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WOOD ANATOMY OF FAMILY SALVADORACEAE FROM THE INDIAN SUBCONTINENT WITH SPECIAL REFERENCE TO THE ULTRASTRUCTURE OF THE VESSEL WALL

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ABSTRACT

The present study describes the wood microstructure of *Azima tetracantha*, *Salvadora oleoides*, and *S. persica*, the members of family Salvadoraceae represented in the Indian Subcontinent. An identification key based on wood anatomical features has been developed for the separation of the species. SEM studies revealed the presence of vesturing in intervessel pits of *Salvadora*.

Key words: *Azima*, ecology, evolution, *Salvadora*, Salvadoraceae, vested pits, wood anatomy.

INTRODUCTION

Family Salvadoraceae, the mustard-tree family, consists of three genera (*Azima* L., *Dobera* Juss., and *Salvadora* L.) with 12 species. It comprises trees, shrubs, and scramblers distributed in dry, hot regions of Africa, Madagascar, and Asia. Two genera and three species are represented in the Indian Subcontinent. *Azima* has two species of erect, thorny shrubs distributed in Myanmar and India. Only one species, *Azima tetracantha* Lam., occurs in India (Purkayastha 1985). *Salvadora* has five species of shrubs and small trees distributed in warmer parts of Africa and Asia, of which two—*S. oleoides* Decne. and *S. persica* L.—occur in India (Purkayastha 1985). *Salvadora* occurs in a diverse array of habitats, ranging (in order of increasing aridity) from the margins of mangroves, saline environments, swamps, and near riverbanks where the ground water level is high, to seasonally wet sites, grass savannah, thorn scrub, along irrigation lines in arid zones, and desert flood plains, indicating its tolerance of a wide range of water quality, soil, and soil pH conditions (Zodape and Indusekhar 1997; Ahmad 2007).

The wood of *Salvadora persica*, the toothbrush tree (Almas 2002), has useful antiseptic properties, contributing to its use in the manufacture of toothpicks (Miswak sticks) for oral hygiene. It is also used by the Egyptians to make coffins. The wood of *S. oleoides* is used for construction and in the manufacture of agricultural implements, Persian wheels (wheels operated by draught animals to lift water), and the knees of boats. Almost all parts of *Salvadora* spp. have been found to be pharmaceutically important. The leaves, roots, bark, fruits, and seeds are used for the treatment of cough, fever, asthma, and as a purgative. Roots are also used to treat chest infections and the latex to treat sores (Mahar and Malik 2001; Savithramma et al. 2007).

Prior to this work, no detailed account of microscopic wood structure was available for family Salvadoraceae from India. Gamble (1922) described gross features of these species in brief. Metcalfe and Chalk (1950) summarized microscopic features at the generic level. Den Outer and Van Veenendaal (1981) described wood and bark anatomy of *Azima tetracantha*, and Carlquist (2002) provided some detail of wood and bark anatomy of the family. Saxena and Gupta (2004) reported perforated ray cells in Salvadoraceae, and Gupta and

Saxena (2005) described perforated ray cells in order Celastrales.

MATERIAL AND METHODS

The wood anatomical microstructure of *Azima tetracantha*, *Salvadora oleoides*, and *S. persica* was studied as per the feature list developed by the International Association of Wood Anatomists (IAWA Committee 1989). The wood samples featured in Table 1 are housed at the Xylarium of Forest Research Institute (DDw), Dehradun, India.

For microscopic examination and photomicrographs, 15–20 μm -thick transectional (Fig. 1–2), tangential (Fig. 3–4, 6), and radial (Fig. 5) sections were cut on a Reichert sliding microtome, stained in Heidenhain's hematoxylin and safranin, and mounted following a standard laboratory protocol, i.e., passing through an ethanol (10–100%) and xylol series to make permanent slides. For determination of fiber and vessel element length, small radial chips were macerated following Schultz' method (30% nitric acid and a pinch of potassium chlorate). Thirty measurements were taken for fiber length, vessel length, fiber diameter, and lumen diameter from macerated material. The mean tangential diameter of the vessels was determined from 25 measurements from transverse sections taken along the maximum width in radial direction. The frequency of vessels was determined from the average of 10 counts per mm^2 area. Ray frequency (rays per mm) was based on an average of 10 counts per linear mm in tangential sections. Maximum ray height and ray width was also determined from tangential sections (Table 2). Data on specific gravity and gross features follow Purkayastha (1985). Ecological adaptability was measured in terms of vulnerability (mean vessel diameter/mean vessel frequency) and mesomorphy (vulnerability $\times$ mean vessel length) of each sample. Intervessel pitting was studied by scanning electron microscopy.

RESULTS

Generic Description and Identification Key

Azima

Azima tetracantha.—Growth rings indistinct. Wood diffuse porous, vessels exclusively solitary, rarely clustered, round to

Table 1. Species of Salvadoraceae studied, with information on accession number, collection locality, specific gravity, vulnerability, and mesomorphy.

Species	Accession number	Locality	Specific gravity	Vulnerability	Mesomorphy
<i>Azima tetracantha</i>	DDw 5639	India: Tamil Nadu State: Coimbatore	0.63	1.6	428
<i>Salvadora oleoides</i>	DDw 1382	Pakistan: Sindh Province	0.85	6.1	831
<i>Salvadora persica</i>	DDw 1381	Pakistan: Sindh Province	0.49	5.5	935
	DDw 5129	Pakistan: Sindh Province	0.58	8.0	1456
	DDw 5695	India: Tamil Nadu State: Coimbatore	0.67	2.9	647

oval. Perforation plates simple. Mean tangential diameter of vessel 72 (19–130) μm , mean vessel element length 262 (161–375) μm . Intervessel pits non-vestured, alternate, 3 μm in diameter, vessel-ray pits similar to intervessel pits in shape and size. Vessel frequency 33–55/ mm^2 . Fibers non-septate, mean fiber length 817 (642–1017) μm , mean fiber wall thickness 10 μm , thick-walled with slit-like apertures, mean fiber diameter 17 (14–22) μm . Parenchyma storied, in wavy bands up to 3–12 cells wide, in strands of 3–4 cells, strands sometimes fusiform. Rays 1–21-seriate (Fig. 4), of two distinct sizes, heterogeneous with mostly procumbent, square, and upright cells mixed throughout the rays. Ray frequency 1–4/ mm , mean uniseriate ray height 214 (107–331) μm , 3–12-celled, mean uniseriate ray width 11 (8–14) μm , mean multiseriate ray height 890 (268–3467) μm , 9–14-celled, mean multiseriate ray width 142 (32–407) μm . Perforated ray cells present (Fig. 2). Prismatic non-chambered crystals present in ray cells.

Salvadora

Salvadora oleoides and *S. persica*.—Growth rings indistinct. Wood diffuse porous, vessels solitary and in radial multiples of 2–5 cells, few in clusters, round to oval. Perforation plates simple. Mean tangential diameter of vessels 61 (22–122) μm , mean vessel element length 178 (75–268) μm . Intervessel pits vestured, alternate, 3–5 μm in diameter (Fig. 5–6), vessel-ray pits similar to intervessel pits in shape and size. Vessel frequency 5–21/ mm^2 . Fibers non-septate with simple to minutely bordered pits and slit-like apertures. Mean fiber length 638 (342–856) μm , mean fiber diameter 14 (8–27) μm , wall thickness 4 μm , thin walled. Parenchyma banded, bands up to 15 cells wide, parenchyma strands storied and fusiform (Fig. 3). Rays 1–4-seriate in both species, except for one sample (DDw 5129) of *S. persica* that showed rays 1–6-seriate. Ray frequency 2–8/ mm , mean ray height 240 (86–449) μm with 4–20 cells, mean ray width 32 (14–81) μm . Rays heterogeneous with procumbent, square, and upright cells mixed throughout the rays. Perforated ray cells present in both the species. Non-chambered prismatic crystals present in ray cells. Included phloem distinct (Fig. 1).

Species Identification Key of Salvadoraceae in the Indian Subcontinent

1. Rays 1–21 seriate *Azima tetracantha*
1. Rays 1–6 seriate 2
2. Rays 1–4 seriate . . . *Salvadora oleoides*, *Salvadora persica*
2. Rays 1–6 seriate *Salvadora persica*

DISCUSSION

Carlquist (2002) reported anatomical characteristics of *Azima tetracantha* and *Salvadora persica* from South Africa, and in Table 3 we compare our data to his. Wide variation was observed in the quantitative anatomical features. These differences likely can be attributed to site conditions, age of the plant, or growth form.

While studying the wood microstructure, we observed wall ingrowths in the minute intervessel pits of *Salvadora*. Scanning electron microscopy showed these ingrowths to be vestures in the intervessel pits. The occurrence of vestured pits in *Salvadora* is consistent with the prevalence of pit vesturing in plants from tropical environments (Jansen et al. 2004). The present study is the first to report vestures in genus *Salvadora*.

Vulnerability and mesomorphy were proposed by Carlquist (1977) as indices of ecological variation in wood anatomy. Low values of vulnerability (<1.0) and mesomorphy (<75) indicate adaptation to xeric conditions, i.e., the capacity of species to resist water or freezing stress, whereas high values of vulnerability (1.0–2.5) and mesomorphy (>200) show adaptation to mesic conditions. Consistent with their tropical origin, our samples show vulnerability values of >1 and mesomorphy values of >200.

Several wood characters are seen as indicators of phylogenetic advancement, i.e., short vessel elements, simple perforation, minutely bordered pits, storied features, and the ratio of fiber and vessel element lengths (F/V ratio). A F/V ratio of >2.6 is considered to characterize phylogenetically advanced families (Sporne 1969; Carlquist 1988). In the present study, Salvadoraceae exhibit mostly advanced characters of wood evolution. Sporne (1969) cited an advancement index of 66 for this family, based on a suite of 22 morphological, anatomical, and embryological characteristics.

A majority of taxonomists working on genus *Salvadora* recognize *S. oleoides* and *S. persica* (Qureshi 2010) with no intraspecific ranks. Our wood anatomical study, however, showed appreciable intraspecific variation in intervessel pit diameter, vessel diameter, vessel frequency, ray seriation, ray width, ray height, and mineral inclusions within *S. persica* (Table 4). These findings agree with those of Korejo et al. (2010) who reported intraspecific variation in leaf, branch, fruit, seed, and pollen characteristics among white- and red-fruited forms of *S. persica*. Further studies with broader sampling are required before taxonomic realignment within *S. persica* can be contemplated.

Fig. 1-6. Wood microstructure of Salvadoraceae.—1. *Salvadora persica*. Transection showing included phloem (arrow).—2. *Azima tetracantha*. Transection showing perforated ray cell (PRC; arrow).—3. *Salvadora persica*. Tangential section showing fusiform and storied parenchyma strands.—4. *Azima tetracantha*. Tangential section showing rays (1-21 seriate).—5-6. SEM photomicrographs of *Salvadora persica*.—5. Radial section showing vestured pits.—6. Tangential section showing shallow elliptical grooves interconnecting pit apertures. Scale bars: Fig. 1-4 = 100 µm; Fig. 5 = 1 µm; Fig. 6 = 10 µm.

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Table 2. Wood anatomical features of the members of family Salvadoraceae from the Indian Subcontinent.

Species	VF	VL ¹	VD ¹	FL ¹	FD ¹	RS	C	F/V
<i>Azima tetracantha</i>	33–55	262 (±62)	72 (±27)	817 (±950)	17 (±4)	1–21	+	3.1
<i>Salvadora oleoides</i>	5–14	136 (±19)	55 (±19)	646 (±106)	12 (±2)	1–3	–	4.75
<i>Salvadora persica</i>	5–21	195 (±47)	63 (±21)	632 (±111)	16 (±2)	1–3 (6)	+/–	3.2

¹ Values are means (±standard deviation); VF = vessel frequency (number of vessels/mm²); VL = vessel length (in µm); VD = vessel diameter (in µm); FL = fiber length (in µm); FD = fiber diameter (in µm); RS = ray seriation; C = crystals in rays (+ = present, – = absent); F/V = ratio of fiber length to vessel element length.

Table 3. Comparison of wood anatomical features of *Azima tetracantha* and *Salvadora persica* collected in South Africa (Carlquist 2002) and the Indian Subcontinent.

Species	Wood anatomical features	Carlquist (2002)	Present study
<i>Azima tetracantha</i>	Origin of samples	South Africa	India: Tamil Nadu State: Coimbatore
	Mean vessel diameter	25 µm	72 µm
	Mean multiseriate ray height	1200 µm	890 µm
	Mesomorphy	127	419
	Crystals	Present in parenchyma	Present in rays
<i>Salvadora persica</i>	Origin of samples	South Africa	India: Tamil Nadu State: Coimbatore; Pakistan: Sindh Province
	Mean vessel frequency	251/mm ²	13/mm ²
	Mean vessel diameter	12 µm	63 µm
	Mesomorphy	6.3	1013
	Crystals	Present in rays and occasionally in parenchyma	Present in rays

Note: The quantitative feature of ray height for *Salvadora persica* is similar to the feature observed by Carlquist (2002).

Table 4. Wood anatomical features of three samples of *Salvadora persica*.

Sample	IVP	VD	VF	RS	RW	RH	C
DDw 1381	3	66	8–14	1–4	28	211	–
DDw 5129	3–5	72	5–12	1–6	42	269	+
DDw 5695	3	50	12–21	1–3	21	210	–

IVP = intervessel pit diameter (in µm); VD = vessel diameter (in µm); VF = vessel frequency (number of vessels/mm²); RS = ray seriation; RW = multiseriate ray width (in µm); RH = multiseriate ray height (in µm); C = crystals in rays (+ = present, – = absent).

LITERATURE CITED

AHMAD, F. 2007. GIF, GPS and remote sensing application to investigate agricultural potential in Cholistan. *Sociedade & Natureza, Uberlândia* **19**: 55–64.

ALMAS, K. 2002. The effect of *Salvadora persica* extract (Miswak) and chlorhexidine gluconate on human dentin: a SEM study. *Journal of Contemporary Dental Practice* **3**: 027–030.

CARLQUIST, S. 1977. Ecological factors in wood evolution: a floristic approach. *Amer. J. Bot.* **64**: 887–896.

———. 1988. Comparative wood anatomy: systematic, ecological and evolutionary aspects of dicotyledon wood. Springer Verlag, Berlin, Germany.

———. 2002. Wood and bark anatomy of Salvadoraceae: ecology, relationships, histology of interxylary phloem. *J. Torrey Bot. Soc.* **129**: 10–20.

DEN OUTER, R. W. AND W. L. H. VAN VEENENDAAL. 1981. Wood and bark anatomy of *Azima tetracantha* Lam. (Salvadoraceae) with description of its included phloem. *Acta Bot. Neerl.* **30**: 199–207.

GAMBLE, J. S. 1922. A manual of Indian timbers. Sampson Low, Marston & Co., Ltd., London, UK.

GUPTA, S. AND V. SAXENA. 2005. New record of occurrence of perforated ray cells in the order Celastrales from India. *Indian Forester* **131**: 1064–1070.

IAWA COMMITTEE. 1989. IAWA list of microscopic features for hardwood identification. *IAWA Bull n.s.* **10**: 219–332.

JANSEN, S., P. BAAS, P. GASSON, F. LENS, AND E. SMETS. 2004. Variation in xylem structure from tropics to tundra: evidence from vested pits. *Proc. Natl. Acad. Sci. U.S.A.* **101**: 8833–8837.

KOREJO, F., S. A. ALI, S. S. TAHIR, M. T. RAJPUT, AND T. AKHTER. 2010. Comparative morphological and biochemical studies of *Salvadora* species found in Sindh, Pakistan. *Pakistan J. Bot.* **42**: 1451–1463.

MAHAR, A. Q. AND A. R. MALIK. 2001. A study on the medicinal plants of Kotdiji, District Khairpur, Sindh, Pakistan. *Scient. Sindh J. Res.* **8**: 31–38.

METCALFE, C. R. AND L. CHALK. 1950. Anatomy of the dicotyledons. Clarendon Press, Oxford, UK.

- PURKAYASTHA, S. K. 1985. Indian woods—their identification, properties and uses, vol. 5. Forest Research Institute, Dehradun, Uttarakhand, India.
- QURESHI, S. 2010. Salvadoraceae. In S. I. Ali and M. Qaiser [eds.], Flora of Pakistan, vol. 29. University of Karachi & Missouri Botanical Garden, <http://www.efloras.org> (2 Aug 2010).
- SAVITHRAMMA, N., Ch. SULOCHANA, AND K. N. RAO. 2007. Ethnobotanical survey of plants used to treat asthma in Andhra Pradesh, India. *J. Ethnopharmacol.* **113**: 54–61.
- SAXENA, V. AND S. GUPTA. 2004. Occurrence of perforated ray cells in secondary xylem of *Salvadora* and *Azima*—a new record for the family Salvadoraceae. In Proceedings of the 91st Session of the Indian Science Congress, Chandigarh, India.
- SPORNE, K. R. 1969. The ovule as an indicator of evolutionary status in angiosperms. *New Phytol.* **68**: 555–566.
- ZODAPE, S. T. AND V. K. INDUSEKHAR. 1997. *Salvadora persica*: a boon to wasteland development. *J. Sci. Industr. Res., C, Biol. Sci.* **56**: 657–661.