

WOOD ANATOMY AND TECHNOLOGICAL PROPERTIES OF SOME NON-COMMERCIAL TIMBERS GROWN IN PUNJAB

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Abstract

Anatomical properties of commercially less important timbers grown in Punjab were studied to assess their technological properties and predict better utilization other than the traditional uses. Permanent slides of cross, radial and tangential sections of each species were prepared by standard laboratory techniques and observed under the microscope for various structural features. Data were collected for the frequency and dimensional measurements of different wood elements/ structures in each species. Results showed that on the basis of fiber morphological characteristics, the wood of Phulai, Ipil Ipil, Black Siris and White Siris may be stronger or better in strength whereas, Pipal, Lasura and Jand may be medium and Gul-i-Nishtar light in strength. Due to abundant axial parenchyma, higher frequency or larger size of wood rays, the wood of all the studied species need preservative treatment before their utilization. The vessels are larger in diameter in Gul-i-Nishtar, White Siris, Pipal and Lasura wood, and these can be easily seasoned and preserved. Whereas, in Phulai, Black Siris, Ipil Ipil and Jand, the vessels are medium sized or smaller in diameter due to which drying process and preservative treatment of these woods may be slow. Furthermore, on the basis of Runkel ratio, the wood of all the studied species may also be suitable for pulp and paper manufacture.

Introduction

Production of commercial timbers grown in the country is becoming short, whereas, their demand is increasing. Therefore, it is necessary to pay attention on the other locally grown commercially less important timbers to find out their suitability to be used as substitute of commercial timbers to meet the requirements.

Phulai is a deciduous, thorny moderate size tree, 3 to 9 m tall. It is found below 1200m in the foothill ranges of the salt range, Himalayas, Suleman hills, Balochistan and Kirthar range. It is also found in the plains close to these mountains. Black Siris is a fast growing deciduous tree 12 to 30m tall with a diameter of 1m. It is native to the Sub-Himalayan tract. It grows in a narrow belt from Sialkot to Hazara, Bajaour, Buner and Malakand. It has been planted throughout the plains of Punjab and Sindh. Ipil Ipil is a fast growing, evergreen shrub or small tree 5 to 20m tall and 20cm in diameter. It is cultivated in the plains and foothill areas. Gul-i-Nishtar is a medium size tree, 12 to 15m in height. It is native to subcontinent. In Pakistan it is distributed in Punjab west of the Ravi river. White Siris is a fast growing, deciduous tree 12 to 30m tall having a diameter of 1m. It has been planted in the Punjab and NWFP. Pipal is a large deciduous tree nearly so for a short period during season. It is common in the Sub-Himalayas but probably is not native. It is cultivated throughout the plains. Lasura is a medium sized deciduous tree, 5-15m tall. It is native to Pakistan and found in the Sub-Himalayan tract from Rawalpindi eastward. It is also found in the salt Range. Jand is an almost evergreen, thorny, large shrub, small sized tree 12m tall. It is found in the dry plains and hills of Sindh, Punjab, Balochistan and NWFP (Sheikh, 1993).

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This study was carried out to compile basic data about the anatomical properties of the wood of all the above mentioned species which will be helpful to assess their technological properties and determine their suitability for different uses.

Seasoning and preservation behavior of wood is related to vessels through which the moisture can move in longitudinal as well as transverse direction. Moreover, these are the main route for the flow of preservative (Brown, 1965; Wilkinson, 1979). Durability of wood is related to parenchymatous cells. High percentage of these cells, reduce the resistance of wood against insect and fungal attack as parenchyma cells contain food material from which the insects and fungi derive their nourishment (Findlay, 1962; Kollmann and Cote, 1968). Density and strength of wood are related to fibers that constitute the mechanical tissue. Thickness of fiber walls is one of the important factors in determining the strength of wood (Dinwoodie, 1983). Greater the fiber wall thickness and narrow the lumen width, higher may be the density and strength of wood or vice versa. Low density woods preferably and medium density woods if available at good prices are used for particleboard manufacturing as a general rule (John and Jim, 1989). Furthermore, fiber morphological characteristics also help to determine the suitability of any wood species for pulp and paper manufacturing. Wide lumened and thin walled fibers produce favourable properties in paper, whereas, stiff and less flexible fibers have high value of Runkel ratio and form bulkier paper of lower bonded area than the low Runkel ratio fibers (James, 1980).

Materials and Methods

To conduct the research work, wood material of Phulai (*Acacia modesta*), Black Siris (*Albizia lebbek*), Ipil Ipil (*Leucaena leucocephala*), Gul-i-Nishtar (*Erythrina suberosa*), White Siris (*Albizia procera*), Pipal (*Ficus religiosa*), Lasura (*Cordia myxa*) and Jand (*Prosopis cineraria*) was collected in log form from different areas of Punjab. In order to study the anatomical properties, the wood samples were collected in the form of disc from the end face of but log of each species. Then the sample blocks of size about 1cm x 1cm x 3cm were removed from the disc of each species and prepared for section cutting by softening. Cross, radial and tangential sections were prepared by standard laboratory procedures (Anon, 1971) and studied under the microscope for the following features in each species.

- Frequency of vessels per unit area.
- Diameter of vessels
- Frequency of rays per mm in cross section.
- Frequency of rays per mm² in tangential section.
- Number of cells along ray height.
- Number of cells along ray width.
- Height of ray in microns.
- Width of ray in microns.
- Fiber diameter.
- Fiber wall thickness.
- Fiber lumen width.

Small portion of wood from each species was macerated in 20% Nitric acid and Potassium Chlorate (Wallis, 1965) to separate the fibers and measure the fiber length by the process of micrometry.

The data collected were analyzed for statistical variables. Runkel ratio (2X cell wall thickness/ lumen width) was also calculated for all the studied species in order to assess their suitability for pulp and paper manufacturing.

Photographs of the wood of each species were prepared to show the wood figure and Photomicrographs of the cross sections of wood of all the studied species were prepared to show the wood structure.

Results and Discussion

1. Phulai (*Acacia modesta*)

General characteristics of the wood

Sapwood is white and wide, heartwood is light russet with a faint greenish cast, aging to dark brown. The wood is hard and heavy, lustrous, without any characteristic odour and taste, straight grained and medium textured.

Structure of wood

Growth rings are inconspicuous, delimited by a broader zone of small sized pores, which are few in number. The growth rate is 1.5 rings per cm.

The vessels are circular to oval shaped in outline, large to medium sized or small, 78u-223u in diameter, arranged in radial rows of 2-3 but mostly occur solitary, 3-9 per mm² in number and thin walled with simple perforations. The largest vessels are present in the middle portion of the ring. Wood rays are fine to broad, 1-6 seriate, undulate, 2-3 per millimeter in cross section, 9-15 per mm² in tangential section and homogeneous. The largest rays are 6 cells (68u) in width and 56 cells (543u) in height. Parenchyma is paratracheal, present in 1 to several seriate sheath around the vessels or vessel groups, extend radially or tangentially joining the vessels and rays. The fibers are libriform, fine and non-septate, somewhat rounded in cross-section and not definitely arranged in radial rows. These are 0.52mm-1.56mm long, 12.75u-30.60u in diameter and the fiber walls are 2.29u-3.82u thick.

On the basis of average values given in Table 1, the fibers are reasonably longer and thick walled in Phulai wood and it may be stronger in strength. The wood rays are somewhat higher in frequency and larger in size because of which the wood may be non-durable. The vessels are medium sized due to which drying process and chemical treatment of the wood may be slow.

2. Black siris (*Albizzia lebbek*)

General characteristics of the wood

Sapwood is yellowish-white and the heartwood is dark brown, streaked with lighter and darker bands. The wood is moderately hard and heavy, without characteristic odour and taste, medium textured and straight or interlocked grained.

Structure of wood

The growth rings are distinct but inconspicuous, delimited by a narrow, mostly continuous light brown lines of thin walled fibers and terminal parenchyma. The growth rate is 1.42 rings/cm.

The vessels are large to medium sized or small, 95u-227u in diameter, open or plugged with deposits of dark reddish-brown gum, majority solitary or arranged in radial rows of 2-4 (mostly 2), evenly distributed throughout the growth ring and are 2-5 per mm² in number. Wood rays are fine to medium, not visible to the naked eye, lighter and more lustrous than the background, 1-5 (mostly 3-4) seriate, 4-5 per millimeter in cross section, 15-45 per mm² in tangential section and homogeneous. The largest rays are 46u (5 cells) in width and 330u (24 cells) in height. Parenchyma is paratracheal, paratracheal-zonate, terminal and meta-tracheal. Paratracheal parenchyma abundant, visible with the naked eye, forming halo around vessels, paratracheal-zonate parenchyma forms tangential bands, terminal parenchyma not distinct with the naked eye and sparse. Meta-tracheal parenchyma is sparse, scattered in the broad tracts of fibrous tissue. The fibers are non-libriform, not obviously aligned in the radial rows, forming extensive tracts between the vessels and rays, in part septate, non-gelatinous or gelatinous 0.65mm – 1.14mm long, 12.75u-25.5u in diameter and the fiber walls are 1.7u-5.1u thick.

On the basis of average values (Table 1), the fibers are short but fairly thick walled in Black Siris wood and the wood may be better in strength. Frequency of wood rays is higher because of which the wood may be moderately non-durable. The vessels are lower in frequency and medium in diameter for the reason drying process and preservative treatment of the wood may be slow.

3. Ipil Ipil (*Leucaena leucocephala*)

General characteristics of the wood

Sapwood is whitish, heartwood is yellowish brown in colour. The wood is hard and heavy, straight grained, fine textured and without any characteristic odour and taste.

Structure of wood

Growth rings are not clearly visible with the naked eyes and are 1.38 per cm.

The vessels are small to very small or rarely medium sized, mostly of similar size, occur solitary or in radial rows, uniformly distributed throughout the ring, 2-7 per mm², oval to circular in outline and 63u-170u in diameter. Wood rays are fine to medium, 3-4 per millimeter in cross section, 15-38 per mm² in tangential section and homogeneous. The largest rays are 5 cells (48u) in width and 20 cells (359u) in height. Parenchyma is paratracheal abundant encircling the vessels or vessel groups, sometimes extending radially. Metatracheal parenchyma is sparse, occasional cells diffused in the fibrous tissue. The fibers are septate, non-libriform and are radially aligned between the rays, 0.57-1.27mm long, 15.3u-25.5u in diameter and the fiber walls are 2.55u-5.1u in thickness.

Based on the average values given in Table 1, the fibers are thick walled and quite narrow lumened in Ipil Ipil wood and it may be stronger in strength. Frequency of wood rays is higher due to which the wood may be somewhat non-durable. The vessels are smaller in diameter due to which seasoning progression and chemical treatment of the wood may be a bit difficult.

4. Gul-i-Nishtar (*Erythrina suberosa*)

General characteristics of the wood

The wood is white when first exposed, ageing to dull pale yellow or pale yellowish-grey, slightly darker in colour near the center, without characteristic odour and taste, extremely light in weight, spongy but tough, straight grained and very coarse textured.

Structure of wood

Growth rings are scarcely distinct, delimited by one or two tangential bands of fibrous tissue and are 1.52 per cm.

The vessels are extremely large to large or rarely medium sized, 169u-312u in diameter, without transitional sizes, the largest vessels are present near the middle of the ring, placed at distance, unevenly distributed, majority solitary, remainder in radial rows of 2-3 and are 1-2 per mm² in number. Wood rays are conspicuous with the naked eye, coarse, 1-11 (mostly 6-9) seriate, 0.8 -1 per millimeter in cross section, 0.5-1.8 per mm² in tangential section and heterogeneous with the cells very variable in size. The largest rays are 286u (11 cells) in width and 2600u (270 cells) in height. Parenchyma is paratracheal, paratracheal-zonate and metatracheal. Paratracheal parenchyma peripherally flattened about the vessels, paratracheal-zonate parenchyma very abundant, forming broad concentric and wavy bands, metatracheal parenchyma abundant, restricted for the most part to the bands of fibrous tissues and mostly confined to their margins. The fibers are semi-libriform, somewhat thick-walled not aligned in radial rows non-septate, gelatinous, 0.91mm-2.13mm long, 12.75u-43.35u in diameter and the fiber walls are 2.55u-5.1u thick.

Based on the average values given in Table 1, the fibers are longer and quite thick walled in Gul-i-Nishtar wood but their lumen width is also much higher and the wood may be light in strength. The rays are very large in size because of which the wood may be highly non-durable. The vessels are sufficient large in diameter and the wood may be easily impregnated with preservative. In the same way it can be seasoned well without any difficulty.

5. White Siris (*Albizzia procera*)

General characteristics of the wood

Sapwood is white, with a yellowish cast and wide, heartwood is brown with lighter and darker bands. The wood is moderately heavy, lustrous, without characteristics odour and taste, straight or interlocked grained and very coarse textured.

Structure of wood

Growth rings are distinct but inconspicuous, delimited by a narrow, continuous light brown line of thin walled fibers and terminal parenchyma. The growth rate is 0.79 rings/cm.

The vessels are very large to large or rarely medium sized, 174u – 291u in diameter, majority occur solitary, the remainder in radial rows of 2-4 (mostly 2), quite evenly distributed and are 1-3 per mm². Wood rays are fine, not visible without a lens, 1-5 (mostly 2-3) seriate, 3-4 per millimeter in cross section, 10-24 per mm² in tangential section and homogeneous. The largest rays are 5 cells (53u) in width and 47 cells (741u) in height. Parenchyma is paratracheal, paratracheal-zonate, terminal and metatracheal. Paratracheal parenchyma is abundant and visible with the naked eye, forming wide haloes about the vessels. Paratracheal zonate parenchyma forms oblique bands around the vessels, terminal parenchyma not distinct with the naked eye, metatracheal parenchyma sparse, diffused and scattered in the broad tracts of fibrous tissue. The fibers are non-libriform, in part septate, in part gelatinous, 0.65mm-1.56mm long, 12.75 u-28.05 u in diameter and the fiber walls are 2.04 u-3.31 u thick.

On the basis of average values given in Table 1, the fibers are thin walled in White Siris wood but their length is greater and the wood may be better in strength. The frequency of wood rays is higher due to which the wood may be somewhat non-durable. The vessels are larger in diameter and the wood can be easily seasoned and treated with chemicals.

6. Pipal (*Ficus religiosa*)

General characteristics of the wood

The wood is grayish-white to yellowish-white when first exposed, turning grayish-brown with age, heartwood wanting with rather rough feel and without characteristic odour and taste. The wood is light to moderately heavy, interlocked-grained and coarse and uneven-textured.

Structure of wood

Growth rings are scarcely distinct or wanting and are 1.5 per cm.

The vessels are extremely large to large, rarely medium sized or small, 114u - 332u in diameter, solitary and in radial rows of 2-6 (mostly 2-3) or rarely in short rows and are 2-5 per mm² in number. Wood rays are broad visible with the naked eye, 1-6 seriate, normally spaced, 3-4 per millimeter in cross section, 3-10 per mm² in tangential section and heterogeneous. The largest rays are 6 cells (80u) in width and 58 cells (727u) in height. Parenchyma is paratracheal, paratracheal-zonate and metatracheal. Paratracheal parenchyma relatively sparse forming 1-several seriate sheath, paratracheal-zonate parenchyma very abundant and metatracheal parenchyma is sparse diffused in the fibrous tracts. The fibers are semi-libriform to libriform, gelatinous, in part septate, not definitely aligned in radial rows, 0.65 mm-1.32 mm long, 12.75 u-25.5 u in diameter and the fiber walls are 2.29 u-5.1 u thick.

Based on the average values (Table 1) the fibers are short but quite thick walled in Pipal and the wood may be medium in strength. The wood rays are larger in size because of which the wood may be moderately non-durable. The vessels are larger in diameter due to which the wood can be easily preserved and may give good response to seasoning.

7. Lasura (*Cordia myxa*)

General characteristics of the wood

The wood is clear-yellow when first exposed turning to grayish-brown to brown, heartwood not distinct, dull to somewhat lustrous, without characteristic odour and taste, light to moderately heavy, straight or interlocked-grained and coarse and uneven textured.

Structure of wood

Growth rings are distinct but relatively inconspicuous, delimited by larger vessels in the spring wood and narrower in summerwood and are 1.26 per cm.

The vessels are extremely large to large, rarely medium-sized or small, 91u–364u in diameter, mostly solitary, less commonly in straight or oblique radial rows, 1-5 per mm² in number, evenly distributed and oval to elliptical in outline. Wood rays are distinct and broad, 1-6 (mostly 4-6) seriate, 2-3 per millimeter in cross section, 3-5 per mm² in tangential section and heterogeneous. The largest rays are 6 cells (145u) in width and 33 cells (1638u) in height. Parenchyma is paratracheal, paratracheal zonate and metatracheal. Paratracheal parenchyma is fairly abundant, forming a narrow 1-several seriate sheath, paratracheal-zonate parenchyma is extremely abundant and metatracheal parenchyma is very sparse, restricted to the islands of fibrous tissue and chiefly contiguous to the rays. The fibers are libriform, non-gelatinous, frequently septate and not aligned in radial rows, 0.91mm-2.86mm long, 12.75u –38.25u in diameter and the fiber walls are 2.29u – 5.1u thick.

On the basis of average values given in Table 1, the fibers are much longer and thick walled in Lasura wood but their lumen width is also higher and the wood may be medium in strength. The wood rays are very large in size and the wood may be non-durable. The vessels are sufficient large in diameter and the wood can be easily treated with preservative. In the same way the wood could behave better during seasoning process.

8. Jand (*Prosopis cineraria*)

General characteristics of the wood

Sapwood is whitish; heartwood is purple brown in colour. The wood is moderately heavy, without any characteristics odour and taste, interlocked and close grained and fine textured.

Table 1. Frequency and dimensional measurements of different wood elements/ structures in the studied non-commercial timbers grown in Punjab (Average values)

Microscopic Features	Phulai (<i>Acacia modesta</i>)	Black Siris (<i>Albezzia lebbek</i>)	Ipil Ipil (<i>Leucaena leucoccephala</i>)	Gul-i-Nishtar (<i>Erythrina suberosa</i>)	White Siris (<i>Albezzia procera</i>)	Pipal (<i>Ficus religiosa</i>)	Lasura (<i>Cordia myxa</i>)	Jand (<i>Prosopis cineraria</i>)
Vessel frequency /mm ²	5.85	2.99	3.78	1.00	2.14	3.23	2.20	6.21
Vessel diameter u	158.03	175.19	122.94	254.15	244.84	233.66	215.47	107.91
Ray frequency /mm In cross section	2.25	4.24	3.208	0.88	3.20	3.33	2.26	1.44
Ray frequency /mm ² in tangential section	11.54	31.06	27.27	1.04	17.01	6.80	3.28	1.51
Ray height cells u	24.17	14.47	8.86	84.17	18.7	28.55	18.2	52.6
	341.40	229.64	240.80	1545.7	307.31	476.44	1109.55	1230.45
Ray width cells u	3.87	3.35	2.92	7.15	3.25	4.55	3.77	12.97
	50.19	27.22	35.89	214.5	35.41	56.70	105.00	245.05
Fiber length mm	1.05	0.87	0.99	1.61	1.08	0.92	2.03	0.93
Fiber diameter u	17.85	18.10	19.72	31.62	18.89	20.31	27.71	16.23
Fiber wall thick- Ness u	3.57	3.49	3.52	3.46	2.61	3.34	3.64	2.72
Fiber lumen width u	10.71	11.12	12.68	24.7	13.67	13.63	20.43	10.97

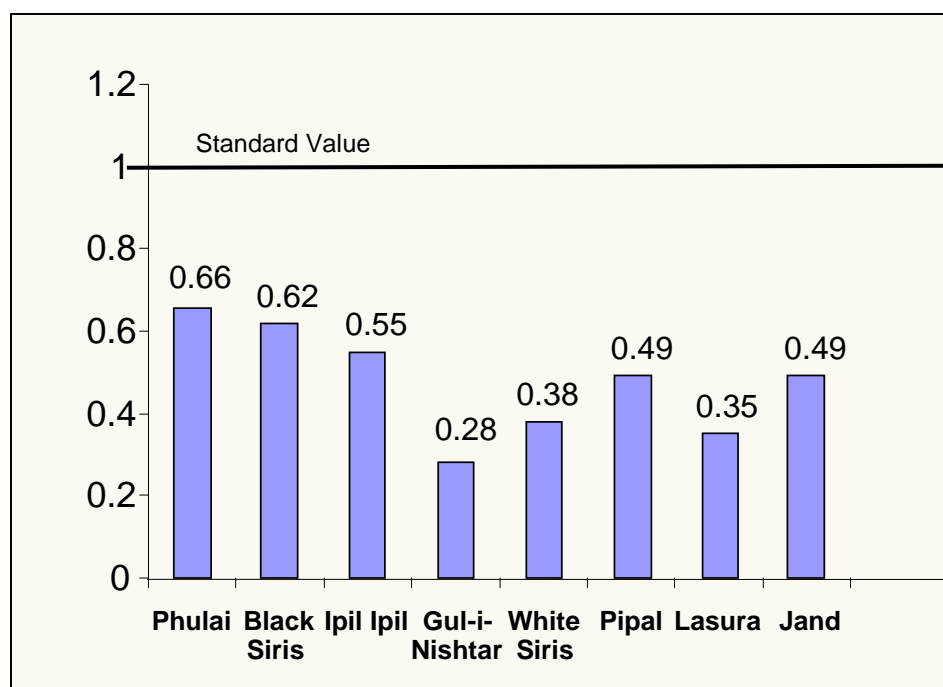


Fig. 1. Runkel ratio of the studied non-commercial timbers grown in Punjab

Structure of wood

Growth rings are not prominent and are 1.01 per cm.

The vessels are small to very small, 58u-155u in diameter, circular or oval shaped in outline, evenly distributed throughout the ring, 3-9 per mm² in number, occur solitary or in radial rows, mostly in groups of 2-3. Wood rays are broad to very broad, 1-1.5 per millimeter in cross section, 1-2 per mm² in tangential section and heterogeneous. The largest rays are 28 cells (390u) in width and 108 cells (2210u) in height. The fibers are thin, libriform, non-septate and short, 0.52mm-1.56mm long, 10.2u-20.4u in diameter and the fiber walls are 2.29u-3.82u thick.

Based on the average values as given in Table 1, the fibers are short and thin walled but narrow lumened in Jand and the wood may be medium in strength. The rays are very large in size because of which the wood may be highly non-durable. The vessels are smaller in diameter for the reason the wood may be somewhat difficult to treat with preservative and seasoned however, their frequency is higher which may ease the processes.

As shown in Fig.1, all the species have Runkel ratio below the standard value (1) hence, the wood of all the studied species may also be used for pulp and paper. Furthermore, Gul-i-Nishtar, White Siris and Lasura wood may be more suitable among the studied species on the basis of fiber morphological characteristics.



Phulai (*Acacia modesta*)



Black Siris (*Albezzia lebbek*)



White Siris (*Albezzia procera*)



Lasura (*Cordia myxa*)



Gul-i-Nishtar
(*Erythrina suberosa*)



Ipil Ipil
(*Leucaena leucocephala*)

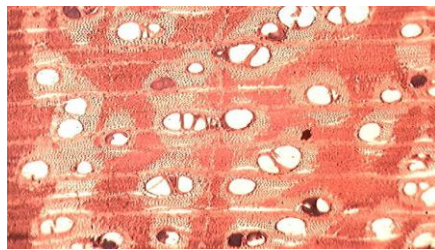


Pipal (*Ficus religiosa*)

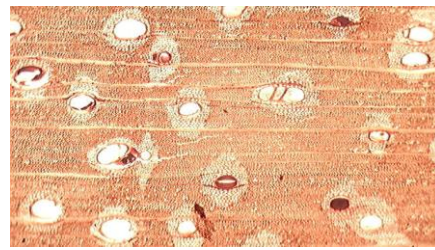


Jand (*Prosopis cineraria*)

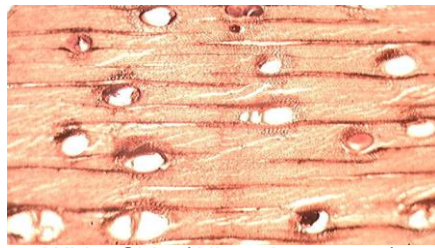
Fig. 2. Photographs showing the wood figure of the studied non-commercial timbers grown in Punjab



Phulai (*Acacia modesta*)



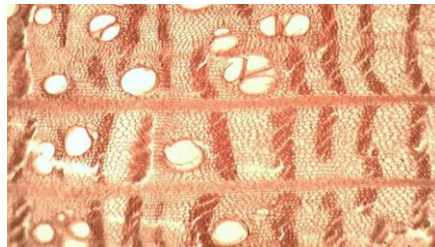
Black Siris (*Albezzia lebbek*)



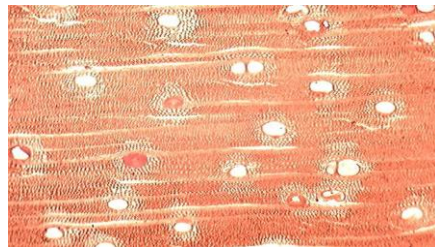
White Siris (*Albezzia procera*)



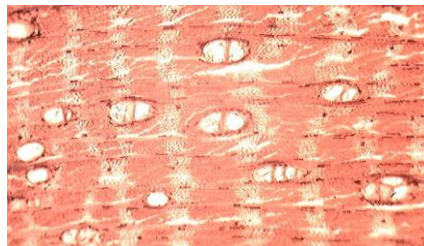
Lasura (*Cordia myxa*)



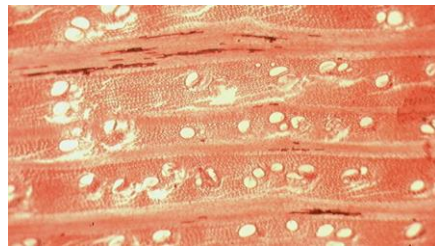
Gul-i-Nishtar
(*Erythrina suberosa*)



Ipil Ipil
(*Leucaena leucocephala*)



Pipal (*Ficus religiosa*)



Jand (*Prosopis cineraria*)

Fig. 3. Photomicrographs showing the wood structure of the studied non-commercial timbers grown in Punjab

Conclusions

- Phulai, Ipil Ipil, Black Siris and White Siris wood may be stronger or better in strength and suitable for manufacturing of various wood products.
- Pipal, Lasura and Jand may be medium and Gul-i-Nishtar wood light in strength and used for light furniture articles and composite wood products.
- Preservative treatment of the wood is necessary for all the studied species before their utilization as timber in order to increase the service life.
- Gul-i-Nishtar, White Siris, Pipal and Lasura wood could behave better during seasoning and preservation, whereas, the drying process and chemical treatment of Phulai, Black Siris, Ipil Ipil and Jand wood may be slow.
- The wood of all the studied species may also be used for pulp and paper. Gul-i-Nishtar, White Siris and Lasura wood may be more suitable on the basis of fiber morphological characteristics.

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