ANATOMY AND SUITABILITY OF MAZRI (*NANNORRHOPS RITCHIANA*, GRIFF.) FOR PULP AND PAPER AS BASED ON FIBER CHARACTERISTICS

MOHAMMAD AYAZ, LOGGING OFFICER, FOREST PRODUCTS RESEARCH DIVISION, PAKISTAN FOREST INSTITUTE, PESHAWAR

ABSTRACT

Mazri, beside it's traditional uses in making of various household and other utility articles, is also very rich in fibers. Studies on fiber characteristics like average fiber length, relative fiber length and Runkel ratio show that the fibers from Mazri are suited for the production of pulp and paper of good quality. Mazri fibers being "medium long" can supplement hardwood and non-woody pulps as pulp furnish. At present low and scattered supplies and competition from traditional uses are the technical and economic constraints in it's utilization as a raw-material for pulp and paper.

INTRODUCTION

Mazri (*Nannorrhops ritchiana*) is a gregarious, tufted, low growing palm with robust, prostrate and branching stem, reaching a height of more than 6 m. Leaf blade is about 1 m long, cuneately flabellate, rigid, plicate, split to the middle or lower into 8-15 curved, 2-fid segments often with inter-posed fibers; petiole 15-30 cm long, unarmed, concave with a mass of rust coloured wool at the base (Parker, 1956). Mazri grows naturally in Makran, Kharan, Khuzdar, Harnai and Sibi in Balochistan and Kohat and Kurram Agency in the province of NWFP (Mughal, 1992).

Mazri leaves are used as raw-material to support an important cottage industry, in the nearby areas of it's production, in the provinces of Balochistan and NWFP. Men, women and children prepare various household and other utility articles like mats, baskets, brushes, brooms, fans, hats, sandals, ropes and cordage etc from Mazri leaves. The average annual production of

Mazri leaves (1971-72 to 1988-89) is 23,906 tonnes, of which 21,987 tonnes (92%) come from Balochistan and 1,919 tonnes (8%) are procured from NWFP (Amjad and Khan, 1990). Pakistan is deficient in pulp and paper and a foreign exchange of Rs.3,034 million (Anonymous, 1994) is annually spent on the import of this commodity from other countries to meet the domestic needs. The main reason for low local production is the shortage of raw-material for pulp and paper. Mazri leaves are very rich in fiber which could supplement raw-material supplies for pulp and paper in the country. With this objective in view studies were under taken at the Forest Products Research Division, Pakistan Forest Institute, Peshawar on the anatomy of Mazri leaf and petiole with special attention to the fiber characteristics as basic determinants of it's suitability for pulp and paper.

MATERIAL AND METHODS

- Material:

Fresh Mazri leaves were procured from the Hangu area of Kohat Forest Division and brought to the laboratory for the study of anatomy and fiber characteristics of leaf and petiole. Pieces from the middle portion of leaf and petiole were fixed in Formalin-Aceto-Alcohol (FAA) for a minimum duration of 18 hours (Johansen, 1940).

- Methods:

Sectioning

20 micron (μ) thick free hand cross sections of the middle portion of leaf and petiole were prepared on a sliding microtome. This was done by holding a convenient sized piece of leaf with mid-rib in the slot made in a soft and water soaked wooden block of about 1.5x1.5 cm cross section. The recesses between the wooden block and leaf were filled with 10% celloidin-ether-alcohol solution. This wooden block, holding the piece of leaf, was attached to the microtome, properly orientated, and sectioned. A piece of petiole of Mazri, being more rigid and woody, was directly attached to the microtome and sectioned. During sectioning each time the cut faces of leaf and petiole were coated with a layer of 10% celloidin-ether-alcohol solution to ease sectioning. Celloidin from the sections was mechanically removed after immersion under water till the film of celloidin started loosening from the sections.

Staining

Sections of leaf and petiole were given double staining with safranin and fast green (Johansen, 1940)). Stained sections were rinsed in water and then dehydrated after passing them through grades of alcohol-water mixtures of increasing concentration upto 100% of alcohol. The rate of destaining in 100% (absolute) alcohol was carefully watched and at the required point the sections were quickly cleared in clove oil and then given a few washing in xylol. Finally the stained sections were mounted on a slide in neutral canada balsam-xylol solution.

Maceration

For the measurement of fiber length, match-stick sized pieces from the middle portion of leaf with mid-rib and petiole were taken and macerated separately by Schultze's Reagent (boiling in a test tube with 10% Nitric acid and a little Potassium chlorate). Macerated material was thoroughly washed in water and fibers separated with the help of a hand centrifuge. Fibers were stained by teasing them in a drop of weak solution of methylene blue on a slide. Temporary slides of fibers were made for measurement of fiber length.

Studies and Measurements

Anatomy of Mazri leaf and petiole was studied from the cross sections. Fiber length from

temporary slides of fibers and fiber diameter and lumen diameter, from permanent slides of cross sections of leaf and petiole, were measured in microns (μ) under different magnifications of microscope with the help of an eye-piece micrometer. 50 measurements of fiber length and 25 measurements each for fiber diameter and lumen diameter were taken both for leaf and petiole.

Analysis of Data

Average, minimum and maximum values of different fiber dimension were calculated. Data on fiber length in micron were converted to mm along with the calculation of standard deviation. From the fibre dimensions the other fibre values like Relative Fiber Length (fiber length/fiber diameter) and Runkel Ratio (2x cell wall thickness/lumen diameter) were also calculated.

Results and Discussion

The anatomy of Mazri leaf and petiole [figures 1 and 2, page 5] exhibit xerophytic adaptation by having sunken stomata, thick cuticle and the absence of spongy parenchyma from the leaf. The anatomical features of leaf and petiole of Mazri strongly resemble to the typical structure of leaf and stem of family Gramineae of monocots (Metcalfe, 1960). Further details on the anatomy of leaf and petiole and fiber characteristics of Mazri are given as under:

a. Anatomy:

I. Leaf: For the anatomical description of leaf reference is made to figure 1.

i. Epidermis

Epidermis consists of a unicellular layer of colourless cells covered externally with thick cuticle [1]. In cross section epidermal cells are smaller than hypodermal cells and slightly radially compressed. Stomata are sunken [2] and present on both adaxial and abaxial leaf surfaces, but more numerous of the abaxial side. Stomata have sub-stomatal air spaces.

ii. Hypodermis

Hypodermis consists of 2-3 layers of more or less rectangular chlorenchyma cells just beneath the epidermis [3], interrupted at places by the sub-stomatal air spaces.

iii. Bulliform parenchyma

There is a broad zone of colourless polygonal bulliform parenchyma cells in the region of mid-rib [4] above the large vascular bundle and below the upper epidermis interspersed with patches of sclerenchyma [5].

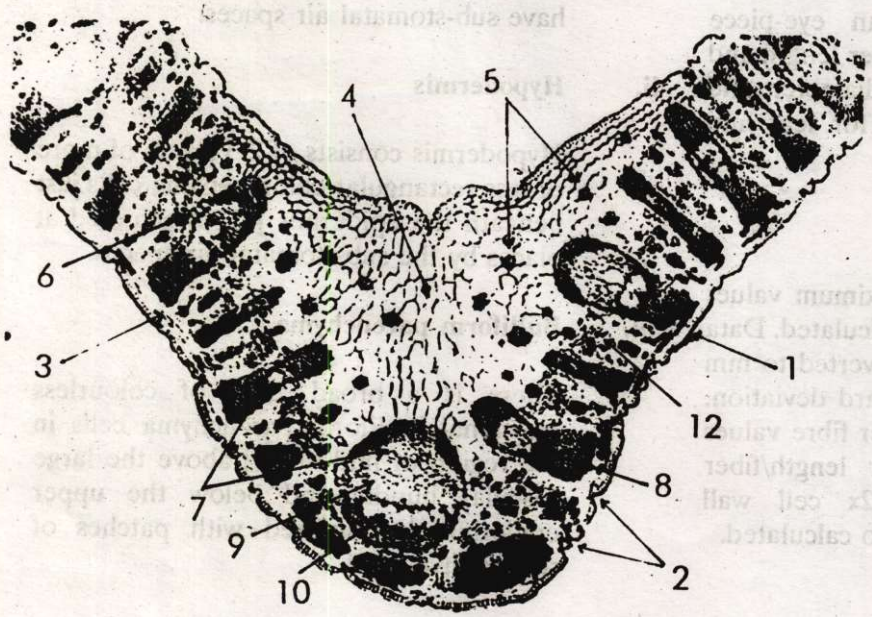
iv. Mesophyll tissue

Mesophyll tissue consists of polygonal chlorenchyma cells without inter-cellular spaces and differentiation of palisade region, distributed in between the vascular bundles containing patches of sclerenchyma [12].

v. Vascular bundles

Vascular bundles are numerous and distributed in a single layer [7] except at the region of mid-rib where about three vascular bundles are degenerated and are replaced by a single, large and roundish vascular bundle. In size also the vascular bundles are variable. Each bundle has a unicellular but incomplete bundle sheath [6] which is more prominent on the lateral sides. Inner to the bundle sheath lies a continuous sheath of sclerenchyma which is much broader above the xylem and

three figures



1. Epidermis with cuticle
2. Sunken stomata
3. Hypodermis
4. Bulliform Parenchyma
5. Patches of sclerenchyma
6. Bundle sheath
7. Vascular bundles
8. Sclerenchyma sheath
9. Xylem
10. Phloem
11. Ground tissue
12. Mesophyll tissue

Fig: 1 Cross Section of Mazri Leaf through Mid-rib (50X)

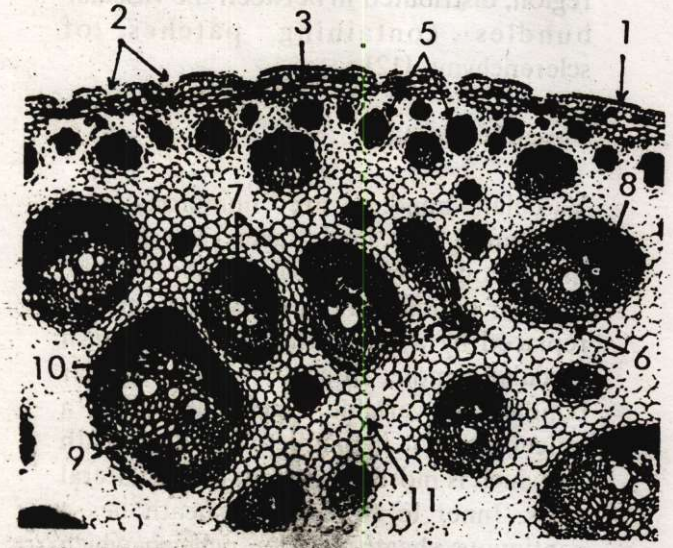


Fig: 2 Cross Section of a part of Mazri petiole (50X)

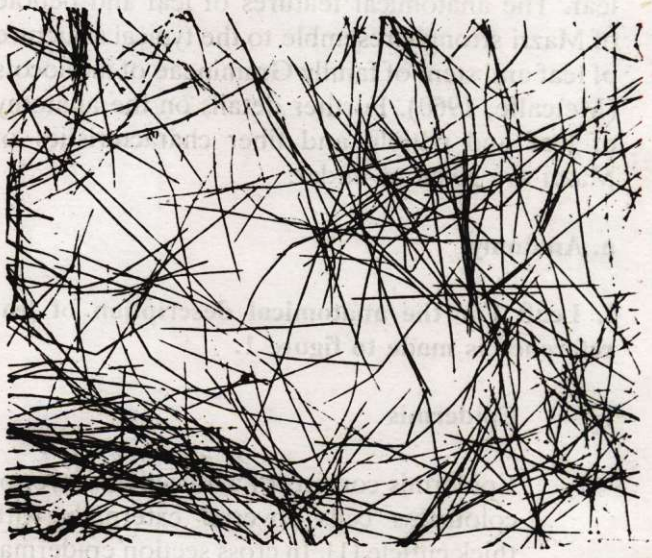


Fig: 3 Mazri Fibers (15X)

below the phloem. This condition reaches it's maximum in the vascular bundles of the lamina (wings), giving them a vertically compressed appearance [8]. Xylem tissue [9] lies above the phloem [10] separated by a layer of sclerenchyma. Metaxylem consist of larger vessel elements than protoxylem. Phloem consists of scattered phloem tissue and sclerenchyma.

Sclerenchymatous sheath of vascular bundles constitute the bulk of the fiber content of the leaf.

II. Petiole: **For the anatomical description for petiole, reference is made to figure 2.**

i. Epidermis

Petiole is covered with a unicellular layer of colourless epidermal cells having a thick cuticle [1]. In cross section epidermal cells are smaller than hypodermal cells and slightly radially compressed. Epidermis has sunken stomata [2] leading to sub-stomatal air spaces which are equally frequent on all sides.

ii. Hypodermis

Hypodermis consists of 3-4 cells thick layer of more or less rectangular chlorenchyma just beneath the epidermis [3] and is interrupted at places by the sub-stomatal air spaces.

iii. Ground tissue

Ground tissue consists of thin walled, round, colourless parenchyma with inter-cellular spaces, filling the entire space between vascular bundles and inner to hypodermis [11]. Parenchyma cells of ground tissue at the peripheral region are smaller in size containing chloroplast and strands of sclerenchyma [5] which are probably vascular bundles with totally degenerated conducting tissue.

iv. Vascular bundles

Vascular bundles are numerous and scattered throughout the ground tissue [7]. The vascular bundles at the peripheral region are smaller than those in the center. Each vascular bundle is roundish or elliptical in outline, with phloem [10] directed outwards, xylem [9] inwards and surrounded by a thick sheath of sclerenchyma [8], which is broadest above the phloem and below the xylem. Each vascular bundle is partially surrounded by a parenchymatous bundle sheath [6]. Xylem and phloem are separated by a layer of sclerenchyma. Phloem contains scattered patches of phloem tissue and sclerenchyma. Protoxylem lies inner to the metaxylem and consists of a few smaller vessel elements in association with xylem parenchyma. Metaxylem consists of 2-3 large vessels elements. Vascular bundles at the periphery have a more thicker sclerenchymatous sheath directed towards the periphery with poorly differentiated conducting elements.

Sclerenchymatous sheath of vascular bundles constitute the bulk of the fiber content of the petiole.

b. Fiber Characteristics:

All the sclerenchymatous tissue described above under the anatomy of Mazri leaf and petiole are also termed as fibers for the purpose

of pulp and paper [Fig:3]. The results of studies on fiber length and other fiber characteristics of Mazri are given in following table:

Table Fiberdiension of Mazri leaf and patiole

Parts	Fiber length (mm)			Av. Fiber Dia. (μ) [D]	Av. lumen dia. (μ) [d]	Relat-ive Fiber Length [L/D]	Runkel Ratio [D-d/d]
	Average [L]	Minimum	Maximum				
Leaf	2.16 ± 0.35	1.39	3.09	9.6	4.2	226	1.29
Petiole	2.08 ± 0.36	0.76	3.21	10.3	6.6	202	0.56
Average	2.12 ± 0.35	1.07	3.15	9.9	5.4	213	0.83

i. Fiber length

Casey, (1979) mentions a positive correlation between fiber length and tear strength of the paper. The longer the fiber the higher is the tear strength.

The over all average fiber length of Mazri (leaf+petiole) is 2.12 mm (1.07-3.15 mm). The average fiber length of petiole as 2.08 mm (0.76-3.21 mm) is shorter than the fiber of leaf having an average length of 2.16 mm (1.39-3.09 mm).

The average fiber length of 2.12 mm of Mazri is higher than the fiber length of most of the hardwoods (0.80 -1.2 mm) and grasses (1-2 mm); comparable to bamboo (2-3 mm) and shorter than softwoods (3-5 mm). On this basis the fibers of Mazri are categorized as "medium long" to produce a paper with high tear strength.

ii. Relative fiber length

Relative fiber length is the fiber length/diameter (L/D) ratio and is an expression of slenderness or flexibility of the fibers.

The relative fiber length of Mazri is 213 (202 for petiole and 226 for leaf). High relative fiber length and fiber flexibility of Mazri is suited for good felting properties and higher bond strength of paper.

iii. Fiber diameter

The over all average diameter of Mazri fibers (leaf+petiole) is 9.9 μ. Fibers of petiole are wider having a diameter of 10.3 μ than the fibers of leaf with a diameter of 9.6 μ. Fiber diameter as such is no parameter in determining the suitability of fibers for pulp and paper, but it is to be seen in relation to fiber length and lumen diameter for the calculation of other useful indices like relative fiber length and Runkel ratio.

iv. Lumen diameter

The over all average lumen diameter of Mazri fibers (leaf+petiole) is 5.4 μ. Fibers

of petiole have wider lumen than the fibers of leaf as 6.6 and 4.2 μ, respectively. Lumen diameter as such does not convey any idea about fiber's suitability in paper making but is a useful parameter in the determination of Runkel ratio and fiber wall thickness.

v. Runkel ratio

Runkel ratio is a ratio between double of fiber wall thickness and fiber lumen diameter or expressed other way as fiber diameter-lumen diameter/lumen diameter (D-d/d). The fibers with higher Runkel ratio have relatively thick walls, are stiffer, less flexible and therefore, form bulkier paper with low bonded area.

The over all Runkel ratio of Mazri fibers is 0.83. Fibers of leaf are comparatively thick walled than the fibers of petiole with Runkel ratios of 1.29 and 0.56, respectively. The average Runkel Ratio of Mazri fibers (leaf+petiole) is less than 1 and is very desirable for the production of a well bonded paper.

CONCLUSION

Fiber characteristics like average fiber length, relative fiber length and Runkel ratio all show that the fibers from Mazri (petiole+leaf) are suited for the production of pulp of good felting and bonding properties and paper of high tear strength. Fibers being "medium long" are recommended as supplement to hardwood and non-woody pulps as pulp furnish.

The yearly supplies of Mazri from all sources are fairly uniform to the tune of about 24,000 tonnes from an area of 24,000 ha giving a yield of 1 tonne/ha/annum. These supplies are scattered over various parts of Balochistan and some parts of NWFP. Due to low supply and dispersed availability the collection, to a centralized point for pulp processing, is very difficult and expensive. Moreover, there is a strong competition from the traditional uses of Mazri due to cheep manual labour. Therefore, to base a pulp industry on Mazri, at this stage, is not technically and economically feasible.

However, with diminishing traditional uses due to increasing labour cost, in future, and increase in the production of Mazri by enlarging the area under Mazri plantations, at suitable locations, will improve the supply situation of Mazri, at competitive prices, for pulp and paper.

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