31
Fiber wall thickness	Microns	4.77	3.02	2.601	5.46	2.32	4.22	2.19
Fiber lumen width	Microns	9.53	7.51	23.01	6.3	7.11	48.97	10.91



As shown in Fig.1, Kabuli keker, Alstonia, Jacaranda, Sohanjna and Mesquite woods have the value of Runkel ratio below the standard value (1) and Beri Patta is at the edge towards the maximum value of Runkel ratio. Hence, these wood species may be used for pulp and paper manufacture whereas, Neem wood may not be suitable because of higher value of Runkel ratio.

CONCLUSIONS

The wood of Neem, Mesquite, Kabuli Keker and Beri Patta may be stronger or better in strength and used for various wood products in which strength is required.

The wood of Alstonia and Jacaranda may be medium and that of Sohanjna weak in strength and used for light wooden articles and composite wood products.

Preservative treatment of wood is required for all the studied species (except Neem) before utilization in order to enhance the durability of wood.

Preservative treatment and seasoning of wood of all the studied species (except Sohanjna) may be slow. Sohanjna wood may be easily seasoned and treated with chemical due to very large diameter of vessels.

Kabuli keker, Alstonia, Jacaranda, Sohanjna, Mesquite and Beri Patta woods may also be used as raw material for pulp and paper manufacture, whereas, Neem wood may not be suitable.

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