

Chapter 12

Medicinal plants of the Combretaceae: *Terminalia* (2) and *Combretum* (1)

4. *Terminalia arjuna* (Roxb.) Wight & Arn.

Hindi- *Arjuna*; **Beng.** - *Arjhan*; **Mar.-** *Sanmadat, Sadaru, Vellamardo*; **Guj.** - *Sadado*;
Tel.- *Yerramaddi*; **Tam.-** *Vellamatta*; **Kan.-** *Maddi*; **Oriya-** *Arjuno, Sahajo*, **Assam-**
Orjun; **Punjab-** *Arjan*

Trade name: - *Arjun*

Distribution: - Common throughout the Indian Peninsula along rivers, streams, ravines and dry water-courses; extends northwards to the sub- Himalayan tract, Punjab, Chota Nagpur, Orissa, Northern Circars and extensively planted in India for shade and ornament in avenues or park.

It is an evergreen tree with a spreading crown and drooping branches. Stem is rarely long or straight which is generally always buttressed and often fluted. Bark is very thick, grey or pinkish green, smooth, exfoliating in large, thin, irregular sheets. Leaves are sub-opposite, oblong or elliptic, coriaceous, usually 10-15 cm long, occasionally 25 cm, cordate and shortly acute or obtuse at the apex. Flowers are in paniced spikes. Fruits are 2.5-5.0 cm. long, nearly glabrous, ovoid or ovoid-oblong, with 5-7 hard winged angles.

Parts Used: - Bark, leaves

Medicinal Uses: - **Arjun bark** is a well known cardi tonic, also used as a diuretic, febrifuge, tonic, antidysenteric and cures wounds and urinary diseases. Its ashes are prescribed in scorpion sting. Bark is acrid and has styptic, tonic, febrifugal and antidysenteric properties. The powdered bark is taken with milk in fractures and contusions, with excessive ecchymosis. The powdered bark also gives relief in

symptomatic complaint in hypertension. It had a diuretic and a general tonic effect in cirrhosis of the liver. Decoction of bark is used as a wash in ulcers. It is also used as anti-HIV agent. Leaves are used externally as a cover for sores and ulcers. Juice of fresh leaves is used for earache. The twigs are used by tribals of Bastar to cure blisters and ulcers of the mouth. The fruit is tonic and deobstruent (Anon., 1999).

Previous phytochemical reports: -

Bark of *Terminalia arjuna* was found to contain arjunine, pyrocatechol, β -sitosterol, ellagic acid and a new trihydroxytriterpene monocarboxylic acid, arjunic acid. From the alcoholic extract of the bark, a glucoside arjunetin had been isolated. Presence of friedelin in bark had also been reported. Fruits contained 7-20 % tannin (Anon., 1999).

Previous pharmacognostic studies:-

Pharmacognosy of bark (T.S.) had been studied.

In the present work, the bark, leaves and fruits were analysed for their flavonoids, phenolic acids, quinones, etc. in bark, leaves, stem and fruits. Pharmacognostic studies of bark and leaves have been conducted.

Materials and Methods:

The materials of *T. arjuna* were collected from Baroda. The voucher specimen of the plant has been deposited in the Herbarium, Department of Botany, The Maharaja Sayajirao University of Baroda (BARO), Vadodara. Standard methods, presented in chapter 2 were followed for the extraction, isolation and identification of the phytochemicals. Pharmacognosy has been conducted by standard methods mentioned in chapter 2.

Results: -

Phytochemistry: -

Bark was devoid of flavonoids. Cyanidin was identified as the anthocyanidin in bark. Vanillic, syringic, melilotic and *p*-coumaric acids were the phenolic acids present. Quinones also were present in the bark. In stem, the flavonols were kaempferol, quercetin, 3'- OMe quercetin, 3', 4'- diOMe quercetin and gossypetin and the phenolic

acids were *p*-hydroxy benzoic, vanillic, syringic, gallic and *p*-coumaric acids. Quinones were found to be present. Quinones were present. In leaves, flavonols identified were kaempferol, quercetin, 3'-OMe quercetin, 3', 4'-diOMe quercetin and myricetin. Phenolic acids were vanillic, syringic and gallic acids. Quinones were absent. Fruits contained 4'-OMe kaempferol and 3', 4'-diOMe quercetin as well as vanillic and syringic acids. Alkaloids and glycoflavones were absent in all parts of the plant.

Phytochemical biomarkers of bark - Cyanidin and *p*-coumaric acid

- “ leaves- Kaempferol, quercetin derivatives and myricetin
- “ stem - Kaempferol, quercetin and gossypetin with quinone ,
p-hydroxy benzoic acid
- “ fruits - Quinones, 4'-OMe kaempferol

Pharmacognosy of bark, leaf and stem: -

Bark- T.S. (Fig. 12)

The transverse section had been taken in three parts – outer, middle and inner regions. Outer region showed 4 – 5 layered cork cells (10-14 x 17-38µm) followed by three layers of phellogen. Secondary cortex was composed of 5 -6 layers of chlorenchymatous cells (10-13 x 17-38µm) with sphaeraphides (14-20µm). Primary cortex consisted of parenchyma cells (24-34 x 10-20µm) along with sphaeraphides and red/pink colored cells. Gelatinous fibres (13-23 x 10-20µm) were observed in patches. Sphaeraphides were found solitary or in clusters. Medullary rays (27-48 x 17-24µm) were uniseriate with starch grains (4-7µm). Parenchyma cells contained very few starch grains. Middle portion showed parenchymatous cells with more number of sphaeraphides and starch grains. Red colored tannin cells were observed in single rows along with sphaeraphides of large size (27-51µm) and starch grains. Medullary rays were uniseriate with starch grains. Patches of gelatinous fibres were also observed. Inner region showed parenchymatous cells in rows in horizontal as well as vertical manner. Other tissues observed were same as that of upper and middle portions.

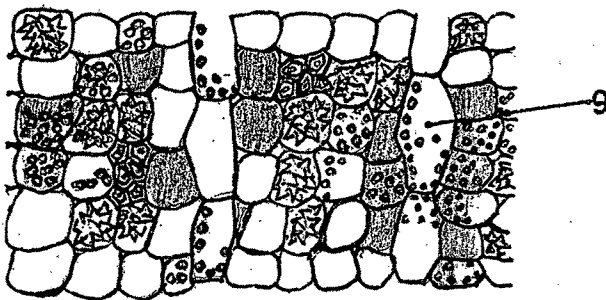
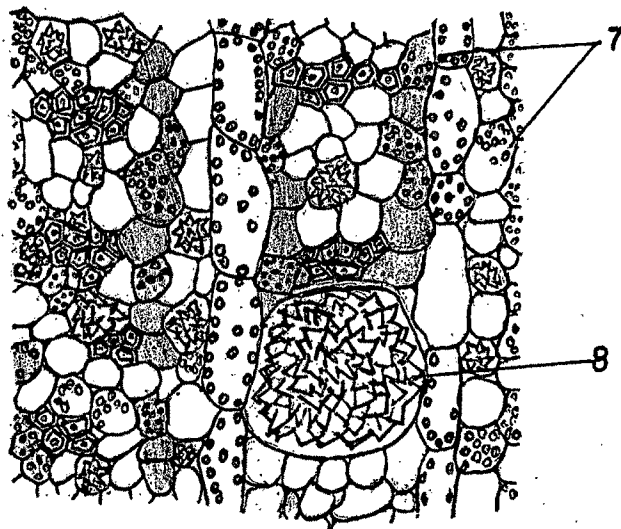
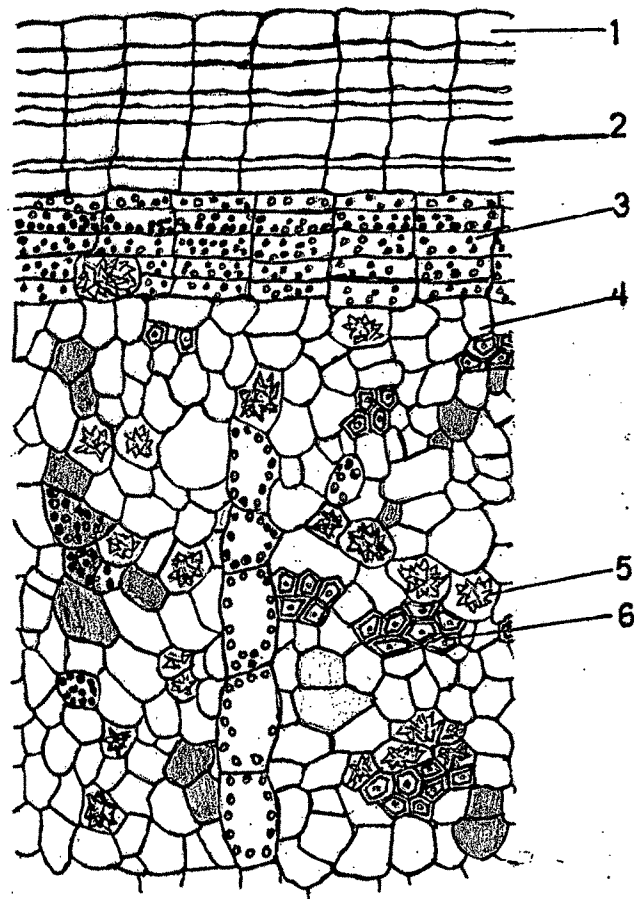


Fig. 12 *Terminalia arjuna* Bark, T.S.: 1. Cork, 2. Phellogen, 3. Chlorenchyma, 4. Parenchyma, 5. Sphaeraphides, 6. Gelatinous fibres, 7. Starch grains, 8. Large sphaeraphide, 9. Medullary rays with starch grains

Bark- L.S (Fig. 13)

Few layers of cork cells (13-37 x 17-38 μ m) of hexagonal to pentagonal shape with small pits were seen followed by two to three layers of chlorenchyma (17-34 x 14-38 μ m). Cortex was of parenchyma cells (27-68 x 14-20 μ m) of irregular shape filled with pink contents alongwith big and small sphaeraphides (14-27 μ m). On one side of fibre were horizontally elongated cells (50-80 x 17-25 μ m) and on the other side are vertically elongated cells (15-20 x 75-90 μ m). Horizontally elongated cells had pink contents and sphaeraphides. Medullary cells were covered on either side with fibres and square shaped cells as well a pink cells. Big sphaeraphides (27-51 μ m) were also seen. Cells were with sphaeraphides and starch grains.

Powder study (Fig. 14)

The powder was reddish brown in colour. The following constituents were seen- parenchyma cells (24-34 x 10-20 μ m) with starch grains and sphaeraphides; cells with pink color, fibres, medullary rays (27-48 x 17-24 μ m) with fibres and square shaped cells, square shaped cells containing sphaeraphides alongwith horizontally elongated parenchyma cells, large sphaeraphides (27-51 μ m), cork cells (13-37 x 17-38 μ m) and starch grains (4-7 μ m).

Pharmacognostic markers: Parenchyma with red deposits

- : Gelatinous fibres
- : Large sphaeraphides
- : Crystal fibres

Leaf micromorphology

Stomata were anomocytic found only on lower epidermis. Stomatal index was 28-30. Trichome index of long, pointed with slightly broad base trichomes were 8-10 and short, sessile globular trichomes were 3-5.

Leaf -T.S. (Fig. 15)

Leaf was dorsiventral in nature. Midrib was highly ridged. Upper epidermis consisted of barrel shaped cells (10-17 x 17-20 μ m) covered by a thin cuticle. Two types of

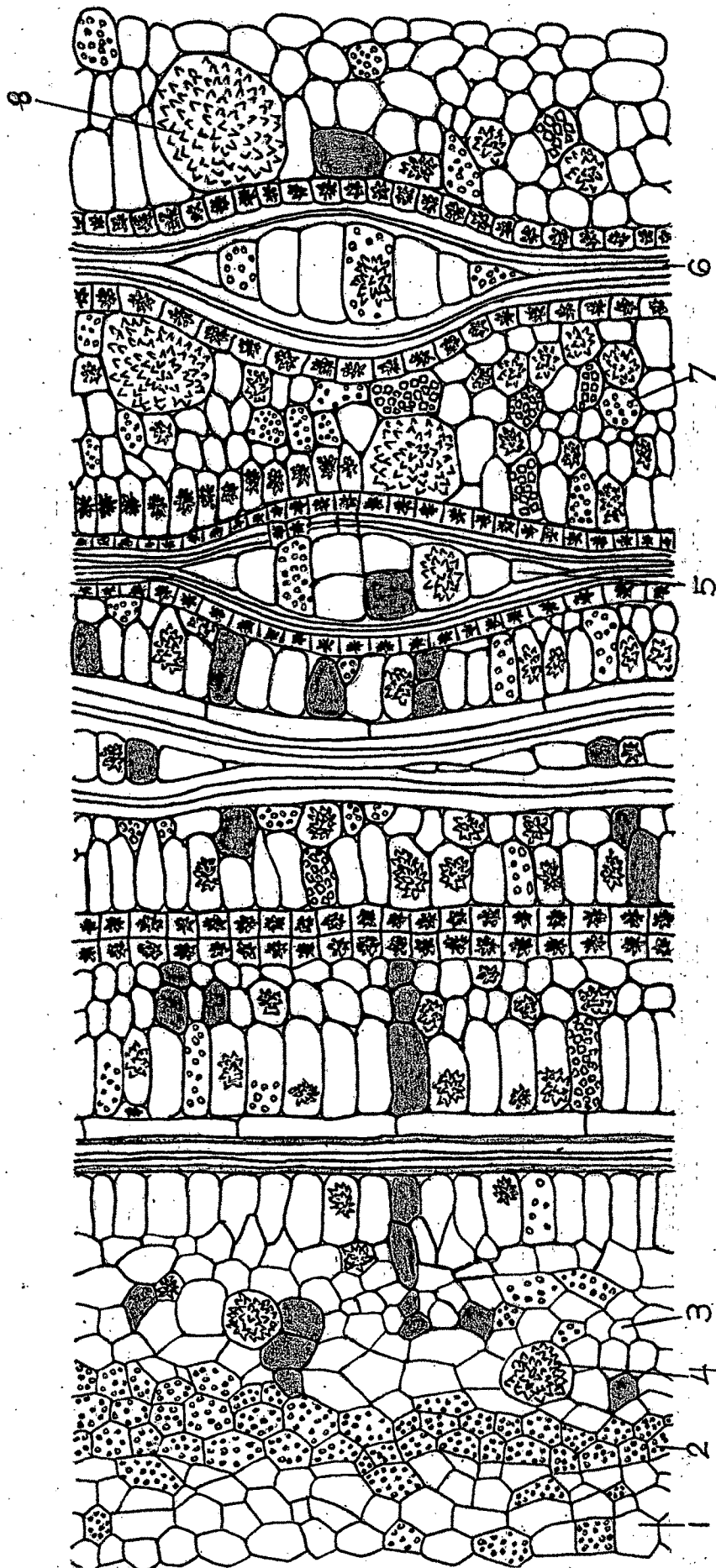


Fig. 13 *Terminalia arjuna* Bark, L.S.: 1. Cork, 2. Chlorenchyma, 3. Parenchyma, 4. Sphaeraphides, 5. Medullary rays, 6. Fibres, 7. Starch grains, 8. Large sphaeraphide

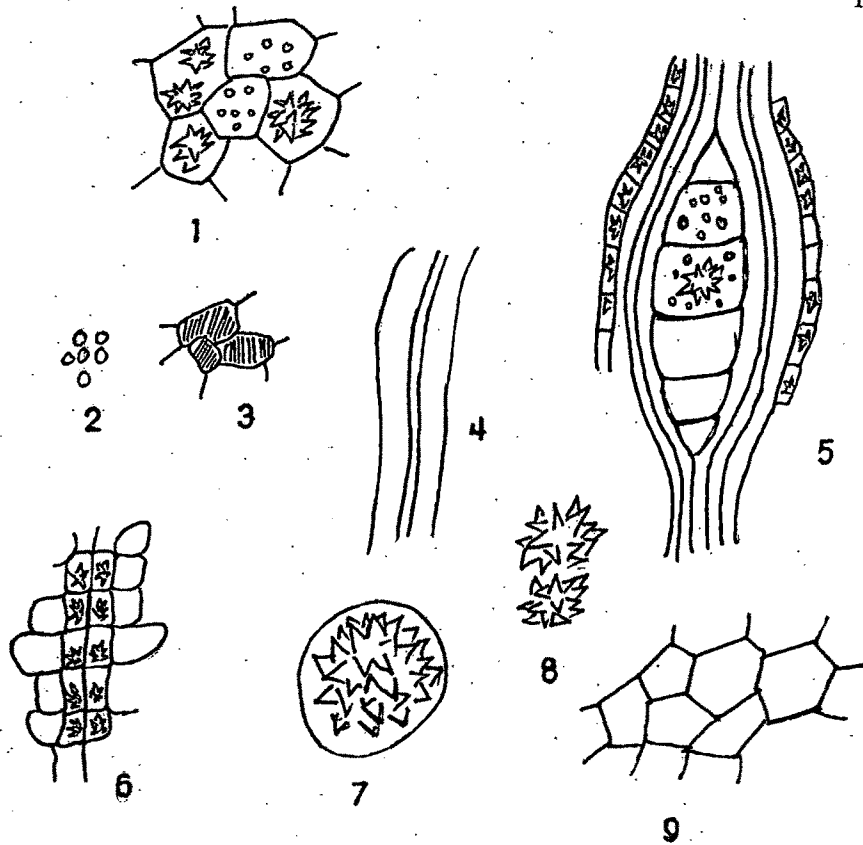


Fig. 14 *Terminalia arjuna* Bark, Powder study: 1. Parenchyma cells with sphaeraphides and starch grains, 2. Starch grains, 3. Pink colored cells, 4. Fibres, 5. Medullary rays with fibres and square shaped cells, 6. Square shaped cells containing sphaeraphides alongwith horizontally elongated parenchyma cells, 7. Large sphaeraphide, 8. Sphaeraphide, 9. Cork cells

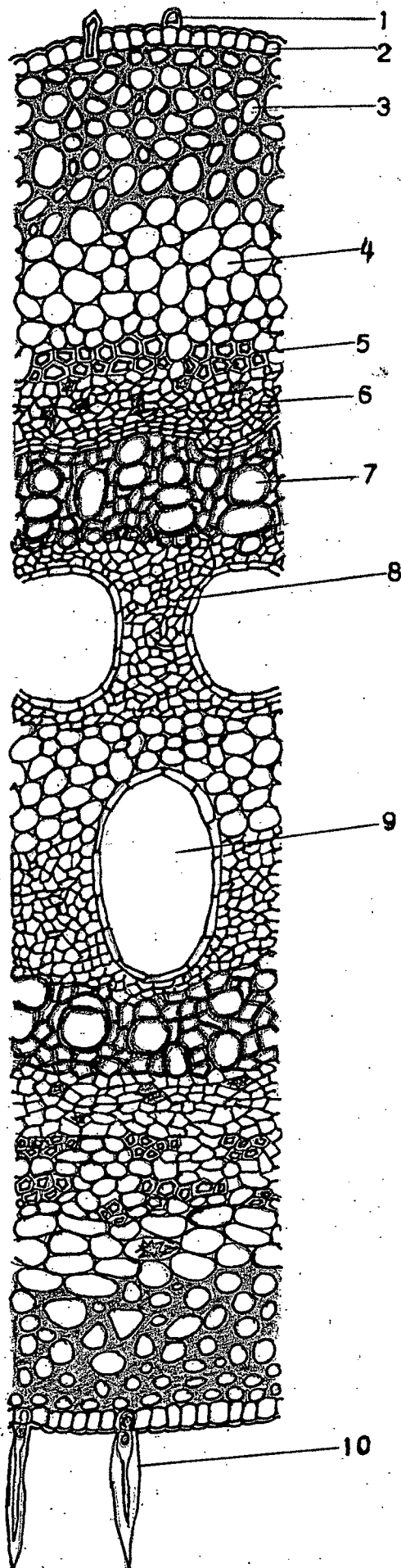


Fig. 15 *Terminalia arjuna* Leaf, Midrib-T.S.: 1. Short unicellular trichome, 2. Epidermis, 3. Lacunar collenchyma, 4. Parenchyma, 5. Sclerenchyma, 6. Intraxylary phloem, 7. Xylem, 8. Phloem, 9. Resin canals, 10. Long unicellular trichome.

unicellular non glandular trichomes were seen in upper epidermis. They were 1) Long, pointed with slightly broad base (109-238 x 7-24 μ m) and 2) Short, sessile globular trichomes (24-37 x 7-24 μ m). In the mid rib region, hypodermis consisted of broad lacunar type of collenchyma (17-30 μ m) of five to six layers. Below this region were five to six layers of large isodiametric parenchyma cells (24-58 μ m). Endodermis was not well-differentiated. Pericycle composed of long patches of two layered sclerenchyma (13-20 μ m) was found encircling the vascular bundle. The vascular bundle was bicollateral and in the shape of an inverted triangle with three resin canals in a Y shaped arrangement in the centre. The outer phloem consisted of small polygonal cells (10-16 μ m) surrounding the xylem. Tannin cells were seen in this region alongwith cluster crystals of calcium oxalate (8-10 μ m). Xylem tracheids (32-35 μ m) were oval to rectangle in shape found in radial rows. In between the tracheids, xylem rays (27-34 x 14-21 μ m) were seen in longitudinal rows. Inner to xylem, intraxylary phloem of 12-18 layers was observed. Within this phloem region small spaces or cavities were seen which was also seen in the phloem towards the upper epidermis. Of the three resin canals, the upper two canals (120-150 μ m) were small and the lower (210-260 μ m) was big. Isodiametric parenchyma (17-31 μ m) was seen in the centre of vascular bundle. Below the vascular bundle were eight to nine layers of oval to round parenchyma. Within this tissue, patches of sclerenchyma and cluster crystals of calcium oxalate (14-34 x 14-24 μ m) were seen. Lower hypodermis consisted of five to six layers of annular collenchyma. Lower epidermis was similar to the upper epidermis.

In the lamina portion (Fig. 16a), mesophyll was differentiated into two layered palisade and 10-11 layers of spongy cells. Palisade cells (34-48 x 10-14 μ m) were of unequal length and with walls curved in at many places to give a "crenate" appearance. Vertical patches of seven to eight collenchyma cells were seen at many places interrupting the palisade on the upper side and above lower epidermis among spongy tissue. Resin canals (80-110 μ m) were seen below the palisade. Palisade cells contained many small chloroplasts. Spongy cells (34-48 x 14-24 μ m) were chlorenchymatous cells with many intercellular spaces between them. Cluster crystals of calcium oxalate were observed among spongy cells. Sunken stomata were also present in lower epidermis.

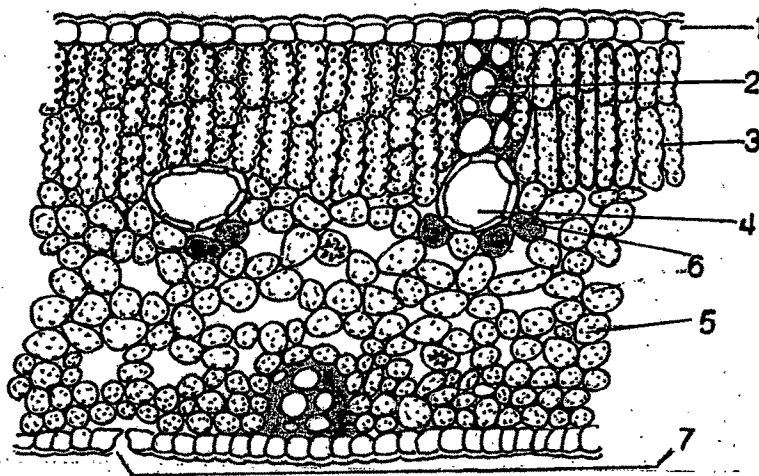


Fig. 16(a) *Terminalia arjuna* Leaf, Lamina-T.S.: 1. Epidermis, 2. Lacunar collenchyma, 3. Two layered palisade, 4. Resin duct, 5. Spongy cells, 6. Tannin cells, 7. Sunken stomata

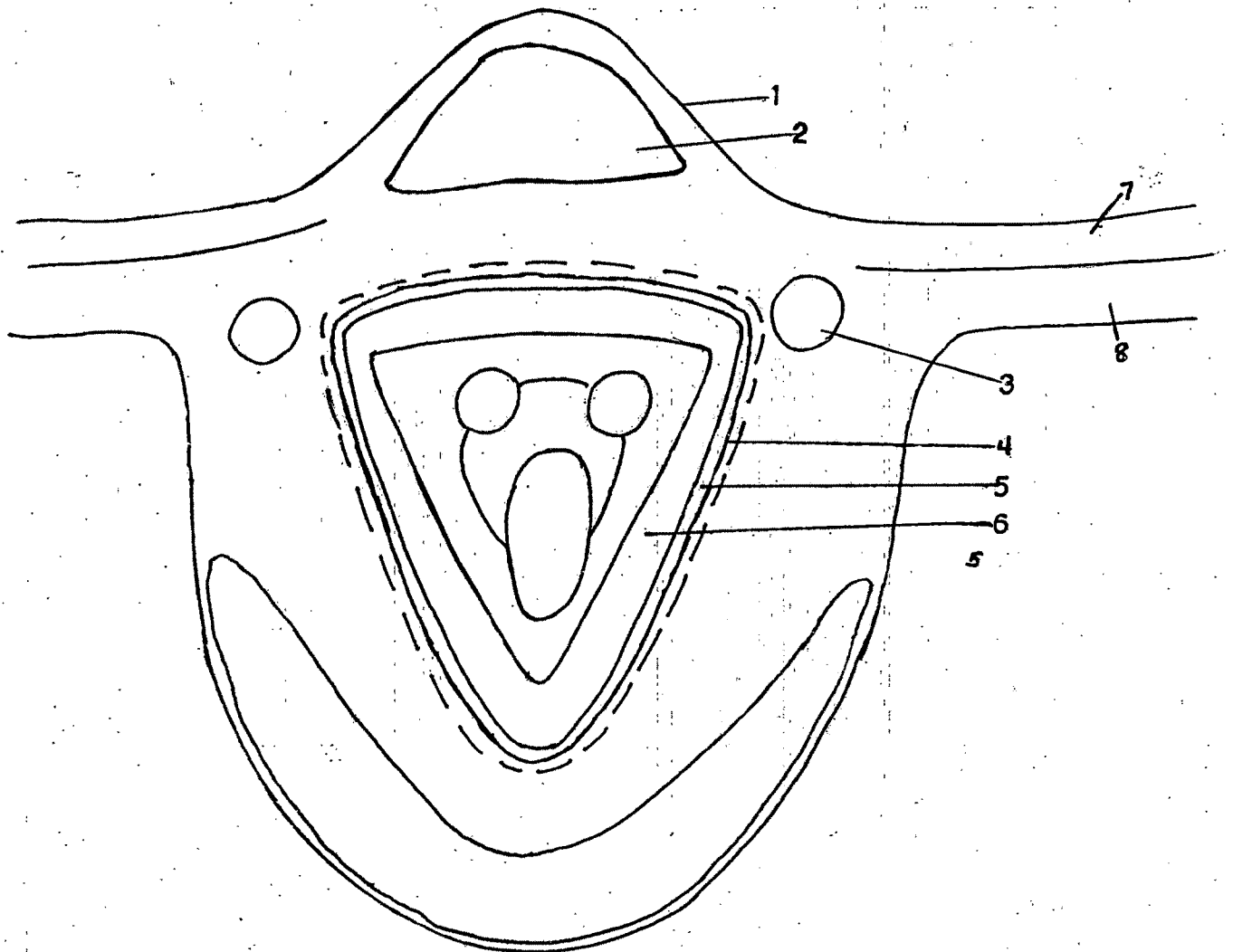


Fig. 16(b) *Terminalia arjuna* Leaf, Schematic representation: 1. Epidermis, 2. Lacunar collenchyma, 3. Vascular bundle, 4. Sclerenchyma, 5. Phloem, 6. Xylem, 7. Palisade tissue, 8. Spongy tissue

Powder study (Fig. 19a)

Unicellular trichomes (109-238 x 7-24 μ m), parenchyma cells (24-58 μ m) with sphaeraphides, sclerenchymatous fibres (lumen: 10 μ m), anomocytic stomata and sphaeraphides (8-10 μ m) were observed. Tracheids (18-25 μ m) with scalariform thickening, two layered palisade tissues (34-48 x 10-14 μ m), lacunar collenchyma cells (17-30 μ m), tannin cells, veins and resin ducts (80-110 μ m) were also seen.

Pharmacognostic markers: Unicellular trichomes long pointed with slightly broad base

and short sessile globular unicellular trichomes

: Vascular bundle of inverted triangular shape and two smaller vascular bundle

: Resin canals in vascular bundle and in lamina

: Two layered palisade with cells of unequal length and "crenate" walls

: Patches of collenchyma in lamina

Stem- T.S. (Fig. 17)

The stem of *T. arjuna* was peculiar in having cork originating from the layers inner to pericycle. This causes the outer region including the primary cortex and epidermis to be peeled off. Therefore only in a few sections the outer epidermis and primary cortex were visible. The stem studied here contained primary cortex.

The transverse section of stem was circular in outline encircled by rectangular to barrel shaped epidermal cells (17-24 x 17-20 μ m) covered by a thin cuticle. Unicellular elongated trichomes (80-110 x 7-24 μ m) having a pointed end protruded from epidermis. The primary cortex was constituted of an outer five to six layered angular collenchymatous zone (17-34 x 17-20 μ m) and an inner region of two to three layered parenchyma (10-17 x 27-58 μ m). Endodermis was not well defined. Pericycle consisted of patches of sclerenchyma (2-5 layers thick) (6-16 x 7-14 μ m) separated by parenchymatous cells. The cork region (24-38 x 10-20 μ m) was seen below the pericycle. The cork formation was in the initial stages and therefore the cork consisted of a single wavy layer of broad rectangular (often elliptic) cells on the outer side of a single layer of narrow

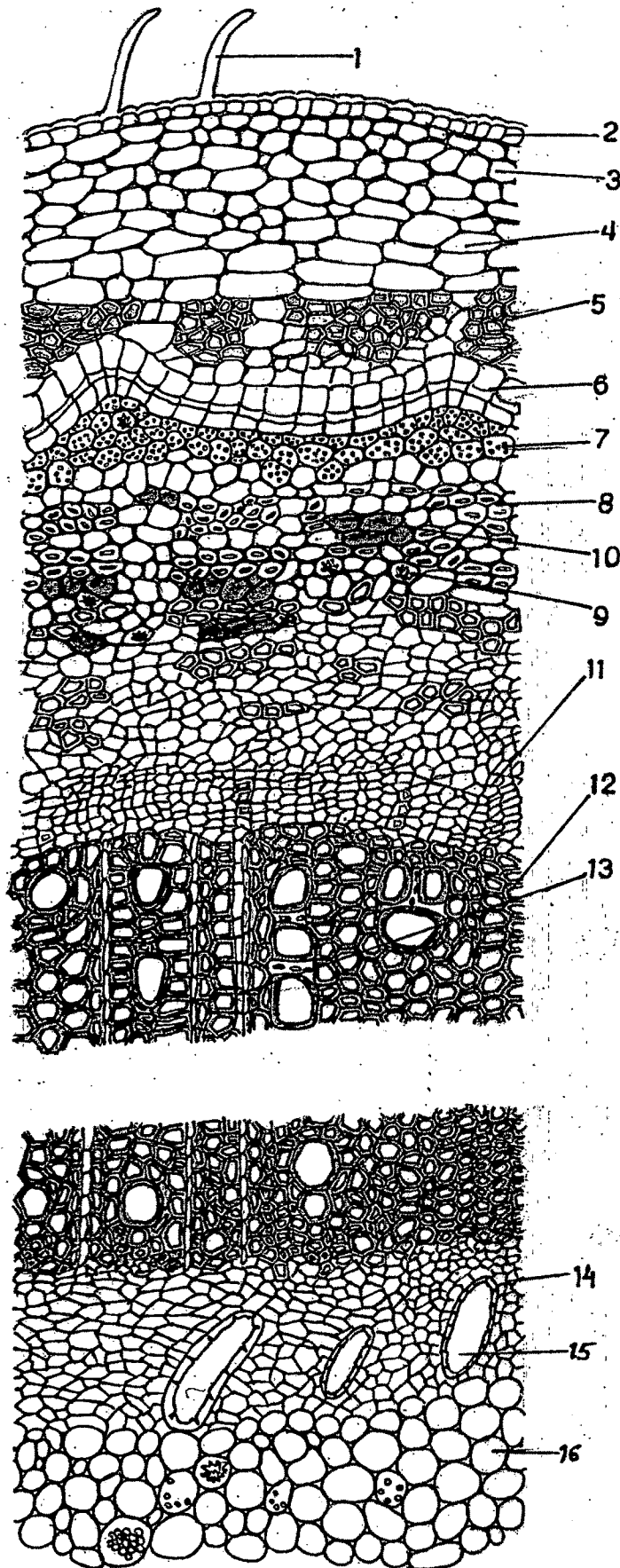


Fig. 17 *Terminalia arjuna* Stem, T.S.: 1. Unicellular trichome, 2. Epidermis, 3. Angular Collenchyma, 4. Parenchyma, 5. Sclerenchyma, 6. Cork, 7. Parenchyma with starch grains, 8. Gelatinous fibres, 9. Sphaeraphide, 10. Tannin cells, 11. Phloem, 12. Xylem, 13. Medullary rays, 14. Intraxylary phloem, 15. Resin duct, 16. Pith

rectangular cork cambium. There was only a single layer of colorless parenchyma representing the secondary cortex (13-24 x 6-17 μ m). The phloem (7-10 x 10-17 μ m) inner to this layer differentiated into an outer broad non functional region and an inner narrow functional region. The outer most three to four layers of non functional phloem consisted of phloem parenchyma (10-17 x 20-51 μ m) filled with simple spherical starch grains (3-11 μ m). The region below this was stratified with bast fibres. There were four to six tangential bands of bast fibres each two to three layers in thickness. The fibres (10-17 x 27-58 μ m) of outer bands were having thick walls and narrow lumen and those towards functional phloem were thin walled with large lumen. These bands were separated by transverse layer of parenchyma, some of which contained tannin. These tannin cells were oval to hexagonal in shape and were more in the outer region. Some of the phloem ray cells contained cluster crystals. The functional phloem consisted of eight to ten layers of sieve tubes & companion cells closely packed.

Wood was diffuse porous. The xylem consisted of radial rows of vessels, tracheids & xylem parenchyma. The tracheids (4-11 μ m) were thin walled. Vessels (20-27 μ m) were oval to elliptical with apotracheal parenchyma. The xylem rays (34-48 x 14-24 μ m) appeared uniseriate. The intraxylary phloem consisted of eight to ten layers of sieve tubes and companion cells. There were large resin ducts (102-119 x 23-38 μ m) in this region. Pith was large consisting of oval to spherical parenchyma cells (17-38 μ m), a few of which contained cluster crystals or groups of small starch grains.

Stem- T.L.S. (Fig. 18a)

In T.L.S., the cork cells (23-38 x 10-20 μ m) were thin walled and elongated. Next to the cork was oval shaped phloem parenchyma (21-40 μ m) filled with starch grains. Crystal fibres were observed among parenchyma cells. Each crystal fibre consisted of elongated spindle shaped thick walled sclerenchyma (lumen: 6 μ m) covered by rows of squarish parenchyma cells (17-38 μ m), each cell containing a large single cluster crystal (14-24 μ m). Phloem rays (24-37 μ m) were biseriate with cluster crystals or starch grains (6-10 μ m) in each cell. Xylem rays (10-22 x 110-421 μ m) were uniseriate and thick walled. Vessels (80-110 μ m) were broad with compactly arranged three to four rows of bordered pits. Perforation plates were also observed in the vessels.

Stem- R.L.S. (Fig. 18b)

In R.L.S., cluster fibres were seen here also. Rays were found with sphaeraphides and starch grains. Phloem rays (17-24 μ m) were having thick walls and contained starch grains. Cluster crystals also were seen here. The tracheids (17-26 μ m) possessed simple pits and vessels (30-70 μ m) were with three to four rows of closely packed bordered pits which appeared like a reticulum. Xylem rays (19-25 x 45-75 μ m) were uniseriate, uprightly placed and thick walled. Primary xylem elements were with annular thickening. Intraxylary phloem (6-10 x 37-44 μ m) was seen as elongated rectangular elements. Spherical parenchyma cells constituted the pith.

Powder study (Fig. 19b)

Powder showed sphaeraphides, sclerenchyma fibres, resin ducts, cork cells, tannin cells, vessels (80-110 μ m) with bordered pits as well as tracheids (17-26 μ m) with scalariform thickening. Parenchyma cells filled with starch grains (27-58 μ m), phloem ray cells (24-37 μ m) alongwith phloem, medullary rays (19-25 x 45-75 μ m) and phloem cells (6-10 x 37-44 μ m) were also observed.

Pharmacognostic markers: Unicellular elongated trichomes

- : Cork formation in lower layers
- : Abscission layers of broad rectangular cells
- : Stratified phloem
- : Resin ducts with intraxylary phloem
- : Crystal fibres
- : Vessels with closely packed bordered pits appearing like reticulum.

5. *Terminalia chebula* Retz.

English name: Chebulic Myrobalan

Hindi- Harra, **Beng.-** Haritaki, **Mar.-** Hirda, **Guj.-** Hardo, **Tel.-** Karakkai,

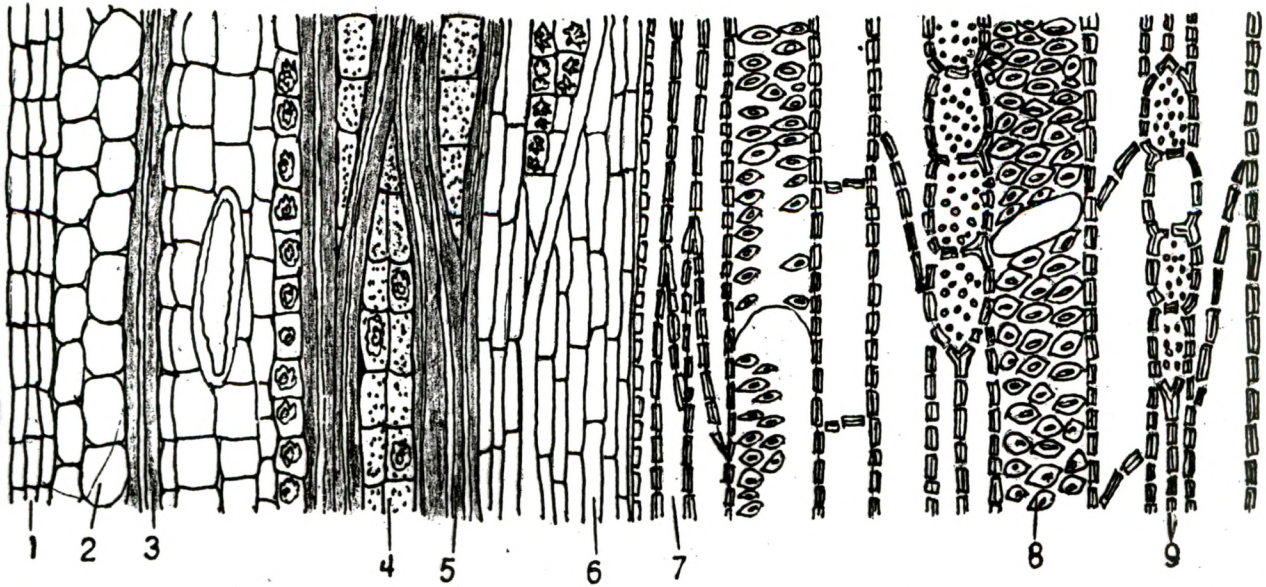


Fig. 18(a) *Terminalia arjuna* Stem, T.L.S.: 1. Cork, 2. Parenchyma, 3. Sclerenchyma, 4. Phloem rays, 5. Fibres, 6. Phloem, 7. Tracheid, 8. Vessels with bordered pits, 9. Medullary ray

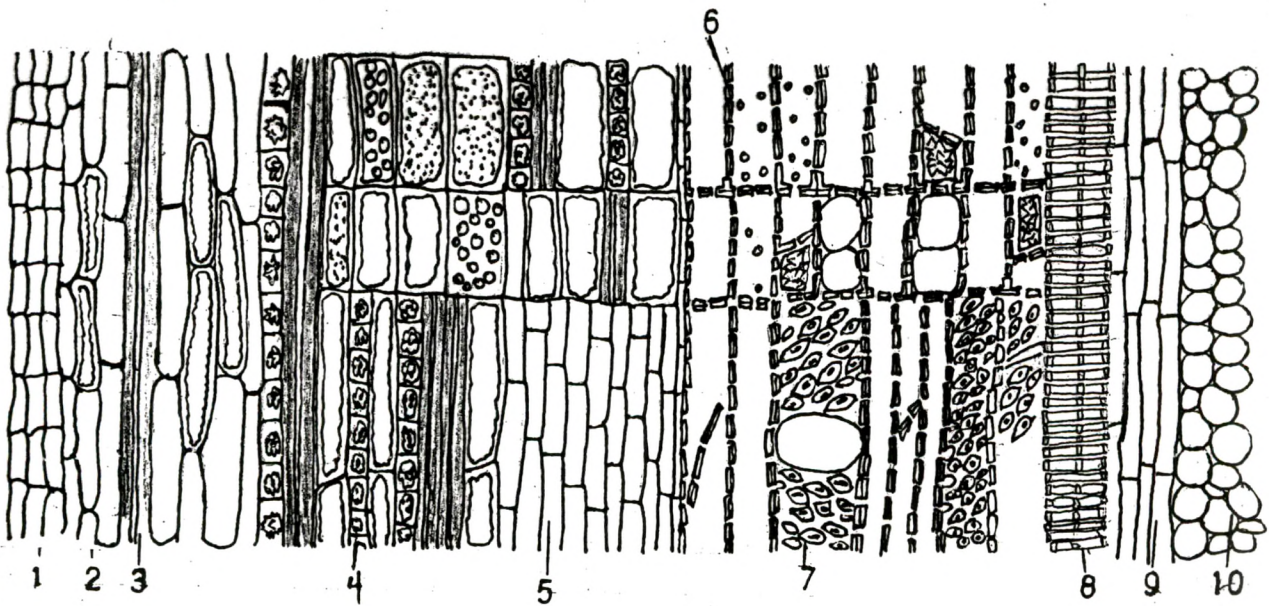


Fig. 18(b) *Terminalia arjuna* Stem, R.L.S.: 1. Cork, 2. Parenchyma, 3. Sclerenchyma, 4. Phloem rays, 5. Phloem, 6. Medullary ray, 7. Vessel, 8. Annular thickening, 9. Phloem, 10. Pith

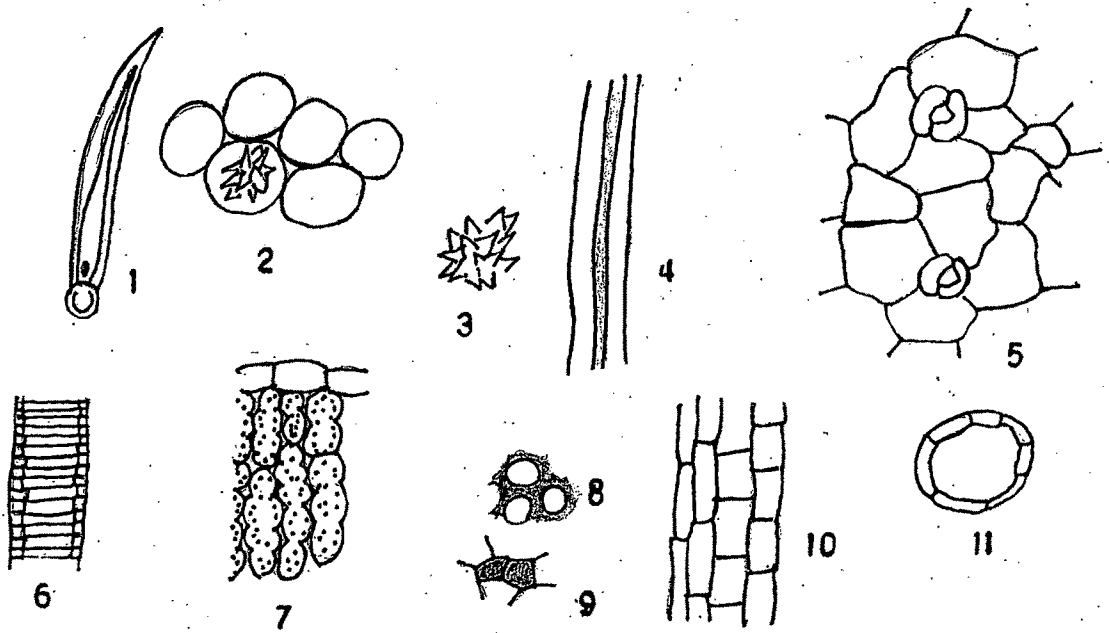


Fig. 19(a) *Terminalia arjuna* Leaf, Powder study: 1. Unicellular trichome, 2. Parenchyma with Sphaeraphide, 3. Sphaeraphide, 4. Sclerenchyma, 5. Anomocytic stomata, 6. Scalariform thickening, 7. Two layered palisade tissue, 8. Lacunar Collenchyma, 9. Tannin cells, 10. Veins, 11. Resin ducts

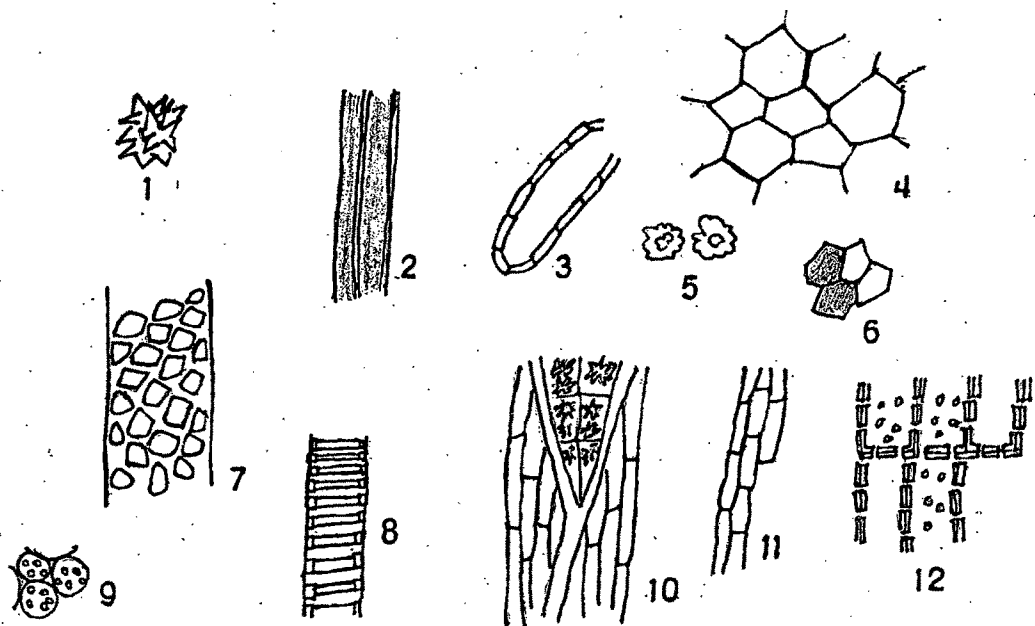


Fig. 19(b) *Terminalia arjuna* Stem, Powder study: 1. Sphaeraphide, 2. Sclerenchyma, 3. Resin duct, 4. Cork cells, 5. Sphaeraphide, 6. Tannin cells, 7. Vessels with bordered pits, 8. Scalariform thickening, 9. Parenchyma with Starch grains, 10. Phloem rays along with phloem, 11. Phloem, 12. Medullary rays

Tam. - Kadukkai, Oriya- Haridra, Punjab- Har, Harar, Assam- Silikha

Sanskrit name: Haritaki

Trade: Myrobalan, Chebulic Myrobalan (tree & fruit)

Distribution: The plant is found in the sub-Himalayan tracts from the Ravi eastwards to West Bengal and Assam, hills of Deccan and South India, Sri Lanka, Nepal and Burma

T. chebula, the fruits of which forms one of the constituents of **Triphala**, a well-known rasayana drug, is a tree of 15 – 24 m in height and 1.5 - 2.4 m in girth, with a cylindrical bole of 4-9 m, a crowded crown and spreading branches, found through out the greater parts of India. Bark is dark brown, often longitudinally cracked, exfoliating in woody scales. Leaves, crowded at the tip of branches, are ovate or elliptic with a pair of large glands at the top of the petiole. Flowers are yellowish – white in terminal spikes. Drupes are ellipsoidal, obovoid or ovoid in shape, yellow to orange-brown or sometimes tinged with red or black and hard when ripe. They are 3-5 cm long which becomes 5-ribbed on drying. Seeds are hard, pale yellow.

Medicinal Uses: Myrobalans are an important group of three fruits, **Triphala**, which is widely used in Ayurvedic medicine since ancient times. Garcia da Orta (1563) had discussed the identity and application of this group of drugs in the ancient India. The Indian 'myrobalans' is constituted by the ripe fruits of haritaki, vibhitaki (*T. bellirica*) and amalaki (Amla) and is a rasayana drug capable of imparting youthful vitality and receptivity of mind and sense organs. The official part of the fruit is the fruit rind. The important preparations using the drug are *Abhayarishtam*, *Triphaladi churnam*, *Agastyarasayanam*, *Dasamularishtam*, etc. Some authors are of the opinion that *vijaya*, *rohini*, *putana*, *amrta*, *abhaya*, *jivanti* and *cetaki* represent seven different varieties of haritaki. Most of them consider these names to be synonyms of the latter (Sivarajan and Balachandran, 1994). In Ayurveda, it is used as a purgative as well as for treatment of sprue. It is considered as a tonic and restorative. In *Charaka Samhita*, it is said to be antiageing in nature (Sukh Dev, 2006).

Detailed medicinal properties:

Fruits have laxative, stomachic, tonic and alterative properties. They are extensively used as adjuncts to other medicines in almost all diseases. The anthelmintic activity of

triphala was found to be more than that of any of its three components (in dilute aqueous extract) possibly due to their synergistic effect. The fruit pulp is used as a dentrifice to cure bleeding and ulceration of gums. Water in which the fruits have been steeped overnight is a good cooling wash for eyes, affording relief in conjunctivitis & similar infections of the eyes. When coarsely powdered and smoked in a pipe the fruit gives relief in asthma (Anon.,1999). Fruits of *T.chebula* & *T. bellerica* alongwith *Lawsonia inermis* leaf & rind of *Punica granatum* showed anti-MRSA activity. Bark has both diuretic & cardiotoxic properties. It helps to wash wounds. Methanolic extract of the trunk bark showed physiological activity on blood pressure and intestine of rabbit and the uterus of guineapig. Aqueous extract was studied which showed that it is a potent antioxidant and may have the potential to be radioprotector. It has hepatoprotective action also (Anon.,1999).

Previous phytochemical reports:-

Leaves are reported to contain shikimic, dehydroshikimic & quinic acids. The dried flesh surrounding the seed is rich in tannin. Fruit contains chebulic acid, 3, 6 – digalloylglucose, ellagic acid, gallic acid, β -D- glucogallin, terchebin, 1, 3, 6-trigalloylglucose and 1, 2,3,4,6 – pentagalloylglucose (Anon., 1999). Anthraquinone glycoside was found by spectrofluorimetric determination (Shah, 2003). Chebulin is reported from the fruit (Anon., 1999).

Previous pharmacognostic studies:

The transverse section of the fruit has been studied. Pharmacognostic data on bark and leaves were not available.

In the present work, leaves, stem and fruit were analysed for their flavonoids, phenolic acids, quinones, etc. Pharmacognostic studies of bark, leaves and fruit also were carried out.

Materials and Methods:

Plant materials for the present study were collected from Baroda. The voucher specimen of the plant has been deposited in the Herbarium, Department of Botany, The Maharaja Sayajirao University of Baroda (BARO), Vadodara. Standard methods,

presented in chapter 2 were followed for the extraction, isolation and identification of the phytochemicals. Pharmacognosy has been conducted by standard methods mentioned in chapter 2.

Results:-

Phytochemistry:-

Quercetin was present in fruit, stem and leaves. 3'-OMe Quercetin was identified in both leaves and stem, while 3', 4' -diOMe quercetin was seen only in leaves. Phenolic acids like vanillic, syringic and gallic acids were present in all; melilotic acid was present only in leaves while *p*-coumaric acid was seen in stem and fruits. Gossypetin, 3' -OMe Gossypetin and 3', 4' -OMe Gossypetin were identified in bark. Quinones and glycoflavones were absent in all parts, but steroids were present in all the four parts of the plant.

Phytochemical biomarkers of fruit: Quercetin and *p*-coumaric acid

stem: Quercetin and *p*-coumaric acid

leaves: Quercetin, 3',4'-diOMe quercetin and melilotic acid

bark: Gossypetin, 3' -OMe Gossypetin and 3', 4' -OMe Gossypetin and no other flavonoids

Pharmacognosy of bark, fruit and leaf:

Bark - T. S. (Fig. 20)

Cork was thick and consisted of broad rectangular and thick walled cells (17-37 x 10-14 μ m). The cells next to cambium (6-7 x 17-37 μ m) towards the outer side were very large square-shaped cells similar to those of abscission layers (24-27 x 10-14 μ m). Bast appeared stratified with tangential bands/groups of fibres alternating with phloem parenchyma (24-34 x 10-20 μ m). The outer bands of fibres were of gelatinous fibres (17-34 x 10-14 μ m) and inner groups were of libriform fibres (24-37 x 10-17 μ m). There were radial rows of parenchyma. The outer phloem rays (17-27 x 14-24 μ m) were red containing tannins/proanthocyanidins. The wood appeared diffuse porous. Active phloem

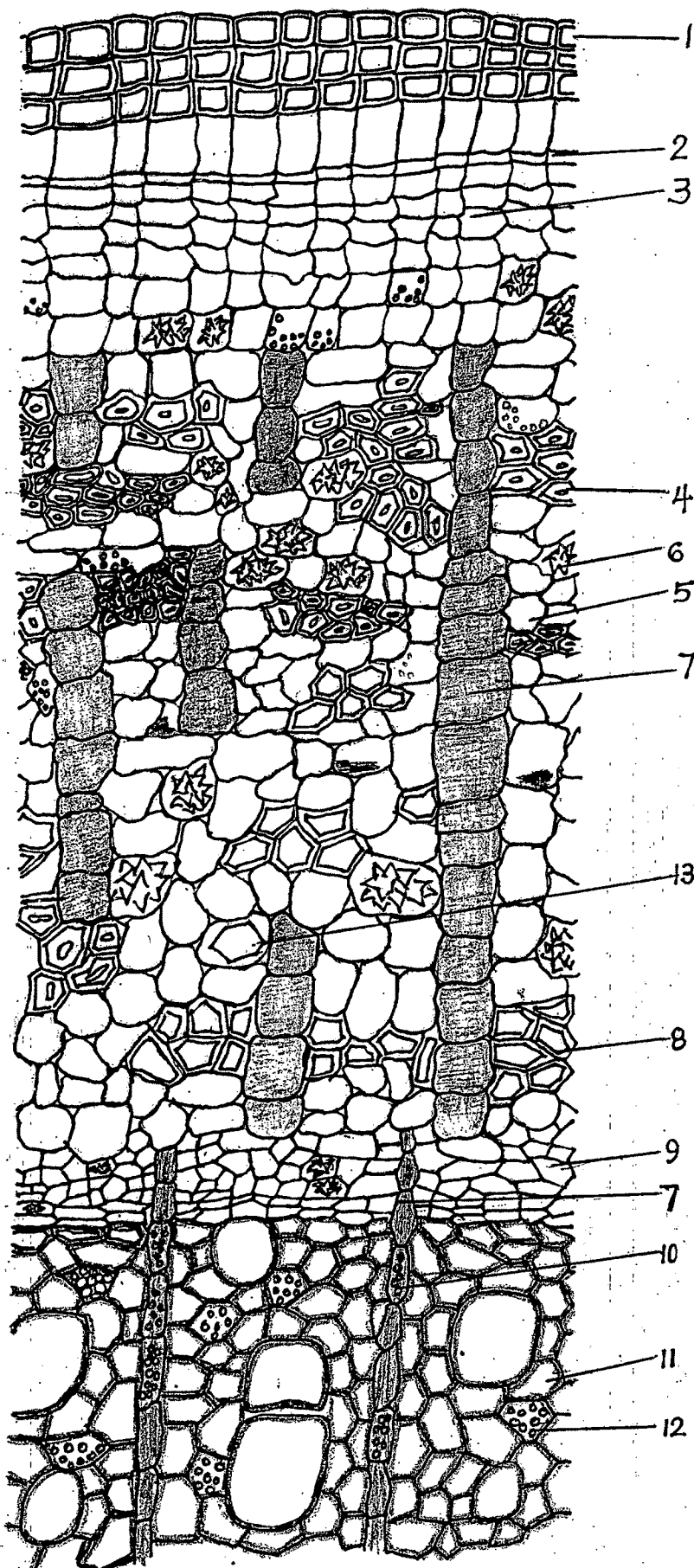


Fig. 20 *Terminalia chebula* Bark, T.S.: 1. Cork, 2. Cambium, 3. Abscission layer, 4. Gelatinous fibre, 5. Phloem parenchyma, 6. Sphaeraphide, 7. Phloem ray containing tannins, 8. Libriform fibres, 9. Phloem, 10. Xylem rays containing starch grains, 11. Xylem, 12. Starch grains, 13. Crystal

elements (20-27 x 10-13 μ m) were of five to seven layers of polygonal shaped cells wherein some contained sphaeraphides (6-10 μ m) as well as crystal, one in each cell. Phloem rays towards the inner side were of elongated cells and with some brown contents which extended to the xylem cylinder. Xylem rays (11-15 μ m) contained starch grains along with the brown deposits. Xylem vessels (42-107 μ m) were almost circular singly or in radial pairs and tracheids (14-17 μ m) were in radial rows. Simple starch grains (7-10 μ m) were seen within some tracheids which partly or fully filled the cell.

Bark- L.S. (Fig. 21)

Cork cells (10-17 x 20-48 μ m) were broad, rectangular and thick walled. The bast fibres towards outside (gelatinous fibres) (136-255 x 7-10 μ m) had a very narrow lumen (2-3 μ m). And the inner region of the wall was almost white or light pink. The inner fibres had thin walls and broad lumen (7-8 μ m). The phloem rays were broad, multiseriate and the cells here contained large or small cluster crystals (10-27 μ m).

Powder study (Fig. 23a)

Powder is dark reddish brown in color. Thick walled as well as thin walled cork cells, parenchyma cells containing sphaeraphides, gelatinous fibres (136-255 x 7-10 μ m, lumen: 8 μ m), crystals, phloem parenchyma cells containing starch grains, sphaeraphides, tannin cells, libriform fibres and starch grains were observed

Pharmacognostic markers: Stratified phloem

- : Phloem rays containing tannins
- : Fibres of two types-one with thin walls and broad lumen and other with thick walls and narrow lumen

Fruit (T.S.) (Fig. 22)

Outermost layer was a single layered epidermis consisting of rectangular cells (14-37 x 10-14 μ m) with some tanniferous contents. This was covered by a thin cuticle. Below the epidermis was the hypodermis consisting of 3-4 layers of lacunar collenchyma (27-65 x 10-14 μ m). Cortex contained 4-5 layers of parenchyma cells (34-65 x 10-20 μ m) with sphaeraphides (17-34 μ m). A band of pitted elongated sclereids (68-119 x 14-20 μ m) were found as the next layer. This was followed by ground tissue which consisted of parenchyma (37-85 x 34-61 μ m). The cells of ground tissue contained sphaeraphides (one per cell), simple starch grains and pits. Within the ground tissues, a large number of

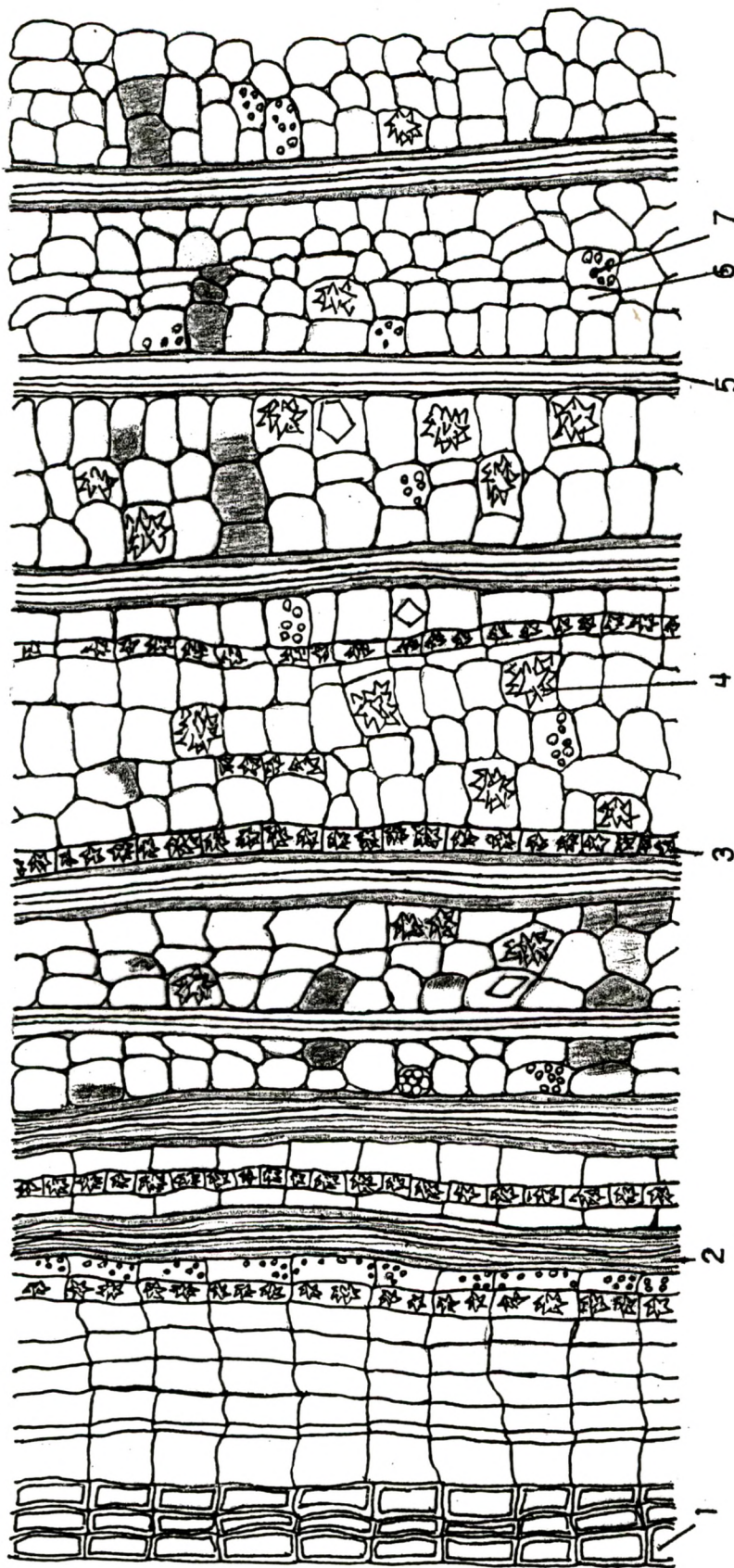


Fig. 21 *Terminalia chebula* Bark, L.S.: 1. Cork, 2. gelatinous fibre, 3. Phloem rays containing Sphaeraphides, 4. Sphaeraphide, 5. libriform Fibres, 6. Phloem Parenchyma, 7. Starch grains

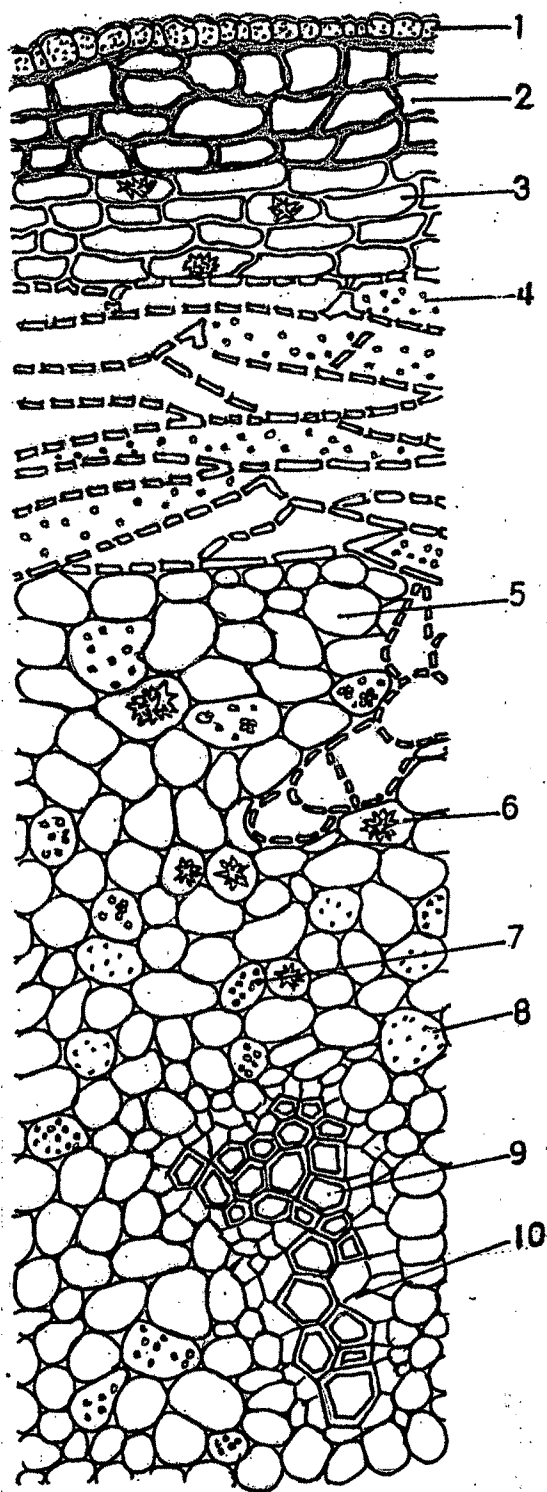


Fig. 22 *Terminalia chebula* Fruit: 1. Epidermis containing tannins, 2. Lacunar Collenchyma, 3. Parenchyma containing Sphaeraphides, 4. Sclereid, 5. Parenchyma, 6. Sphaeraphides, 7. Starch grains, 8. Parenchyma containing pits, 9. Xylem, 10. Phloem

scattered vascular bundles were found. Each vascular bundle consisted of a central xylem surrounded by phloem (10-17 x 6-17 μ m). Xylem contained only tracheids (8-15 μ m).

The difference seen from the previous data given by Aiyer (1957) was the absence of ovoid sclereids in hypodermis and ground tissue.

Powder study (Fig. 23b)

Powder showed elongated pitted spindle shaped sclerieds (68-119 x 14-20 μ m), epidermal cells containing tannin (14-37 x 10-14 μ m), lacunar collenchyma cells (27-65 x 10-14 μ m), parenchyma cells (37-85 x 34-61 μ m) containing sphaeraphides and starch grains and isolated sphaeraphides.

Pharmacognostic markers: Elongated spindle shaped sclereids with pointed ends

: Epidermal cells with tannin

: Many small vascular bundles

Leaf micromorphology

Stomata were anomocytic found only on lower epidermis. Stomatal index was 34-36. Trichome index for unicellular trichomes were 2-4 in the upper epidermis and 6-8 in lower epidermis.

Leaf -T.S. (Fig. 24)

Leaf was dorsiventral. The midrib portion had a crested upper region. Cells of upper epidermis (17-24 x 17-20 μ m) were barrel shaped covered by a thin cuticle. Long, unicellular trichomes were seen protruding from the epidermis. In the midrib portion, the hypodermis was one to two layers of isodiametric chlorenchyma cells followed by three to four layers of angular collenchyma (17-34 x 17-20 μ m) of oval shape. Below the hypodermis was the ground tissue (27-58 μ m) within which embedded was the vascular bundle. The cells of ground tissue contained simple starch grains and sphaeraphides (17-34 x 14-24 μ m). The vascular bundle was enveloped by a pericycle consisting of patches of gelatinous fibres (14-20 x 14-22 μ m) alternating with sclerenchyma (14-20 x 14-18 μ m). Vascular bundle was seen in the shape of an inverted triangle with blunt ends. Phloem elements (10-17 μ m) of the outer region consisted of sieve tubes and companion cells. Cambium was seen inner to the phloem. Xylem consisted of many rows of

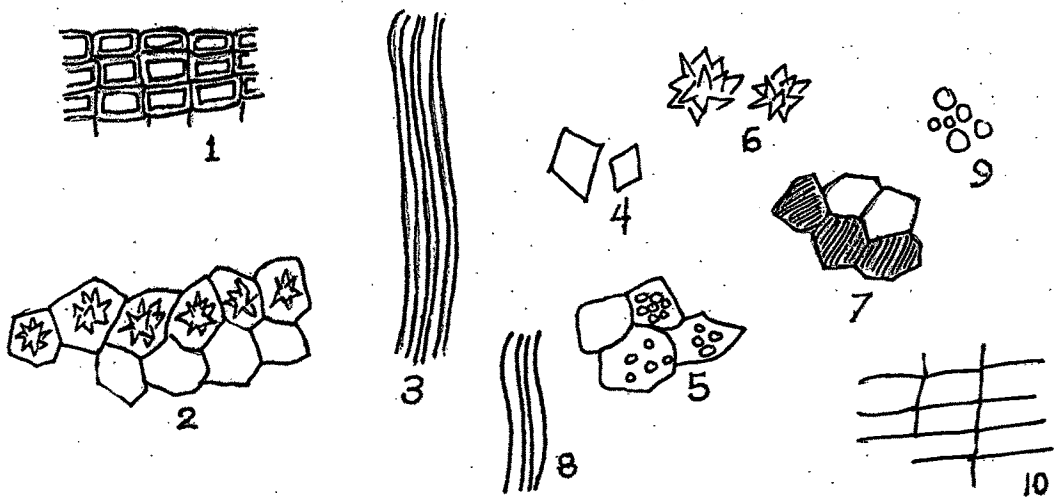


Fig. 23(a) *Terminalia chebula* Bark, Powder study: 1. Thick walled cork, 2. Parenchyma containing sphaeraphide, 3. Gelatinous fibres, 4. Crystals, 5. Parenchyma containing starch grains, 6. Sphaeraphides, 7. Tannin cells, 8. Libriform fibres, 9. Starch grains, 10. Thin walled cork

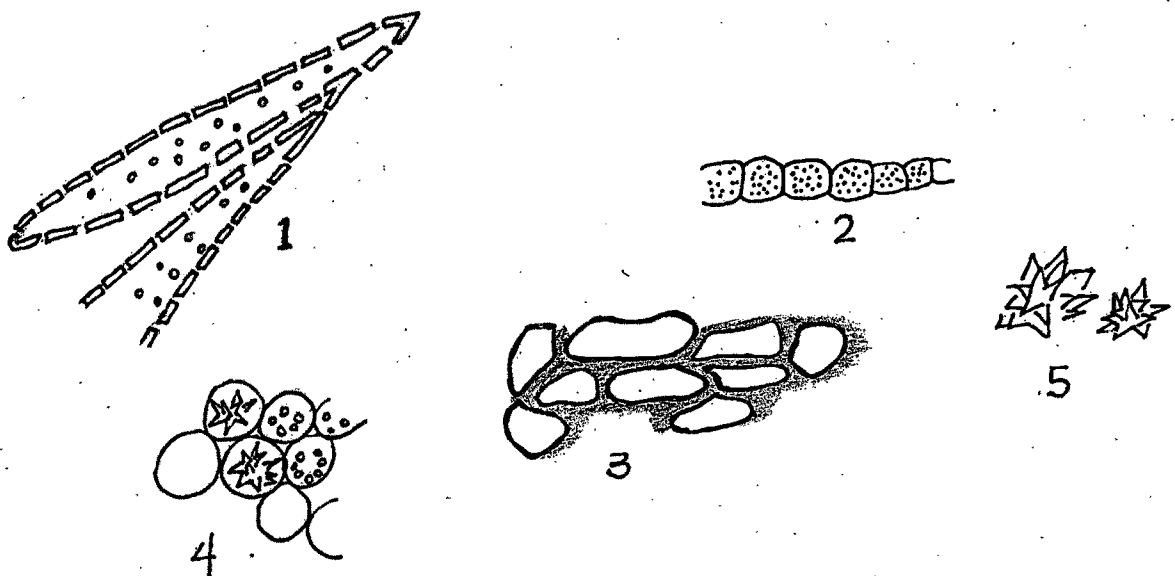


Fig. 23(b) *Terminalia chebula* Fruit, Powder study: 1. Scleried; 2. Epidermis containing tannin, 3. Lacunar collenchyma, 4. Parenchyma containing sphaeraphides and starch grains, 5. Sphaeraphides

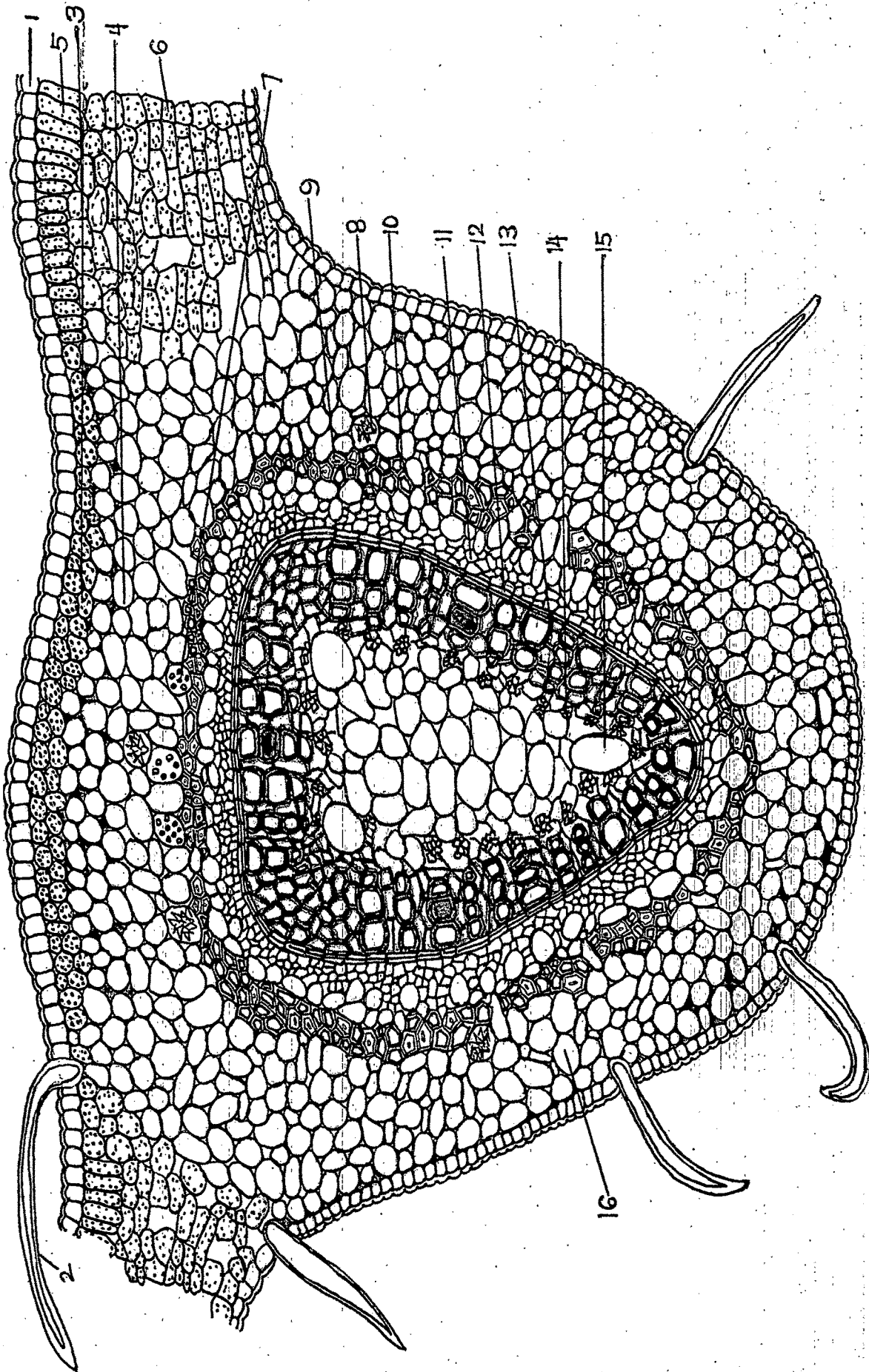


Fig. 24 *Terminalia chebula* Leaf, T.S.: 1. Epidermis, 2. Unicellular trichomes, 3. chlorenchyma, 4. Angular collenchyma, 5. Palisade tissue, 6. Spongy tissue, 7. Parenchyma with starch grains, 8. Sphaeraphide, 9. Gelatinous fibre, 10. Sclerenchyma, 11. Phloem, 12. Cambium, 13. Xylem, 14. Intraxylary phloem, 15. Resin canals, 16. Parenchyma

tracheids (32-37 μ m) arranged in radial rows separated by xylem rays (14-20 μ m). Some dark brown deposits were seen in xylem tracheids and rays. Intraxylary phloem was found in groups immediately inner to the protoxylem group. At the inner three corners of the triangular vascular bundle three resin canals (102-119 μ m) were observed. Round parenchyma cells (68-82 x 58-75 μ m) were present at the center of the vascular bundle. Cells of lower hypodermis were smaller and consisted of two to three layers of angular collenchyma. Unicellular long trichomes (109-238 x 7-24 μ m) were also seen on both surfaces of the leaf.

In lamina portion, the epidermis cells were similar to that of the midrib. Mesophyll was differentiated into single layered palisade (34-44 x 10-13 μ m) and twelve to fourteen layers of spongy cells (34-48 x 17-27 μ m). Spongy cells were closely packed with very less intercellular spaces and were irregularly shaped.

Powder study (Fig. 25)

Unicellular trichomes (109-238 x 7-24 μ m), phloem cells (10-17 μ m), spongy cells (34-48 x 17-27 μ m), sclerenchymatous fibres (34-48 μ m, lumen-10 μ m), gelatinous fibres (40-45 μ m, lumen-7 μ m), parenchyma cells with starch grains (27-58 μ m) and tracheids (17-27 μ m) with scalariform thickening were present in the powder.

Pharmacognostic markers: Long unicellular covering trichomes

- : Gelatinous fibres and libriform fibres
- : Resin canals in vascular bundle
- : Spongy cells closely packed

6. *Combretum ovalifolium* Roxb.

Guj.: *Parmultonda* ; **Mal.** - *Vella korandi*; **Mar.** - *Pilokha, Piwar bel, Zellus*;

Tam. - *Verragay*; **Tel.** - *Are-tiga, Yeda-tiga*

Distribution: - Found throughout upper Gangetic Plain and in parts of peninsular India.

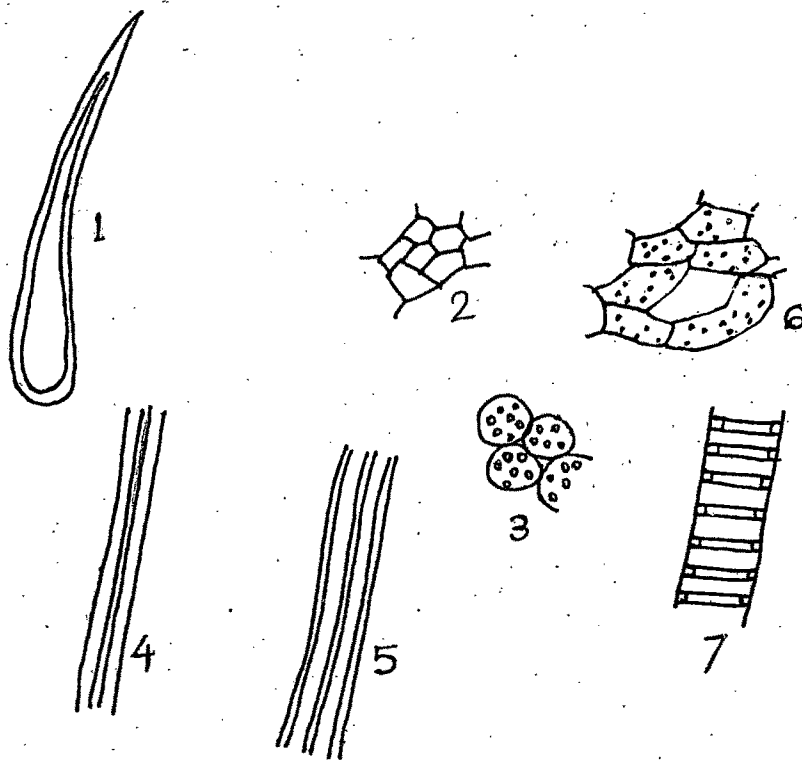


Fig. 25 *Terminalia chebula* Leaf, Powder study: 1. Unicellular trichome, 2. Phloem, 3. Spongy cells, 4. Sclerenchyma, 5. Gelatinous fibres, 6. Parenchyma with starch grains, 7. Protoxylem with scalariform thickening

It is a large climber having pale brown and smooth bark. Branches are terete with glabrous young parts. Leaves are 3.2-11.0 × 2.6-7.0 cm, opposite having elliptic or elliptic-lanceolate with acuminate apex. They are usually narrowed at the base into the petiole and have 4-6 pairs of main nerves. Flowers are small, white and sessile in short, dense paniced axillary spikes. The main rachis of the panicle is densely pubescent. Fruit is pale golden brown with 4 papery finely transversely striate wings. Seeds are four sided.

Parts used in medicine: - Leaves

Medicinal Use: - Leaves are anthelmintic and astringent

Previous reports: - No data are available on pharmacognosy or chemistry on any part of this plant

In the present work, the plant has been screened for its phytochemical constituents such as flavonoids, phenolic acids, quinones, alkaloid, etc. in leaves and stem. Pharmacognosy of only leaf has been studied.

Materials and Methods:-

Combretum ovalifolium was collected from Baroda. Voucher specimen of the plant has been deposited in the Herbarium, Department of Botany, The Maharaja Sayajirao University of Baroda (BARO), Vadodara. Standard procedures are described in chapter 2 were followed for the extraction, isolation and identification of the phytochemicals and also for pharmacognosy.

Results:-

Phytochemistry:-

Leaves contained 3', 4' -diOMe quercetin, 7, 3', 4' - triOMe quercetin and 3'OMe-gossypetin. Vanillic, syringic, gallic, melilotic and *o*-coumaric acids were identified in leaves. Stem yielded quercetin, 3'- OMe quercetin, 3', 4'- diOMe quercetin, 7, 3', 4'- triOMe quercetin and gossypetin as well as vanillic, syringic, gallic and *p*-coumaric acids were seen in stem. Quinones, steroids, were present in both stem and leaves. Glycoflavones and alkaloids were absent in both.

Phytochemical biomarkers of leaves: Derivatives of quercetin (pure quercetin absent),

3'-OMe gossypetin and *o*-coumaric acid

Stem : Quercetin and *p*-coumaric acid

Pharmacognosy of leaf:-

Leaf micromorphology

Stomata were anomocytic found only on lower epidermis. Stomatal index was 24-26. Trichome index for unicellular trichomes were 6-8 in the lower epidermis

Leaf -T.S. (Fig. 26)

Leaf was dorsiventral and the midrib region was ridged on the upper side. Epidermis (17-24 x 17-20 μ m) consisted of barrel to rectangular shaped cells covered by a thin cuticle. In the midrib region hypodermis was of 4-5 layered collenchymatous cells (17-34 x 17-20 μ m), some of which contained large sphaeraphides (17-34 μ m). The ground tissue above was of 1-2 layered parenchyma (27-58 μ m), a few of which contained larger cluster crystals (24-51 μ m). The vascular bundle in the centre was crescent-shaped with phloem (7-16 μ m) present on both outer and inner (intraxylary) sides of xylem. Endodermis was not clearly differentiated but the pericycle was represented by two to three layered sclerenchyma (10-20 x 14-17 μ m), which almost encircled the vascular bundle completely. The inner phloem was continuous and more or less omega shaped enclosing an oval patch of large parenchyma cells. Xylem consisted of radial rows of medium sized squarish tracheids (34-44 x 34-37 μ m) separated by xylem rays (14-17 x 10-20 μ m). The cells of rays were having thick walls. The outer phloem consisted of seven to nine layers of cells radially separated by phloem ray cells. There were some parenchymatous patches with in the inner phloem. Between the outer phloem and pericycle were three to four layers of large parenchyma. Outer to pericycle on the lower side were two to three layered parenchyma (31-58 μ m), some of which contained sphaeraphides. The hypodermis on the lower side consisted of two to three layered collenchyma. Cells of the lower epidermis (14-24 x 14-20 μ m) were smaller in size when compared to those of

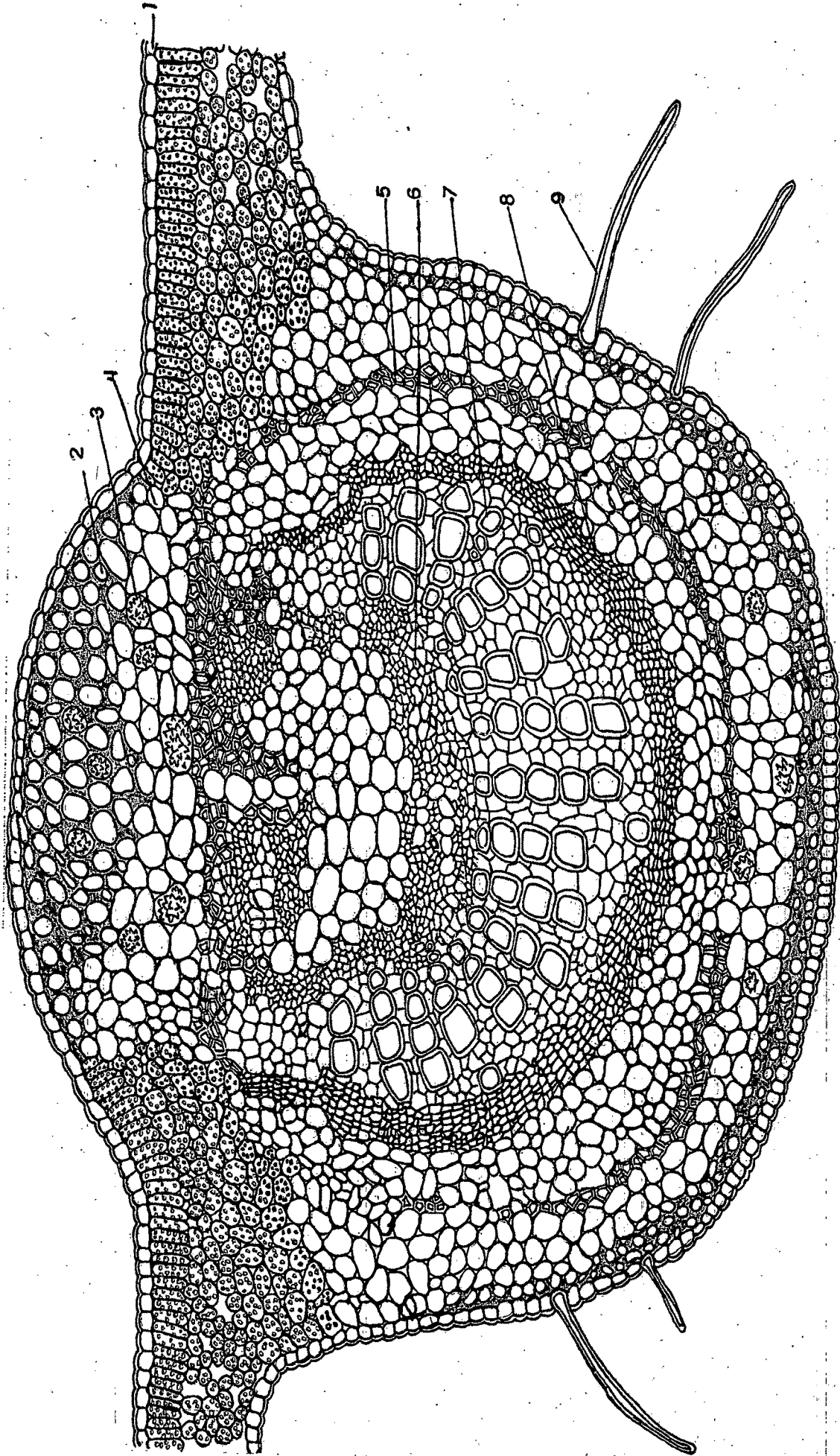


Fig. 26 *Combretum ovalifolium* Leaf, Midrib-T.S.: 1. Epidermis, 2. Lacunar Collenchyma, 3. Sphaeraphide, 4. Parenchyma, 5. Sclerenchyma, 6. Intraxylary Phloem, 7. Xylem, 8. Phloem, 9. Unicellular trichome

upper epidermis. These cells were barrel shaped in mid-rib region and rectangular in lamina portion. Unicellular elongate thick walled non-glandular trichomes (100-148 x 10-23 μ m) and stomata were seen in lower epidermis.

In lamina (Fig. 27a), the mesophyll consisted of a single layer of palisade (34-48 x 10-13 μ m) and four to eight layers of spongy tissue (34-48 x 31-48 μ m). The palisade cells were long and cylindrical, packed with many small chloroplasts. Cystoliths (34-48 x 31-44 μ m) were seen among the palisade cells. The spongy tissue consisted of isodiametric almost closely packed chlorenchyma where in each cell contained five to six small chloroplasts.

Powder study (Fig. 27b)

Cystoliths (34-48 x 31-44 μ m), sphaeraphides (17-34 μ m), unicellular trichomes (100-148 x 10-23 μ m), cicatrix and anomocytic stomata were present in the powder of the leaf.

Pharmacognostic markers: Cystoliths in palisade

: Omega shaped intraxylary phloem

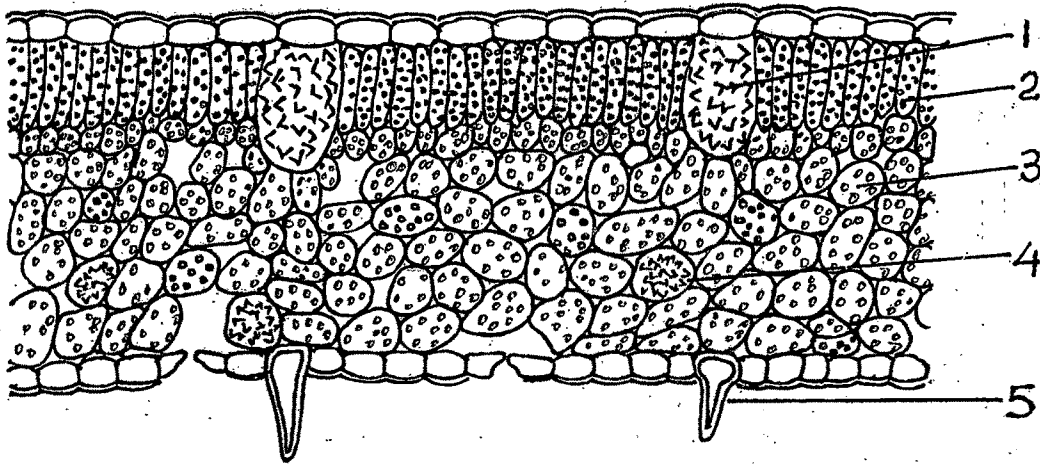


Fig. 27(a) *Combretum ovalifolium* Leaf, Lamina-T.S.: 1. Cystolith, 2. Palisade tissue, 3. Spongy tissue, 4. Sphaeraphides, 5. Unicellular trichome

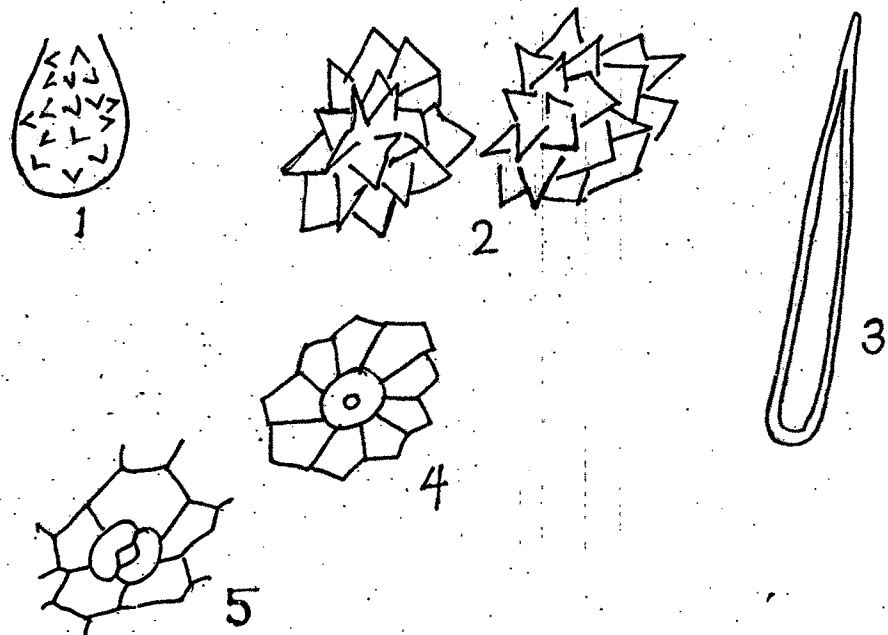


Fig. 27(b) *Combretum ovalifolium* Leaf, Powder study: 1. Cystolith, 2. Sphaeraphide, 3. Unicellular trichome, 4. cicatrix, 5. Anomocytic stomata