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Anatomical investigation of *Terminalia chebula* Retz.

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Terminalia chebula Retz. is a well-known species of family Combretaceae, commonly known as Chebulic Myrobalan. It is an important medicinal plant from ancient period. Bark powder gargled in water as a dentifrice is used to treat toothache and bleeding gums, as well as chronic ulcers and fruits are common constituent of '*Triphala*' capable of imparting youthful vitality and receptivity of mind and sense. Present paper deals with the morphology, anatomy and maceration studies of bark, wood, petiole and leaves, the work has been carried out in order to characterize and standardize the species.

Key Words: *Terminalia chebula*; anatomy; Combretaceae

Introduction

Terminalia chebula Retz. well-known species of family Combretaceae is commonly known as Chebulic Myrobalan and '*Haritaki*' in Sanskrit. It is an important plant in both, Indian as well as Korean and Chinese traditional medicine (Lee *et al.* 1995). Bark powder is gargled in water as a dentifrice to treat toothache and bleeding gums, as well as chronic ulcers (Singh *et al.* 2002). Fruits are common constituent of '*Triphala*', capable of imparting youthful vitality and receptivity of mind and sense (Reddy *et al.* 1990; Sharma 1995 and Kochhar 1998). It is a major constituent in the Ayurvedic preparations like *Abhayarishta, Abhayamodak, Haritakikhand, Triphaladichurnam* and *Agastyarasayanam*. In Allopathy, it is used in astringent ointments. In Unani system, it is used as a blood purifier. The pulp of the fruit is given in piles, chronic diarrhoea, dysentery, costiveness, flatulence, asthma, urinary disorders, vomiting, hiccup, intestinal worms and enlarged spleen and liver (Cheng 2002, Masoko & Eloff 2007). Powder of the fruits is used in chronic ulcers and wounds, carious teeth and bleeding ulceration of the gums. Fruits are used for diabetes, fever and anemia (Daniel 2005). Bark and fruits are good cardiac tonic and laxative (Singh *et al.* 1979). '*Triphala*' is used in biliousness, hemorrhoids, enlarged liver and other disorders. The kernel oil is applied to hairs and to rheumatic swellings, mixed with honey, fruit pulp is employed in ophthalmia (Bose *et al.* 1998). Fruits are astringent (Masoko & Eloff 2007). Finely powdered fruits are also used as dentifrice and considered useful in various teeth bleeding and ulceration of gums (Jain 1994 and Sharma 1995). The fruits are valuable for tannins and dyes. The wood is used for building purposes, agricultural implements, ply-wood and in match box industry. It is also grown as a shade tree (Joy *et al.* 1998; Joshi 2002; Khare 2007 and Trivedi 2008), also for cabinet work, furniture and interior fitting (Sambamurty 2005). This plant is also used as fodder (Anonymous 1909 and Kumar & Bhatt 2006).

T. chebula Retz. occurs typically in dry deciduous forests and favoring clay soil, up to 1450 m in southern India, 450 m in Central India, 200 m in Western India, 500 m in North East India, 1500 m in Himalaya and 1050 m in Myanmar. It is also reported from Sri Lanka and Bangladesh and cultivated elsewhere.

Materials and Methods

The plant parts were collected from the tree planted in Milind College of Science, Aurangabad (MS), Field no.7073, Latitude N 19°53'17", Longitude E 075°18' 79", altitude 600 m. Transverse sections (T. S.), tangential longitudinal sections (T. L. S.) and radial longitudinal sections (R. L. S.) of wood, transverse sections of bark, leaves and petioles were taken by free hand method with the help of razors. Sections were double stained and permanently mounted. The bark, wood and leaves were macerated by Jeffery's method (Khandelwal 2006). Trichomes were studied by scrapping. The dimensions were measured and microphotographs were taken by Motic Microscope with image processing software.

Observations and Results

Morphology

Terminalia chebula Retz., Obs. 5: 31. 1789; Roxb., Pl. Corom.: t. 197. 1805 & Hort. Beng.: 33. 1814 & Fl. Ind. 2: 433. 1832; DC., Prodr. 3: 12. 1828; G. Don, Gen. Hist. 2: 659. 1832; Wight & Arn., Prodr.:

313. 1834; Miq., Fl. Ind. Bat. 1(1): 601. 1855; Thw., Enum. Pl. Zeyl. 2: 103. 1859; Bedd., Fl. Sylv. S. India 1: t. 27. 1869; Brandis, For. Fl. NW. India: 446. 1878 (*excl. var. parvifolia* (Thw.) Clarke; Trimen, Handb. Fl. Ceylon 2: 159. 1894; Prain, Bengal Pl. 1:481. 1903; Cooke, Fl. Bombay Pres. & Sind.1:336. 1903; Duthie, Fl. Upper Gangetic Pl. 1. 336. 1903; Talbot, For. Fl. Bombay Pres. & Sind. 2: 14. 1911; Parker, For. Fl. Punjab, 239. 1918; Gamble, Fl. Pres. Madras 3: 464. 1919; Haines, Bot. Bihar & Orissa 3:352. 1922; Blatter in J. Ind. Bot. 8: 253. 1929 (incl. formas); Kirtikar & Basu, Indian Med. Pl. ed. 2, 2:1020, t. 413. 1035; Kanjilal, Fl. Assam 2: 244. 1938; Gandhi in Saldanha & Nicolson, Fl. Hassan: 294. 1976; Whitmore in Enum. Fl. Pl. Nepal 2: 168. 1979; Deb., Fl. Tripura 1: 385. 1981; Matthew & Britto, Fl. Tamil Nadu Carnatic 2(1): 304. 1991.

Myrobalanus chebula (Retz.) Gaertn., Fruct. 2: 91, t. 97, f. 2(f-m). 1790.

Terminalia reticulata Roth., Nov. Pl. Sp.: 381. 1821; DC., Prodr. 3:13. 1828, *edescr.*

Terminalia aruta Buch.-Ham., ex G. Don, Gen. Hist. 2: 659. 1832.

Terminalia acuta Walp., Rep. 2: 61. 1843.

Terminalia zeylanica Heurck & Muell.-Arg., in Heurck, Obs. Bot.: 220. 1971.

Terminalia tomentella Kurz., in J. As. Soc. Bengal 42(2): 80. 1873 & For. Fl. Brit. Burma 1:455. 1877.

Terminalia chebula var. *gangetica* (Roxb.) Clarke, Fl. Brit. India 2: 446. 1878

Terminalia chebula var. *tomentella* (Kurz) Clarke, Fl. Brit. India 2: 446. 1878.

Combretum extensum sensu. Prain, Bengal Pl. 1:483. 1903, *p.p.* (*non* Roxb. ex G. Don, 1827).

Vernacular names

Sanskrit*: Abhaya, Amoga, Amruta, Avaytha, Balaya, Bhisha, Gvara, Bishakpriya, Haritaki, Jivnika, Jivanti, Rasayanphala, Triphala, vanatikta*; Marathi: *Hirda;* Hindi: *Haritaki, Harra, Hirdi, Har*; Kannad: *Alae, Anile, Arale, Harade, haritaki*; Myanmarese: *Pankha, Pangah*; Nepali: *Harra, Herro*; Oriya: *Karidha, Haritaki, Harida, Kasaphal*; Punjabi: *Halela, Har, Harrar, Hurh*; Sikkimese: *Hana, Silimkung*; Tamil: *Amagola, Arabi, Aridadi, Attam, Kaku, Kaddukkaai, Nechi, Seya*; Telgu: *Haritaki, Karoka, Nallakaroka, Resaki.*

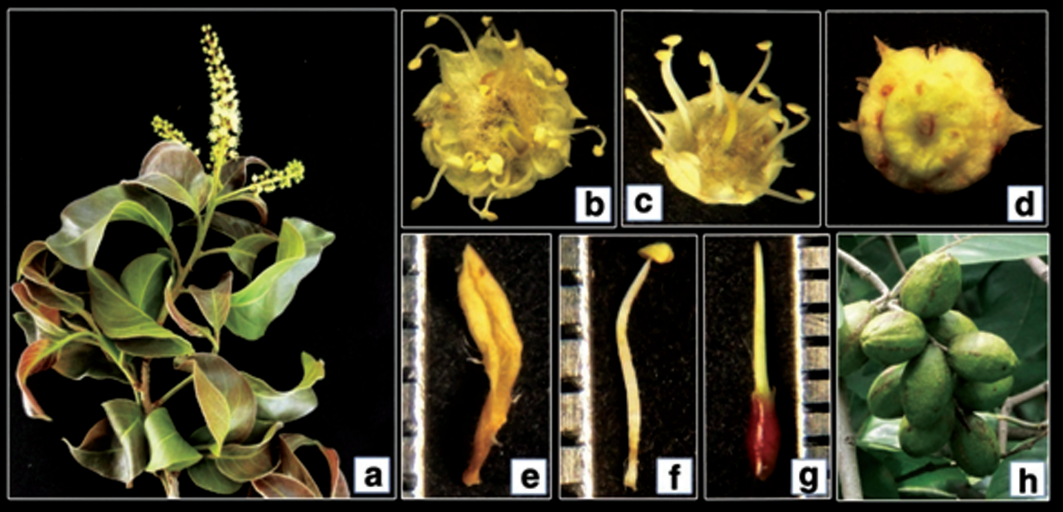
Much branched trees 25–45 ft tall. Bark dark brown or greyish to blackish, shallowly to deeply fissured. Young branches densely pubescent, branchlets terete, 3 – 8 mm thick with white, elongate markings of lenticels. Leaves alternate or sub opposite, ovate-elliptic or oblong-elliptic or ovate to ovate-oblong, slightly curved, 10–25×4–14 cm. Petioles densely pubescent, 3–5cm, two glands on either side at or near the apex of the petioles, circular or button shaped, sessile, up to 2 mm in diameter. Dometia usually present 1 or 2, circular to oval, 1–2 mm at the junction of the petiole and lamina or on the lamina blade. Leaf-base rounded, obtuse, acute, acuminate; apex acute or acuminate, upper surface chartaceous to coriaceous, rarely glabrous. Lower surface grayish, tomentellous or villous, rarely glabrous except midrib. Young leaves greenish-brown, turn yellow after weathering. Midrib slightly elevated above, raised beneath. Lateral nerves 6–10 pairs, sub-opposite, prominent above, conspicuous, beneath and anastomosing near the margin, tertiary nerves obscure scalariform or sometimes reticulate. Inflorescence axillary and terminal, simple, paniculate, 5–15cm long, villous to sparsely puberulous. Bracts caducous, linear, lanceolate, 5–7mm long, puberulous. Flowers creamish-yellow, bisexual, diameter of open flower 3–4mm. Calyx tube 1.5 – 3× 1–1.5 mm, calyx lobes usually 5 occasionally 6–9, triangular, puberulous. Stamens usually 10 occasionally 12–18, 5–7 mm long, anthers ellipsoid, yellowish orange, 0.7–1mm long, filament whitish cream.Ovary green and red, 2–3 mm long, oblong, lanceolate, style 3–5 mm long, slender, white; stigma pointed. Fruits drupes, ellipsoid, obovoid or ovoid, 3–6×2–3cm, 5 angled, golden yellow to brownish yellow when dry, tender fruits turn black when dry. (Photo plate- I)

Fl.: April-July; ***Fr.***: June-December (persisting over next year)

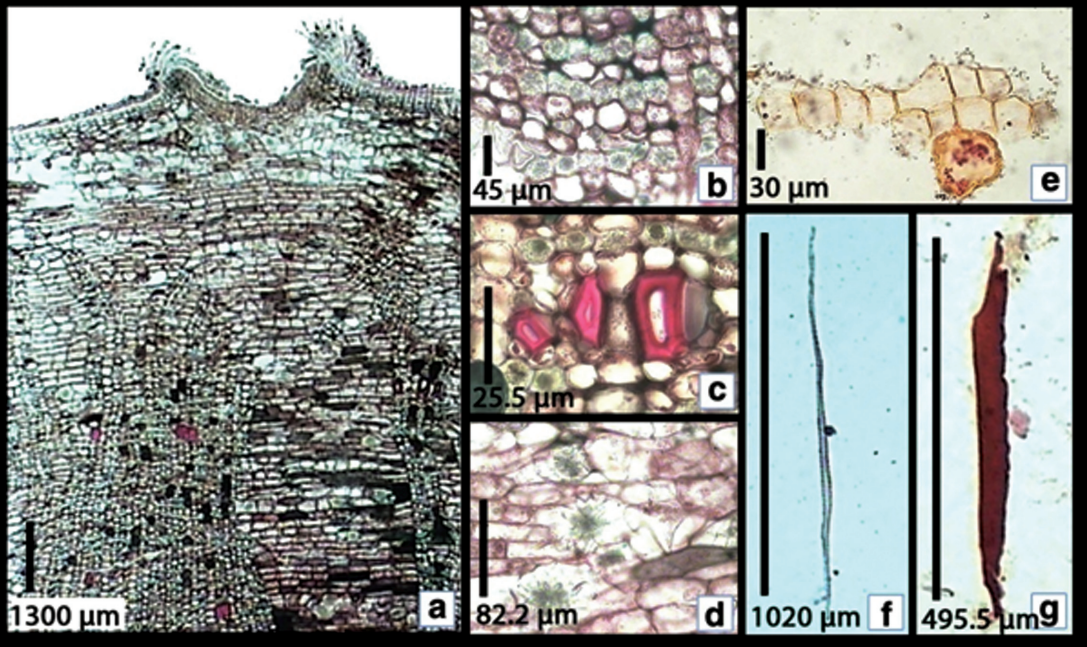
T. S. of bark revealed the cork 18–20 layered thick, ruptured at places because of lenticels; cells rectangular, tangentially elongated, squarish, suberised, tanniniferous, with some inclusions and large crystals. Cork cambium single layered; cells rectangular and prominant. Periderm 4– 6 layered,

Photo Plate 1

Terminalia chebula Retz.



a. Flowering twig; b. Flower with more than 10 stamens; c. Flower; d. Calyx cup; e. Bract; f. Stamen; g. Carpel; h. Fruits.



a. T. S. of bark; b. Fibre bundles and druces in rows; c. Stone cells; d. Druces; e. Thin walled and thick walled parenchyma; f. Fibre; g. Sieve element with companion cell.

cells rhomboid, squarish and brownish with crystals and some inclusions. Cambium followed by uniform cortex, cells squarish, circular, rhomboid, oblong, polygonal, parenchymatous and compactly arranged. Most of the cells filled with starch grains and large circular brownish, blackish crystals. Druses common in the cortex, 11.3 – 82.2 µm in diameter. Rays uniseriate, continuous, cells filled with tannin, compound crystals (druse), and starch grains, cells squarish, rhomboid, polygonal, rectangular and irregular. Patches of sclerenchymatous fibres single, rarely two layered, periodically arranged in a ring in a group of 2 – 17, with small lumen. Fibres may be circular, oval, oblong, rhomboid, polygonal and compressed, 9.0 – 25.5µm. Stone cells few, single or in group of 2 – 5, triangular to polygonal, randomly distributed after 4 – 15 layers of cortex, 12.2 – 91.9 µm in diameter, with small to large lumen.

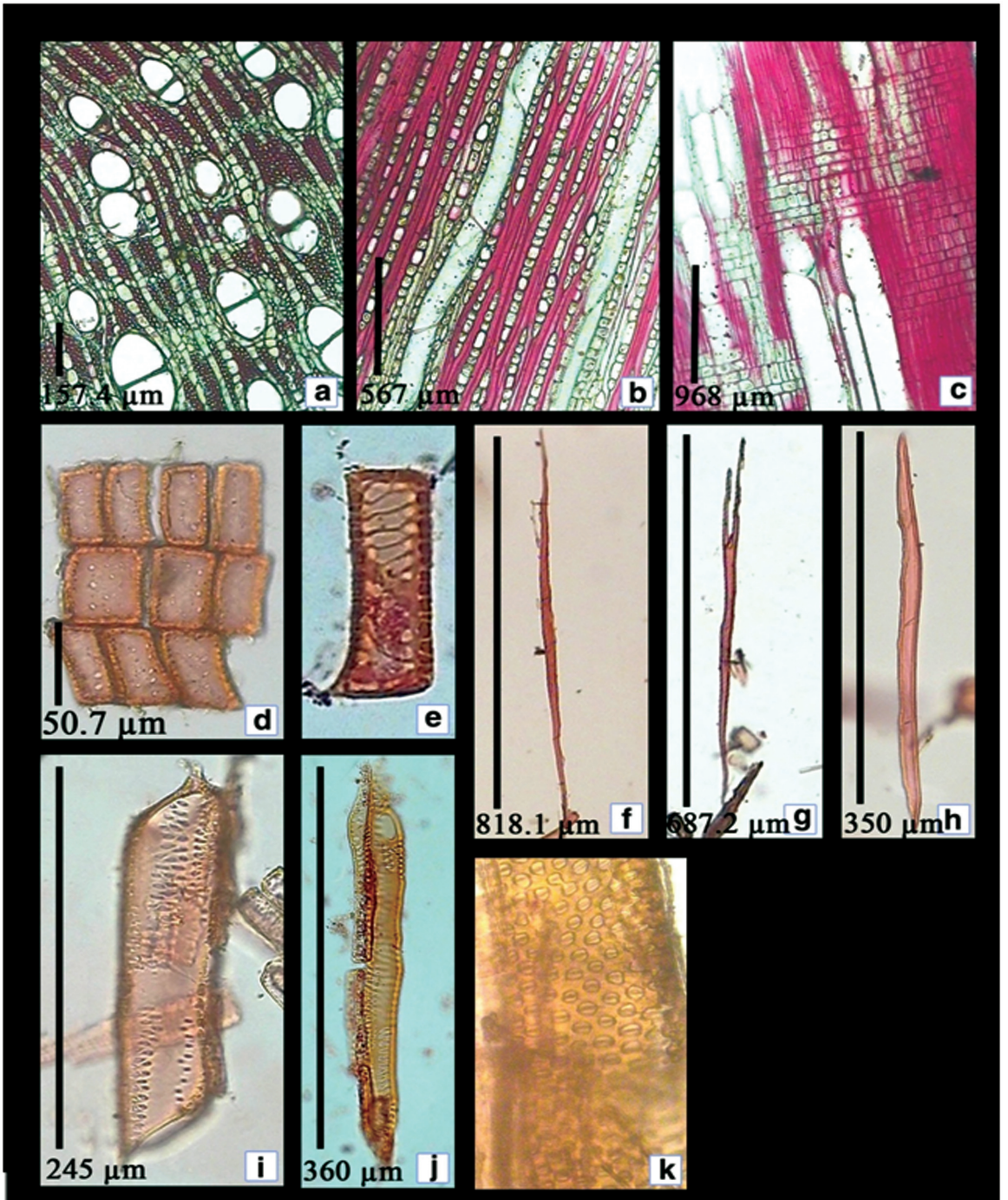
Macerated bark showed two types of phloem parenchyma i) thin walled-squarish, rhomboid, rectangular, irregular or barrel-shaped 32.84×26.21 µm in average and range 27.1– 46.1× 21.8 – 34.3 µm. ii) thick walled- rhomboid, polygonal or irregular 45.0 × 33.83 µm in average and range 34.6 – 65.9 × 23.3 – 51.9 µm. Fibres simple, irregular, slender, irregularly swollen at places, 1280.82 × 28.64 µm in average and range, 829.4 – 1542.7 × 19.1 – 36.9 µm. Sieve elements are of two types- long and short, end walls terminal or sub-terminal, highly oblique, beaks short or long 639.92 × 63.34 µm in average and range 495.1 – 820.5 × 87.1 – 41.6 µm. Companion cell single, squarish or rhomboid and thick walled, average 45.0 × 33.83 µm and range 34.6 – 65.9 × 23.3 – 51.9 µm (Photo Plate I).

T. S. of wood showed indistinct growth ring boundries; wood diffuse porous; vessels in radial multiple of 2 – 4 or more. Vessel elements 136.8 – 157.4 µm diameter. Tracheids few vasicentric. Ground tissue fibres very thick walled with small lumen, polygonal, rhomboidal. Axial parenchyma paratracheal, winged-aliform. T.L.S. of wood showed vessel elements 171.1 – 493.9 × 46.9 – 121.4 µm, end wall oblique, pits on lateral wall vestured alternate, perforation plates simple. Fibres thick, very long. Rays mostly uniseriate, some bi-triseriate, squarish, rectangular, rhomboid, 2–28 cells in height, 97.6 – 1133.8 µm in length, cells at the end tapering, ray deposited with starch grains and tannin. R.L.S. of wood showed heterogenus rays, cells squarish, procumbent and upright, deposited with starch grains. Vessel-ray pits much reduced border to apparently simple, pit outline rounded (Photo Plate II).

Macerated wood showed two types of xylem parenchyma i) parenchyma with few pits: cells rectangular, squarish or rhomboid, trigonal, thick walled, cell wall interrupted, pits few circular or oval, distributed along cell wall, 47.67 × 27.67 µm in average and range 42.1 – 77.6 × 20.8 – 39.8 µm. ii) parenchyma with many pits: cells rectangular, squarish or rhomboid, pits alternate, with much reduced borders to apparently simple, pit outline rounded or oval, distributed throughout, cell wall continuous, may wavy, average size 50.7 × 26.8 µm and range 35.1 – 82.1 × 17.4 – 34.1 µm. Fibres are of two types: i) fibres simple, slender, tapering and sharply pointed, outline entire, average size 818.1 × 21.79 µm and range 702.6 – 968.9 × 17.1 – 32.6 µm. ii) fibres forked, slender, tapering and sharply pointed, outline irregular 687.2 × 24.0 µm. Tracheids slender, ends blunt or pointed, pits few, elongate, in one-many rows, alternate, 356.4 × 20.9 µm in average and range 276.4 – 492.8 × 16.8 – 23.8µm. Vessel elements are of two types: i) vessel elements broader, end walls horizontal with simple perforation, lateral walls with vestured, bordered, alternate pits, tails short, may present on both the ends, 333.1 × 50.3 µm in average and range 245.7 – 365.8 × 29.4 – 71.0 µm. ii) vessel elements long, slender, tails at one or both ends, end walls oblique shifted to lateral side, perforation simple, lateral wall with scalariform thickenings, average size 407.9 × 33.64 µm and range 345.6 – 712.6 × 21.4 – 45.2 µm (Photo Plate II).

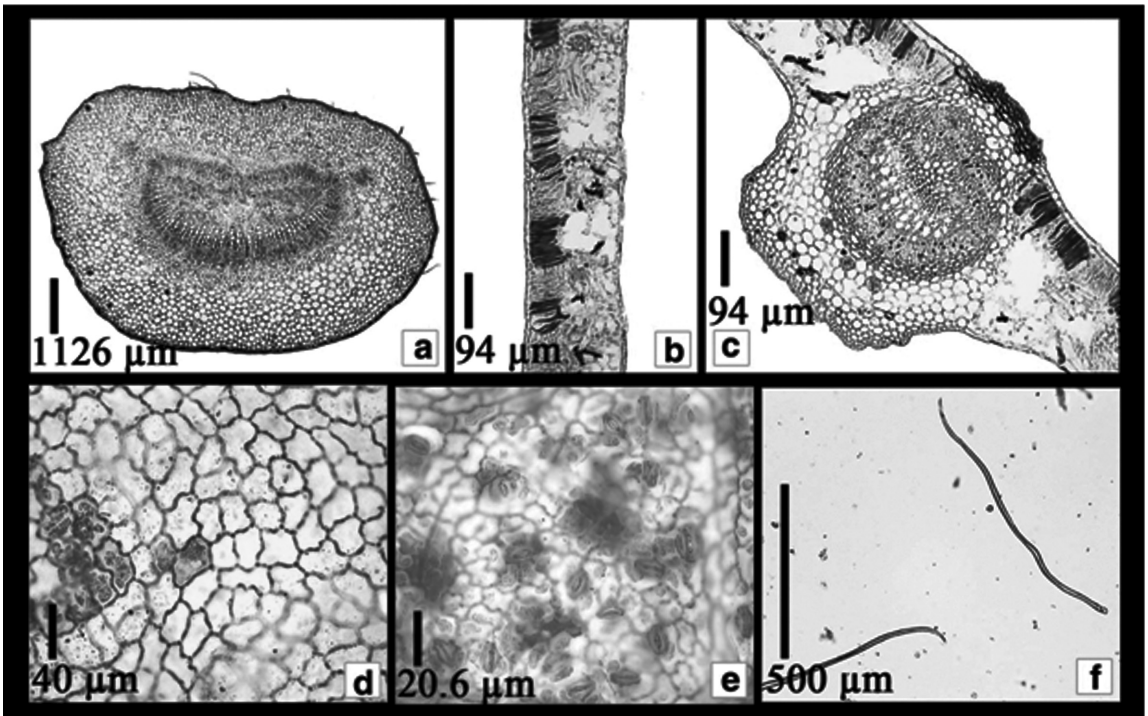
T. S. of petiole showed hemispherical or oblong outline. Epidermis is the outer most layer covered with thin cuticle and combretaceous trichomes. Cells of epidermis circular, oval, 5.6 – 12.2 × 9.1 – 12.0 µm. Hypodermis single layered, composed of circular to polygonal cells. Cortex differentiated into outer and inner cortex. Outer cortex collenchymatous, 4 – 6 layered, cells poygonal, irregular and angular, 13.5 – 58.7 × 9.8 – 53.5 µm. Inner cortex 8 – 12 layered, composed of large circular, polygonal or irregular,

Photo Plate 2



a. T. S. of wood; b. T. L. S. of wood; c. R. L. S. of wood; d-e. Parenchyma; f-g. Fibres; h. Tracheid; i-k. Vessel elements.

Photo Plate 3



a. T. S. of petiole; b. T. S. of leaf through lamina; c. T. S. of leaf through midrib; d. Upper epidermal cells; e. Lower epidermal cells; f. Trichomes.

thin walled parenchymatous cells 25.0 – 82.1× 23.9 – 70.5 µm. Cortex followed by 3 – 5 layered, sclerenchymatous patches of bundle sheath. Bundle sheath cells polygonal and compactly arranged 6.7 – 28.6 × 4.2 – 12.1 µm, in patches. Endodermis single layered composed of large polygonal cells, barrel shaped or irregular. Pericycle 1– 2 layered in patches. Vascular bundle conjoint bicollateral, open and endarch. Peripheral phloem 4 – 6 layered, 3.7 – 15.0 × 3.0 – 10.0 µm, cells polygonal, squarish. Vascular cambium 1 – 2 layered, cells rectangular. Metaxylem circular to polygonal 3 – 5 layered 17.6 – 32.7× 16.8– 24.2 µm. Protoxylem circular to polygonal 12.2 – 15.9 × 9.9 – 14.5 µm. Inner phloem 10 – 15 layered, in patches on adaxial surface. Pith parenchymatous, cells large, polygonal. Two lateral vascular bundles, conjoint, concentric, amphicribal and closed, situated at the corners on eighter side towards adaxial surface. Druses common in cortexand pith (Photo Plate III).

T. S. of the leaf showed typical dorsiventral structure. The epidermis of both the surfaces single layered, covered with thick cuticle. The cells of upper epidermis composed of squarish, upright and rectangular cells. The upper epidermal cells range from 11.3 – 28.9 × 9.4 – 15.6 µm. Lower epidermal cells rectangular, oval or circular, range from 8.6 – 14.5 × 6.0 – 13.3 µm. Epidermal cells at the midrib region circular, oval or polygonal and smaller than the lamina region. Upper epidermis followed by vertically elongated, single layered palisade, 61.6 – 94.3 × 5.2 – 8.3 µm. Spongy mesophyll cells circular, oval, polygonal and irregular, with wavy cell wall, thin walled, loosely arranged, 13.8 – 23.3 × 8.3 – 19.3 µm, with inter cellular spaces. Some of the mesophyll cells showed starch grains. Few tanniniferous cells also reported from mesophyll region. At the midrib region, epidermis followed by single layered hypodermis, restricted to this region. Cortex differentiated into inner and outer cortex. Outer cortex 3 – 5 layered, poygonal or irregular, angular collenchyma, 7.7 – 30.0 × 7.4 – 29.3 µm. Inner cortex 4 – 8 layered, composed of large circular, polygonal or irregular, thin walled parenchymatous

cells 13.4 – 59.2 × 9.8 – 50.2 µm. Rhytidomes single layered present between collenchyma and sclerenchyma of the cortex on adaxial side at midrib region only. Cortex followed by 3 – 5 layered sclerenchymatous bundle sheath. Bundle sheath cells circular, oval, polygonal and compactly arranged 6.7–28.6×4.2–12.1µm, contineous on abaxial side and in patches on adaxial side. Endodermis single layered, cells ovate, oval or circular, elongate, elliptic – oblong, casparianl strips inconspicuous. Pericycle 1–2 layered, cells polygonal, circular or oval. The main vascular bundle conjoint, bicollateral, open and endarch. Peripheral phloem 12 – 15 layered cells squarish, rectangular and polygonal 3.9 – 15.4 × 3.5 – 9.5 µm. Metaxylem circular to polygonal, 2 – 4 layered, facing towards periphery, 17.6 – 32.7 × 16.8 – 24.2 µm, protoxylem circular to polygonal, situated towards center 12.2 – 15.9 × 9.9 – 14.5 µm. Protoxylem followed by irregular, 5 – 8 layered patches of phloem, present only on adaxial surface. Pith composed of parenchyma. Lateral vascular bundles 4, 2 very small, 2 on eihter side situated towards upper epidermis, conjoint, concentric, closed, phloem surrounded by xylem which is enveloped by phloem. Vascular bundles of the smaller vein vertically transcurrent by thin walled large circular to polygonal parenchymatous tissue. The vascular bundles conjoint, collateral and closed. The druces more common in the cortex, phloem and pith (Photo Plate III).

Leaves showed presence of simple, unicellular Combretaceous trichomes, with bulbous base, average length, 749.22 µm and range 154.3 to 1120.3 µm. Trichomes present on both the surfaces, but however, they are more common on lower surface. Stomata anomocytic (Ranunculaceous), hypostomatic, pore length 12.96 µm in average and range 10.2 to 19 µm. The average size of guard cell, 22.91 × 6 µm and range 20.1 – 26.9 × 4.6 – 7.4 µm. Upper epidermal cells slightly larger (the average cell size 38.78 × 17.95 µm and range 27.6 – 52.7 × 23.6 – 36.2 µm) than lower epidermal cells (the average cell size 27.73 × 18.15 µm and range 20.3 – 38.9 × 14.8 – 21.8 µm). Upper epidermal cells are wavy in outline than lower epidermal cells, both the cells irregular in shape. Mean stomatal number for lower epidermis 14.9 and range 9 – 20. Stomatal index for lower epidermis in average 10.40 and range 7.14 – 12.99. Palisade ratio in average 6.75 and range 4.5 – 8.5. Vein islet number in average 10.2 and range 8 – 12. Veinlet termination number average 12.4 and range 8 – 14 (Photo Plate III).

Conclusion

Drupes ellipsoid, obovoid or ovoid, 5- angled, golden to brownish-yellow when dry. Stone cells are single or in group of 2-5, long and short sieve elements in bark. Axial parenchyma is paratracheal, winged-aliform, rays mostly uniseriate, some bi-seriate, vessel elements are of two types, broader vessel elements with simple, alternate pits and longer vessel elements with scalariform pits in wood. The main vascular bundle conjoint, bi-collateral, open and endarch. Vascular bundles of smaller vains, vertically transcurrent by thin walled, large, circular to polygonal parenchymatous tissue. Trichomes simple, unicellular, Combretaceous and stomata anomocytic (Ranunculaceous), hypostomatic these morphological, anatomical and dermatological parameters were found to be diagnostic features of *Terminalia chebula* Retz. which may be useful in characterization and standardization of the species.

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