TECHNOLOGICAL PROPERTIES AND SUITABILITY DETERMINATION OF SOME NON-COMMERCIAL TIMBERS ON THE BASIS OF ANATOMICAL PROPERTIES

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Abstract

In order to decrease the pressure on commercial timbers grown and utilized in the country, some non-commercial timbers grown in NWFP such as Ber (*Zizyphus mauritiana*), Bakain (*Melia azedarach*), White Bakain (*Ailanthus altissima*), Phulai (*Acacia modesta*), Amaltas (*Cassia fistula*), Paper Mulberry (*Broussonetia papyrifera*), Ghaz (*Tamarix aphylla*), Chinar (*Platanus orientalis*) and Ipil Ipil (*Leuceana leucocephala*) were studied for their anatomical properties to assess their various technological properties and to find out their better utilization on the basis of basic data. Permanent slides of cross, radial and tangential sections of each species were prepared by standard laboratory techniques and observed under the microscope for the structure and dimensional measurements of various wood elements/ structures. Results showed that in Amaltas, Ber, Bakain, White Bakain and Paper mulberry woods, the vessels were sufficient large in diameter and in Chinar and Paper mulberry woods, the frequency of vessels was found to be higher. Therefore, the woods may be easily seasoned and preserved. Amaltas, Chinar, Paper mulberry, Ber, Bakain, White Bakain, and Farash woods the frequency or size of wood rays was found to be higher and the woods may be non-durable. Therefore, chemical treatment of these woods is necessary before utilization as structural timbers for manufacturing of products. In Amaltas, Chinar Ipil Ipil, Bakain, White Bakain and Phulai, the fibers were longer or thick walled and the woods may be stronger or comparatively better in strength properties. Moreover, all the studied woods except Phulai can also be used for pulp and paper manufacturing on the basis of higher fibre morphological characteristics.

Introduction

Pakistan has a small number of commercial timber species. Moreover, the demand of conventional/traditional timbers is increasing day by day due to heavy consumption. Whereas, their production is becoming short. In order to solve this problem, it is necessary to pay attention on other locally grown timbers those are not yet commercially used because of lack of information despite of the fact that these are growing successfully in Pakistan.

Bakain tree is planted extensively in the plain areas of NWFP, grows up to 6 to 12 meters in height and 0.57 to 0.70 m in diameter. Chinar has been successfully planted in the N.W.F.P areas, 20 to 25 m tall and 1 to 3 m in diameter. Phulai is very common in the lower hills of Hazara, moderate sized tree, 3 to 9 m tall with diameter up to 2m. White bakain grows well on all kinds of soils, fast growing tree, attains a height of 6 to 10 m. Amaltas grows mostly in plain regions and continuing north into the Himalayas, 5 to 9 m in height. Ber grows well at lower elevations in N.WF.P and other parts of the country, shrub or small sized tree about 12 m tall with a diameter of 40cm. Farash grows well on well drained soils and can tolerate highly saline/sodic sites, grows 10 to 18 m in height and 1m in diameter. Paper mulberry grows very fast on a variety of well drained, rich

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soils and Ipil Ipil is cultivated in the plains and foothill areas, 5 to 20 m tall. (Sheikh, 1993).

Basic data about the anatomical properties of wood are of prime importance. It helps to assess the behavior of wood and its suitability for different uses. Frequency and size of vessels determine the seasoning and preservation behavior of wood as vessels are the main route for the flow of preservatives (Wilkinson, 1979) and are like drain pipes and moisture can move through them lengthwise as well as side wise (Findlay, 1962). The wood rays influence the durability of wood. They are composed of food cells (Pearenchymatous). Higher the percentage of wood volume occupied by wood rays and parenchyma, lesser may be the resistance of wood to insect and fungal attack (Brown, 1965; Kollamann and Cote, 1968). Fiber morphological characteristics determine the strength of wood as the fibers are comparatively thick walled cells and constitute the mechanical tissue(Desch, 1983). Moreover, suitability of wood for pulp and paper manufacturing can also be determined on the basis of Runkel ratio. Favourable paper strength properties are usually obtained when value of Runkel ratio is 1 (Dadswell and Watson, 1962). Higher Runkel ratio fibers are stiffer, less flexible and form bulkier paper of lower bonded areas than low rankel ratio fibers (James, 1980).

A study was planned at FPRD of PFI to investigate new timber species by studying the wood properties and help the local forest products industry to extend the base of raw materials for manufacturing variety of forest products.

Material and Methods

In order to conduct the research work, wood samples of Ber (*Zizyphus mauritiana*), Bakain (*Melia azedarach*), White bakain (*Ailanthus altissima*), Phulai *(Acacia modesta*), Amaltas (*Cassia fistula*), Paper mulberry (*Broussonetia papyrifera*), Ghaz (*Tamarix aphylla*), Chinar (*Platanus orientalis*), and Ipil Ipil (*Leuceana leucocephala*) were collected in the form of discs from the end face of butt log of each species. Age of the tree, growth rate and average ring width were determined in each species. To study the structure, frequency and dimensional measurements of various wood elements/ structures, the sample blocks of size about 1cm x 1cm x 3cm were removed from the disc of each species and permanent slides of cross, radial and tangential sections were prepared by standard laboratory procedures (Anon, 1971) and data were collected for the following microscopic features of each species.

- Frequency of vessels per unit area.
- Diameter of vessels
- Frequency of wood rays per mm in cross section.
- Frequency of wood rays per mm square 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.

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 in each species by the process of micrometry (Anon.1971).

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 and Runkel ratio (2 X cell wall thickness/ lumen width) was calculated to assess the suitability of each species for pulp and paper production. Detailed results have been presented in Table 1 and Figures.

Results & Discussion

Anatomical Properties of Ber (*Zizyphus mauritiana)*

General characteristics of the wood

The wood is light red in color when first exposed, turning to reddish brown with age, dull, with smooth feel, without characteristic odour and taste, light to moderately heavy, uneven and interlocked grained and medium textured.

Structure of wood

Growth rings are indistinct to reasonably distinct, delimited by a denser fibrous tissue and very narrow inconspicuous lines of terminal parenchyma, varying in width and slightly undulate on the margins and are 1.06/cm.

Vessels are small to medium sized, 77.6µ - 257.05µ in diameter, occur solitary or in radial rows of 2-5 (mostly 2-3), several contiguous in tangential plane or in group in earlywood portion. The smallest vessels are present in the end of the growth rings, unevenly distributed, usually most numerous near the inner third of the ring and are 3-9 per millimeter square in number. Tyloses are absent and deposits of orange brown gum are frequently present.

Wood rays are fine and invisible with naked eye, sometimes darker than the background, very close, 10 per millimeter in cross section, 38 - 83 per millimeter square in tangential section, mostly 1-2 seriate and homogeneous. The largest rays are 48.5µ (2cells) in width and 426.8µ (16 cells) in height.

Parenchyma is terminal, Paratracheal and metatracheal. Terminal parenchyma is visible with a hand lens of 10x and undulate. Paratracheal parenchyma is visible as narrow halo about the vessels, forming 1 – several celled sheath around the vessels, extend tangentially joining the vessels or end blindly. Metatracheal parenchyma is sparse and scattered in groups.

Fibers are semi-libriform, arranged in radial rows, non-septate, short 0.78mm - 1.3mm long, 10.2µ-17.85µ in diameter and walls are 2.29µ-3.82µ thick.

Anatomical Properties of Bakain (*Melia Azedarach*)

General Characteristics of the wood

The sapwood is yellowish-white and the heartwood is red, turning to reddish brown with age. The wood is lustrous, odourless, tasteless, light, straight grained coarse and uneven textured.

Structure of wood

Growth rings are conspicuous delimited by a zone of large springwood pores as the wood is ring porous, variable in width and are 0.97/cm.

Vessels are of two sorts. The earlywood vessels occur solitary or paired radially or contiguous in tangential plane, larger in size, 94.5µ-304.5µ in diameter and are 7-15/mm sq. in number. The latewood vessels occur in groups, forming flame like irregular oblique patches along with longitudinal parenchyma, smaller in size, 63µ-241.5µ wide and are 3 - 15/mm sq. in number. Tyloses are absent. Reddish-brown gummy deposits are abundant occluding the vessels.

Wood rays are broad, visible with the naked eye on the cross surface of wood, homogeneous, 9.-16/mm sq. in tangential section and 3-4/mm in cross section. The largest rays are up to 582µ (32 cells) high and 67.9µ (7 cells) wide.

Parenchyma is Paratracheal and metatracheal. Paratracheal parenchyma is abundant encircling the vessel groups forming flame-like irregular oblique patches extending across the rays. The metatracheal parenchyma forms a broad belt in the beginning of the growth rings or scattered.

Fibers are non-libriform, arranged in radial rows, non-septate, 0.78mm -1.3 mm long, 12.75µ-22.95µ in diameter and the fiber walls are 2.55µ-5.1µ thick.

Anatomical Properties of White Bakain (*Ailanthus altissima*)

General characteristics of the wood

The wood is white and lustrous when first exposed, turning light grayish –white with age, with rough feel, without any characteristic odour and taste. It is very light, straight grained, fairly even and very coarse textured.

Structure of wood

Growth rings are not distinct, wide and are 1.39/cm.

The vessels are of two sorts. Earlywood vessels are appreciably large, visible with the naked eye, 106.7µ-291µ in diameter, arranged in concentric rows forming bands in the beginning of the growth rings, occur singly or sometimes forming radial rows and

are 2 - 5/mm sq. in number. The latewood vessels are small to very small, 33.95µ - 111.55µ in diameter, mostly occur in groups and are 4-17 /mm sq. in number.

The rays are of two sorts, the broad rays, visible to the naked eye on the cross surface of wood and the fine rays. In tangential section, the rays are 3-5 /mm sq. and in cross section they are 2/mm in number. The largest rays are upto 70 cells (777 microns) in height and 9 cells (210 microns) in width.

Parenchyma abundant, paratracheal, paratracheal Zonate and metatracheal. Paratracheal parenchyma abundant, surrounding the vessels or vessel groups. Paratracheal-zonate parenchyma cells attached to the vessels strongly peripherally flattened. Metatracheal parenchyma relatively sparse and scattered.

Fibers are non-libriform, non-septate and gelatinous, somewhat angular in outline in cross section, arranged irregularly, 0.572mm-1.43mm long, 15.3µ-28.05µ in diameter and the walls are 2.5µ -5.1µ thick.

Anatomical Properties of Phulai (*Acacia modesta*)

General characteristics of the wood

Sapwood is white and wide; heartwood is light russet with a faint greenish cast, ageing to dark brown. The wood is somewhat lustrous, without any characteristic odour and taste, fairly even, straight grained and medium textured.

Structure of wood

Growth rings are distinct but inconspicuous, not visible with the naked eye and are 1.42/cm.

Vessels are varying in size, smaller and larger distributed throughout the ring, medium sized to very small, 52.5µ-220.5µ in diameter, occasionally occluded with deposits, occurred solitary or in radial rows of 2-3 and are 4-7 /mm sq. in number.

Rays are scarcely distinct with the naked eye, separated by broad tracts of fibers, 3 - 4/mm in cross section and 13 - 22 /mm sq. in tangential section. The largest rays are 672µ (72 cells) in height and 42µ (5 cells) in width.

Parenchyma paratracheal, paratracheal-zonate, terminal and metatracheal. Paratracheal parenchyma visible with a hand lens (10x) as narrow light brown halo around the vessels, paratracheal-zonate parenchyma cells contiguous to the vessels, terminal parenchyma not visible to naked eye, forming light brown lines, metatracheal parenchyma sparse, diffused in fiber tracts.

Fibers are libriform, non-septate, not definitely aligned in radial rows, 0.728mm-1.352mm long, 10.2µ-17.85µ in diameter and walls are 2.55µ-5.1µ thick.

Anatomical Properties of Amaltas (*Cassia fistula*)

General characteristics of the wood

Sapwood is pale-dirty white; heartwood is brick red to light reddish-brown, having no taste and odour. The wood is somewhat heavy, straight grained and coarse textured.

Structure of wood

Growth rings are not prominent, delimited by terminal parenchyma and are 1.6/cm.

Vessels are varying in size from large to small, large sized are numerous and mostly in the middle of ring, occur mostly solitary, rarely in rows 4-12 /mm sq. in number and are 78µ-221µ in diameter.

The rays are not distinct with naked eye, narrow, straight and separated by rows of parenchyma, 6-10 /mm in cross section and 33 - 62/mm sq. in tangential section, the largest rays are 19 cells (388 microns) in height and 4 cells (40.8 microns) in width.

Parenchyma paratracheal, terminal, paratracheal-Zonate and metatracheal. Paratracheal parenchyma forms halo around vessels; terminal parenchyma forms narrow sharply defined lines of light brown colour, paratracheal- zonate parenchyma is mainly in the middle of the ring, metatracheal parenchyma restricted to the tracts of fibrous tissue.

Fibers are libriform, in part septate, generally gelatinous, 1.35 mm-2.13 mm long, 16.06µ-33.91µ in diameter and the fiber walls are 1.42µ-3.57µ in thickness.

Anatomical Properties of Paper mulberry (*Broussonetia papyrifera)*

General characteristics of the wood

Sapwood is grayish white; heartwood is light brown in colour. The wood looks light in weight and is straight grained, is soft and lustrous, coarse textured, having no odour and taste.

Structure of wood

Growth rings are distinct, delimited by a zone of lighter spring-wood followed by denser zone of late-wood with denser fibrous tissue and are 0.73/cm.

Vessels vary in size. Mostly circular to oval in outline, occur in radial rows of 2-4 as well as solitary and are of two sorts. Late wood vessels 53-220./mm sq, in number and 24.25µ-101.85µ in diameter, Early wood vessels are 143µ-286µ in diameter and are 5-10 /mm sq. in number.

Rays are broad, heterogeneous, visible to naked eye 2-3./mm in cross section and 10 -16 /mm sq. in tangential section. The largest rays are 806µ (40 cells) in height and 77.6µ (5 cells) in width.

Parenchyma paratracheal forms usually 1-seriate sheath around the vessels or vessel groups.

Fibers are non-libriform, thin-walled, fine, non-septate and gelatinous. 0.57mm-0.98mm long, 10.2µ-20.4µ in diameter having 2.04µ-5.1µ thick walls.

Anatomical Properties of Farash (*Tamarix aphylla*)

General characteristics of the wood

Heartwood is too reduced; sapwood is wide and white, with a yellowish tinge. The wood is light, straight to twisted grained, coarse and uneven texture, without having any odour and taste.

Structure of wood

Growth rings are scarcely distinct and wide and are 0.94/cm.

The vessels are small to medium, variable in size, 58.2µ-184.3µ in diameter, somewhat larger in the early portion of the ring forming vessel lines along the grain, occur solitary, mostly paired tangentially or in clusters, distributed unevenly and are 2 -8 /mm sq. in number. Tyloses are absent.

The wood rays are broad conspicuous and visible with the naked eye, 2 - 3 /mm in cross section, homogeneous, and 2 -3 /mm sq, in tangential section. The largest rays are 1690µ (136 cells) height and 271.6µ (16 cells) in width. Ripple marks are abundant on the longitudinal surface of wood.

Parenchyma is paratracheal, forming 1-several seriate sheath around the vessels or vessel groups connecting the vessels with rays.

The fibers are non-libriform, rounded or angled in transverse section and are not arranged in radial rows, gelatinous, non-septate, 0.54mm - 0.88mm long, 10.2µ-20.4µ in diameter and the wall are 2.55µ-5.1µ thick.

Anatomical Properties of Chinar (*Platanus orientalis)*

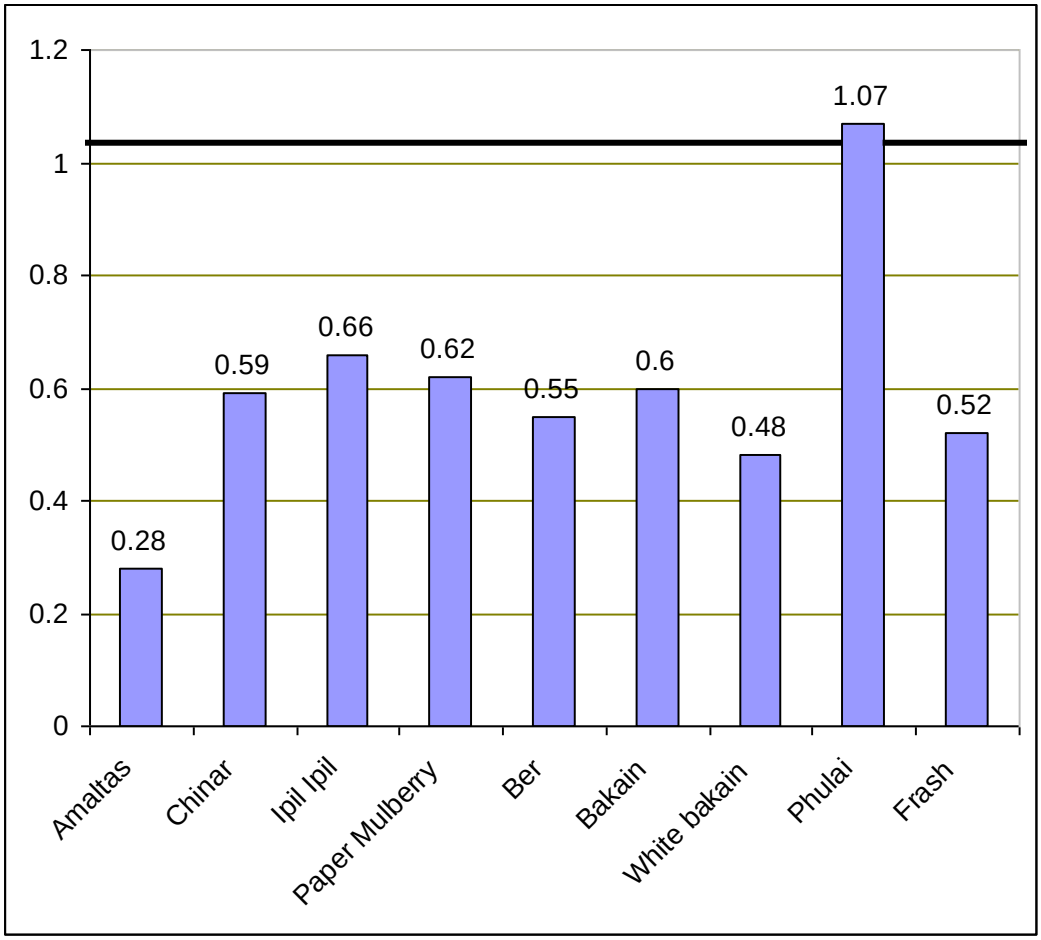
General characteristics of the wood

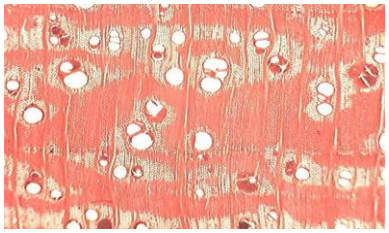
Sapwood is wide, grayish-brown; heartwood is of reddish-brown colour, having no characteristics taste and odour, light in weight, straight grained, medium fine and uneven textured.

Table 1. Frequency and dimensional measurements of various wood elements / structures of some non-commercial timbers

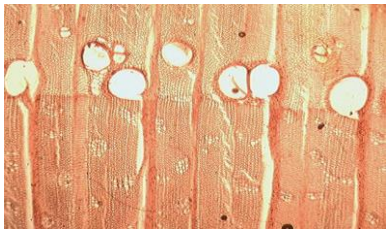
Microscopic Features	Amaltas	Chinar	Iple Iple	Paper Mulberry	Ber	Bakain	White bakain	Phulai	Frash
Number of vessels	5.97/mm^2	57.19 /mm^2	4.19 /mm^2	Late wood 130.44/mm^2 Early wood 6.92/mm^2	5.69 /mm^2	Late wood 8.62/mm^2 Early wood 10.35/mm^2	Late wood 10.92/mm^2 Early wood 3.52/mm^2	5.79 /mm^2	5.12 /mm^2
Diameter of vessel	161.72 µ	82.06 µ	116.01 µ	Late wood 55.87 µ Early wood 203.84 µ	170.9 µ	Late wood 161.17 µ Early wood 249.11 µ	Late wood 77.40 µ Early wood 206.09 µ	134.19 µ	116.78 µ
Number of rays in cross section	8.01 /mm	2.67/mm	3.94 /mm	3 /mm	10.27/mm	3.6/mm	1.84/mm	3.71/mm	2.15/mm
Number of rays in tangential sect.	49.57 /mm^2	1.72 /mm^2	23.29 /mm^2	13.40 /mm^2	52.26 /mm^2	11.78 /mm^2	4.38 /mm^2	18.10 /mm^2	2.54 /mm^2
Width of ray	20.35 µ	203.31 µ	39.01 µ	42.47 µ	27.93 µ	46.17 µ	110.62 µ	30.1 µ	178.68 µ
	2.16 cells	8.5 cells	3.28 cells	3.34 cells	1.22 cells	3.98 cells	5.8 cells	3.27 cells	12.26 cells
Height of ray	200.98 µ	1755.4 µ	192.83 µ	553.28 µ	239.9 µ	302.23 µ	396.9 µ	375.48 µ	959.4 µ
	10.12 cells	111.14 cells	10.85 cells	16.78 cells	6.5 cells	15.76 cells	27.27 cells	36.2 cells	64.36 cells
Fiber Length	1.75 mm	1.07 mm	1.2 mm	0.77 mm	1.03 mm	1.024 mm	1.04 mm	1.06 mm	0.73 mm
Fiber diameter	22.62 µ	14.28 µ	20.91 µ	15.68 µ	14.40 µ	17.08 µ	22.69 µ	13.38 µ	17.34 µ
Fiber wall thickness	2.49 µ	2.66 µ	4.169 µ	3.03 µ	2.58 µ	3.23 µ	3.69 µ	3.46 µ	3.0 µ
Fiber Lumen width	17.64	8.96	12.57	9.62	9.24	10.62	15.31	6.46	11.34

Fig.1. Runkel ratios of different non-commercial tree species

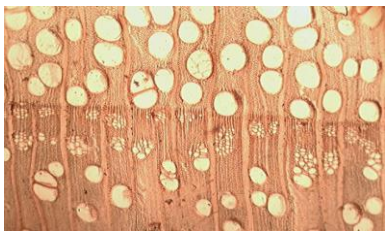




Phulai (*Acacia modesta*)

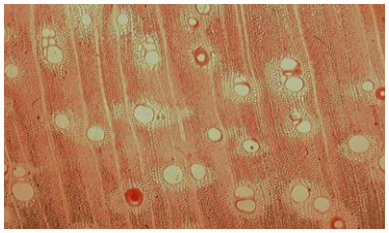


White bakain (*Ailanthus altissima*)

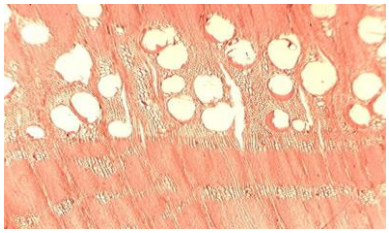


Paper mulberry
(*Broussonetia papyrifera*)

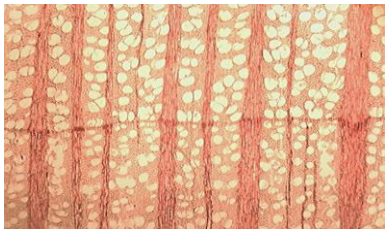
Amaltas (*Cassia fistula*)



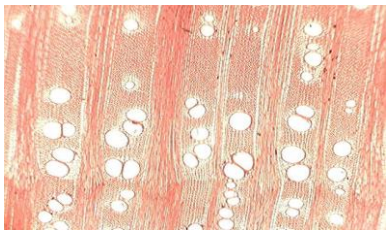
Ipil Ipil (*Leuceana leucocephala*)



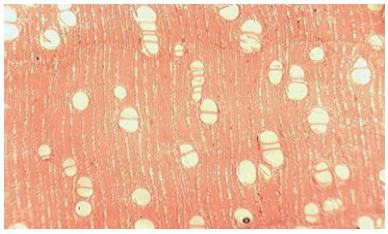
Bakain (*Melia azedarach*)



Chinar (*Platanus orientalis*)



Frash (*Tamarix aphylla*)



Ber (*Zizyphus mauritiana*)

Photomicrographs of some non-commercial timbers

Structure of wood

Growth rings are prominent, and are 0.79/cm.

The vessels are numerous, small in size, occur in groups, evenly distributed 38 - 98 /mm sq., oval to circular in outline, 63.05µ-111.55µ in diameter.

Wood rays are prominent visible to the naked eye, broad and homogeneous, 2-3/mm in cross section and 1-2 /mm sq. in tangential section. The largest rays are 310.4µ (16 cells) in width and 3276µ (260 cells) in height.

The fibers are non-septate and libri-form, 0.78mm-1.43mm long, 10.2µ -17.85µ in diameter and fiber walls are 2.04µ - 3.31µ in thickness.

Anatomical Properties of Ipil Ipil (*Leucaena leucocephala*)

General characteristics of the wood

Sapwood is whitish, heartwood is yellow-brown in colour, wood is heavy, straight grained with medium fine texture and without any characteristics odour and taste.

Structure of wood

Growth rings are not clearly visible with the naked eye and are 1.15 per cm.

The vessels are mostly of similar size, solitary or in radial rows, uniformly distributed throughout the ring and are 2.-7/mm sq. in number, oval to circular in outline and 33.95µ-169.75µ in diameter.

Wood rays are fine or broad, homogeneous, 3 - 4/mm in cross section and 18 - 28 /mm Sq. in tangential section. The largest rays are 5 cells (61.2 microns) in width and 19 cells (388 microns) in height.

The fibers are septate, non-libiform and are radially aligned, 0.624mm-1.69mm long, 15.3µ-25.5µ in diameter and the fiber walls are 2.55µ-7.65µ in thickness.

Parenchyma is para-tracheal, abundant, encircling the vessels or vessel groups, sometimes extending radially. meta-tracheal parenchyma sparse, occasionally cells diffused in the fibrous tissue.

Conclusions

Amaltas, Ber, Bakain, White bakain, Paper Mulberry and Chinar woods can be easily seasoned and preserved whereas, Iple Iple, Phulai, and Farash woods may be somewhat difficult to season and treat with chemicals.

Amaltas, Chinar, Paper Mulberry, Ber, Bakain, White Bakain and Farash woods needs chemical treatment in order to increase durability of wood before utilization as structural timbers for manufacturing of products.

Amaltas, Chinar, Ipil Ipil, Bakain, White Bakain and Phulai woods may be stronger or better in strength properties whereas, paper mulberry, Farash and Ber woods may be medium in strength on the basis of fiber characteristics.

All the timbers except Phulai can also be used for pulp and paper manufacturing due to higher fiber morphological characteristics.

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