



## Comparative pharmacognosy of medicinally important species of Genus *Carissa*

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### Abstract

The standardisation of *Carissa carandas* were carried out as per Ayurvedic Pharmacopoeia of India, Pharmacopoeial standard for Ayurvedic Formulation as per the W.H.O. parameters of quality control for medicinal plants. *Carissa* is wild plant having a number of ethnomedicinal applications. In the present study, the root leaves, and fruits of the plant were subjected to comparative pharmacognostical investigation. The present study comprises taxonomical, macroscopical, microscopical characters and physico-chemical of root, leaf and fruit of four species of Genus *Carissa* i. e. *Carissa congesta*, *C. carandas*, *C. spinarum* and *C. opaca*. Qualitative analysis of plant metabolites like alkaloid, carbohydrates, protein, resins, starch have been carried out.

Key-Words: Medicinal plants, Pharmacognosy, Phytochemical, *Carissa*

### Introduction

*Carissa* belongs to family Apocynaceae. The latter is distributed in many mountainous parts of Indian subcontinent [1-3], from Punjab to Himalayas in Pakistan and India, and Burma and Sri Lanka [4]. A paste of the plant root is used by local people for healing small cuts and wounds. The plant is commonly used as a medicine to kill worm infesting cattle wounds, as fly repellent, as stimulant, and to cure asthma, and its leaves are also used for tanning [1], [3], [5-7]. The plant is known to have cardiotoxic action while roots can be used as purgative. The plant is very valuable for the Indian System of medicine particularly Ayurveda. It is used for alleviating vata and pitta disorders. Its fruits and seed latex are used for treating rheumatoid arthritis, anorexia, indigestion, colic, hepatomegaly, splenomegaly, piles, cardiac diseases, oedema, amenorrhoea, fever and nervous disorder [5]. The roots are useful in stomach disorder, intestinal worms, Scabies, diabetic, ulcer and pruritis [8]. Alcoholic extract of the root exhibits cardiotoxic effect [9]. The plant is also useful to bring down blood pressure [10].

'Karmarda' was a plant mentioned in ancient literature under Rhidyagana, however, was under-utilized. Stanzas as well as different synonyms describing plant characters were inadequate for deciding correct botanical identity [11].

All Indian species of genus *Carissa* L. were also known by the common name Karonda and floristic and taxonomic literature indicated confusions in correct identity at species level because of major diversity within and between the species [2], [12], [13], [14], [15].

### Material and Methods

#### Collection, Authentication and Voucher Deposition:

Collection of plant material was planned from the locations where species occurrence was abundant. Since species identity was easy in fruiting season and fruits also were required for the detailed study, material was collected in fruiting season of respective species. To avoid the variation the material was collected from the same localities. Harvest was done carefully in non-destructive way without disturbing the habitat and population of respective species. During field visits efforts were made to note habit, habitat, phenological stages and local utility. Details of the locations of collections of respective species have been compiled in Table form (Table -I).

Table: I. Details of the locations of collections.

Species Collected	Locality	GPS reading of the location	Dates
<i>Carissa congesta</i> Wight	Tamhini, Taluka	Latitude N 18° 19' 22.8''	03-05- 2007
	Mulshi, District Pune, Maharashtra	Longitude E 73° 20' 22.0''	07-05- 2008

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<i>Carissa carandas</i> L.	House hold garden, Pune city, District Pune, Maharashtra	Latitude N 18 <sup>0</sup> 31' 17.6'' Longitude E 73 <sup>0</sup> 49' 58.2''	25-06-2008 02-07-2007
<i>Carissa spinarum</i> L.	Bellari (Munirabad) Hospet, Karnataka	Latitude N 15 <sup>0</sup> 19' 48.2'' Longitude E 76 <sup>0</sup> 16' 55.4''	11-06-2008 23-07-2008
<i>Carissa opaca</i> Stapf ex Haines	Palu, Ranchi, Jharkhand	Latitude N 23 <sup>0</sup> 30' 18.8'' Longitude E 85 <sup>0</sup> 28' 56.9''	13-09-2008

Tentative Identification of the species was done by referring to regional floras<sup>[21,12]</sup>. The confirmation of the species was done by comparing them with earlier authentic identified specimens at Agharkar Herbarium at Maharashtra Association for the cultivation of Science (AHMA), Agharkar Research Institute, Pune and Botanical Survey of India, Western Circle (BSI). Nomenclature was checked and updated referring to on line sites <http://www.tropicos.org>, [www.theplantlist.org](http://www.theplantlist.org) and also Flora of Maharashtra<sup>[16]</sup>, and Indian species of *Carissa* L.<sup>[17]</sup>.

The authenticated herbarium specimens are deposited in Agharkar Herbarium at Maharashtra Association (AHMA), Agharkar Research Institute, Pune.

#### Exomorphic evaluation:

Exomorphic characters of study samples viz. roots, leaves and fruits were studied for exomorphy. Roots were evaluated for surface characteristics (surface characters such as scales, wrinkles, cracks, scars, etc.); shape of drug after drying and fracture characteristics. Leaves were evaluated for shape, size; surface and venation details. Fruits were studied including details like type of fruit, shape, size, colour and number of seeds.

#### Microscopy

Transverse section- Leaves preserved in 70% alcohol and fresh green fruits were used for sectioning. The roots being hard were boiled on hot water bath at 50-60°C for two days to remove the mucilage and make them soft. For the anatomical studies standard methods described by<sup>[18]</sup> were employed. Free hand sectioning methods was used for this purpose. The sections were dehydrated through ethyl alcohol series and passed through graded xylene. The staining was done with 70% alcoholic safranin and 70% alcoholic light green. The stained sections were mounted in Canada balsam.

Research microscope model Leitz Laborlux D with camera lucida attachment and Olympus CX31 with digital camera were used of observations and photography.

Detailed anatomy of root, leaf and fruit of *Carissa* L. species has been worked out.

Powder microscopy- Root, leaf and fruit powders were sieved (# 60 mesh sieve) separately. Powder contents of roots, leaves and fruits cleared in chloral hydrate, mounted in glycerine were studied for cell contents viz. cork cells, fibres, fibers phloem, xylum, sieve tubes, parenchymatus cells, stone cells, crystals and starch grains. Research microscope model Leitz Laborlux D with camera lucida attachment and Olympus CX31 with digital camera were used of observations and photography.

Qualitative analysis- The qualitative microchemical analysis of powders and extracts was carried out using different chemical reagents as per the method described by<sup>[19]</sup>.

### Results and Discussion

#### *Carissa carandas*

**Root:** T.S of root appears irregularly cylindrical in outline; cork stratified, consist of 4 to 8 layers of lignified cells; cortex consisting of 25 to 30 layers of parenchymatus cells embedded with few prismatic crystals of calcium oxalate, groups or single stone cells and mucilage canals; about 20 to 30 rows of phloem are interrupted by phloem rays, prismatic crystals of calcium oxalate, groups or single stone cells; wood comprises of uni to biseriate medullary rays that traversed through wide secondary xylem and consists of xylem vessels, lignified fibres, trachieds and xylem parenchyma. Starch grains are simple to compound types found scattered throughout the parenchymatus cells (plate- 4.1.2). RLS of wood shows solitary or groups of pitted xylem vessels, trachieds and xylem parenchyma, pointed fibres and uniseriate and radially elongated xylem rays (plate- 4.1.2).

**Leaf:** T.S of leaf passing through midrib shows shallow groove on the upper surface and slightly protruding below; epidermis single layered consisting of polygonal cells possessing straight walls, covered with thick layer of cuticle, trichomes absent. Stomata present only on the lower epidermis and are anomocytic type. A single crescent to arch shaped vascular bundle consisting of 2-6 layers of xylem occasionally transversed by fibres and narrow phloem tissue lies in the centre; 2-4 layers of collenchymatus cells surrounds the upper side and 3-5 layers on the lower side; resin canal cells are present adjacent to collenchymas on both the sides; lamina dorsiventral consisting of 2-3 layers of paliside tissue and 3-6 layers



of spongy mesophyll tissue that transverse with vascular bundles of the veinlets; starch grains and prismatic crystals present throughout the midrib and lamina; stone cells present below the xylem vessel; rosette crystal present in spongy and mesophyll layers. Stomatal index (lower epidermis) 14.6, Palisade ratio 4.0, Vein- islets number 25, Vein-termination number 85.

**Fruit:** T.S circular in outline; pericarp consists of epicarp, the outermost single layer of tangentially elongated cells with thick cuticle and finely granular contents; hypodermis consisting of 2 to 3 rows of tangentially elongated parenchymatous cells filled with deep purplish blackish contents; mesocarp or the pulp consists of irregular to elongated or spherical parenchymatous cells with numerous branching laticiferous tubes and vascular strands; rosette of prismatic crystals of calcium oxalate are also found in mesocarp; endocarp is the innermost layer of thin-walled tangentially elongated cells often getting collapsed.

#### *Carissa congesta*

**Root:** T.S of root appears irregularly cylindrical in outline. The outer stratified cork consist of 14-15 layers of lignified cells; cortex consisting of 15 -18 layers of parenchymatous cells that are embedded with prismatic crystals of calcium oxalate, groups or individual stone cells are present in different rows of cortex and phloem parenchyma. Mucilage canals are found embedded within the cortex; followed by 25 to 28 rows of phloem interrupted by phloem rays; Wood comprises of uni to biseriate medullary rays that traversed into wide secondary xylem and consists of xylem vessels, lignified fibres, trachieds and xylem parenchyma. Starch grains are simple and compound types are found scattered throughout parenchymatous cells; (Plate-4.2.2) Uni to biseriate medullary rays, consisting of radially elongated cells and pitted trachieds are distinctly observed in RLS. (Plate- 4.2.2)

**Leaf:** T. S passing through midrib appears flat on the upper side and slightly protruding below; epidermis is single layered, comprises of rectangular cells covered with thick cuticle, anomocytic type of stomata present at the lower epidermis, trichomes absent; 2-3 layers of collenchymatous cells are present on the upper side and 3-6 layers on the lower side of a single crescent to arch shaped vascular bundle; vascular bundle comprises of 2-4 layers of xylem transverse by fibres and narrow phloem tissue lies in the center; resin canals are located below the colenchyma at both the sides; lamina is dorsiventral, consisting of 2-3 layers of palisade tissue and 3-6 layers of spongy mesophyll tissue which are transversed by the vascular bundles of the veinlets;

starch grain and prismatic crystals are founded in colenchyma, palisade and spongy tissues throughout the midrib and lamina; stone cells and prismatic crystal are located below the xylem vessels. Stomatal index 12.76, Palisade ratio 3.48, Vein- islets number 29, Vein-termination number 53.

**Fruit:** T.S. shows pericarp consists of distinct epicarp, mesocarp and endocarp. Epicarp composed of single layer of tangentially elongated cells with thick cuticle and finely granular contents; hypodermis consists of 4 to 5 rows of tangentially elongated parenchymatous cells filled with deep purplish blackish contents; mesocarp or the pulp consists of irregular to elongated, spherical parenchymatous cells with numerous branching laticiferous tubes and vascular strands; endocarp, the innermost layer of thin-walled tangentially elongated cells often getting collapsed.

#### *Carissa opaca*

**Root:** T.S of root appears irregularly cylindrical in its outline. The stratified cork consist of 8 to 10 layers of lignified cells; cortex comprises of 15 -18 layers of parenchymatous cells that embeds prismatic crystals of calcium oxalate, groups or individual stone cells are found in different rows of cortex and phloem parenchyma. Mucilage canals are present within the cortex; 18 to 20 rows of phloem are interrupted by phloem rays. Wood possesses uni to multiseriate medullary rays traverse the wide secondary xylem that comprises of xylem vessels, lignified fibres, trachieds and xylem parenchyma. Starch grains of both simple and compound types were found scattered throughout the parenchymatous cell layers; (plate- 4.3.2). uni to multiseriate medullary rays consist of radially elongated cells, vessels and fibres. (Plate- 4.3.2)

**Leaf:** T.S of leaf passing through midrib demonstrates groove on the upper surface and slightly protruding below. Its single layered outer epidermis comprises of rectangular cells covered with thick cuticle; unicellular, uniseriate, unbranched and non-glandular trichomes covers the upper surface of leaf; anomocytic type of stomatas are present only at the lower epidermis; 2-3 layers of collenchymas cells follows on the upper side and 8-10 layers on the lower side of the single crescent to arch shape vascular bundle in the centre. Vascular bundle consist of 3-4 layers of xylem occasionally transverse by fibres, followed by a narrow phloem tissue that lies in the centre; lamina dorsiventral with 3 layers of palisade and 6-7 layers of spongy mesophyll tissue that transverse with vascular bundles of the veinlets; starch grains are distributed throughout the midrib and lamina, crystals not seen, stone cells absent; resin canal cells exist below the collenchyma layer on both the side. Stomatal index (lower epidermis) - 10.8,

Palisade ratio- 3.84, Vein- islets number- 35, Vein-termination number-42.

**Fruit:** T.S appears circular in outline; pericarp consists of single layered epicarp, tangentially elongated cells, thick cuticle and finely granular contents on the outside; hypodermis, usually 2 to 3 rows of tangentially elongated parenchymatous cells containing deep purplish blackish contents; mesocarp bears irregular to elongated spherical parenchymatous cells with numerous branching laticiferous tubes and vascular strands; rosette of calcium oxalate; endocarp, the innermost layer of thin-walled possess tangentially elongated cells often getting collapsed.

#### ***Carissa spinarum***

**Root:** T.S of root appears irregularly cylindrical in its outline. Stratified cork consisting of 5 to 15 layers of lignified cells; cortex consisting of 22 to 25 layers of parenchymatous cells that embeds prismatic crystals of calcium oxalate, groups or individual stone cells are present within different rows of cortex and phloem parenchyma. Mucilage canals are present within the cortex region; 20 to 22 rows of phloem are interrupted by the phloem rays. Wood possesses uni to biseriate medullary rays that traverse into wide secondary xylem consisting of xylem vessels, lignified fibres, trachieds and xylem parenchyma. Simple and compound types of starch grains were found scattered within the parenchymatous cells; (plate- 4.4.2). Uni to biseriate medullary rays possesses radially elongated cells. (Plate- 4.4.2)

**Leaf:** T.S of leaf passing through midrib shows shallow groove on the upper surface and slight protrudence below; epidermis single layered of rectangular cells covered with thick layer of cuticle; unicellular, uniseriate, unbranched and non-glandular trichomes are present on upper and lower epidermis; anomocytic type of stomata present only on the lower epidermis; 2-3 layers of collenchymatous cells are found both on the upper and the lower sides with 3-6 layers each; a single crescent to arch shape vascular bundle is present in the centre consists of 3-9 layers of xylem occasionally transverse by fibres and a narrow phloem tissue; lamina is dorsiventral consisting of 2-3 layers of palisade and 3-5 layers of spongy mesophyll tissue which transverses with vascular bundles of the veinlets; starch grains and prismatic crystals are present all over the midrib and lamina; stone cells are found between the xylem vessels, number is more on the lower side; resin canals present on both the sides of the collenchyma layer; rosette crystals present below the xylem vessel. Stomatal index - 15.92, Palisade ratio- 4.40, Vein- islets number-45, Vein-termination number-111.

**Fruit:** T.S appears circular in outline; pericarp consists of single layered epicarp with tangentially elongated cells, thick cuticle and finely granular contents; hypodermis comprises of 2 - 3 rows of tangentially elongated parenchymatous cells with deep purplish blackish contents; mesocarp consists of irregular to elongated, spherical parenchymatous cells with numerous branching laticiferous tubes and vascular strands; endocarp, includes thin-walled tangentially elongated cells which often gets collapsed.

The microscopical investigations are an integral part of the standardization of the drugs. In view of this detailed anatomical studies of roots, leaves and fruits of all the four species of *Carissa* L. have been carried out. Besides, microscopical studies on powders contents of roots, leaves and fruits of all the species have been carried out. Microscopical studies on roots, leaves and fruits for *Carissa congesta* Wight, *Carissa opaca* Stapf ex Haines and *Carissa spinarum* L. are been reported for the first time through our investigations. The *Carissa carandas* L. has been studied for microscopic and the diagnostic characters of the powder of root bark <sup>[20]</sup> the results are comparable to the data in present investigations. The details of shape, size and colour of contents have been worked out for the first time. Macroscopic and microscopic characterization of *Carissa carandas* L. fruits <sup>[21]</sup> are comparable to *Carissa congesta* Wight of our studies. This indicates mistake in nomenclature used in given Pharmacopoeia. Structural stomatal studies have been done for *Carissa carandas* L. <sup>[22]</sup> which matches with our studies. Microscopic characters of roots of *Carissa spinarum* L. ash values, fluorescence characters of the powdered roots have also been determined <sup>[23]</sup>. Unicellular trichomes are found only in *Carissa spinarum* L. On basis of this *Carissa spinarum* L. is differentiated from rest of the three species particularly *Carissa opaca* Stapf ex Haines with smaller similar fruits. Other distinguishing characters found in microscopy of powders have been compiled in table (T-III).(P-4.1.3,4.2.3,4.3.3,4.4.3)

#### **Qualitative phytochemical**

Qualitative phytochemical characterization of roots, leaves and fruits of four *Carissa* L. species viz *Carissa congesta* Wight, *Carissa carandas* L., *Carissa spinarum* L. and *Carissa opaca* Stapf ex Haines reveals presence of alkaloids in roots and leaves; whereas presence of flavonoids, glycosides, reducing sugars, saponins, steroids and tannins in all the parts of all the species. Comparative data obtained have been compiled in table form (T-IV). Presence of alkaloids, flavonoids, saponins and large amounts of cardiac glycosides, triterpenoids, phenolic compounds and



tannins in the roots of *Carissa carandas* L. <sup>[24],[25]</sup>. *Carissa carandas* L. leaves contain alkaloids, tannins, steroids and saponins <sup>[26],[27]</sup>. Roots of *Carissa opaca* Stapf ex Haines contain cardiac glycosides, steroids and triterpenes <sup>[28]</sup>. The results obtained are quite comparable with these reports.

### Conclusion

Detail pharmacognosy of all the four medicinally important species viz. *Carissa carandas* L., *Carissa congesta* Wight, *Carissa opaca* Stapf ex Haines and *Carissa spinarum* L. has been worked out which helped to resolve ambiguity of species delimitations and proper use values of valued species. Studies revealed pharmacognostic characterization for root, leaf and fruit of *Carissa congesta* Wight and *Carissa opaca* Stapf ex Haines as well as leaf and fruit of *Carissa spinarum* L. for the first time

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### References

- Gaur, R. D. Flora of the District Garhwal North West Himalaya. Transindia: Srinagar, Uttaranchal, 1999.
- Hooker, J. D. Flora of British India, 3. Reeve and Co: Ashford, Kent, 1882.
- Rai, S. K., Mallavarapu, G. R., Pandey-Rai, S., Srivastava, S., Singh, D., Mishra, R. and Kumar, S. Constituents of the flower oil of *Carissa opaca* growing in the Aravalli mountain range at New Delhi, Flavour Fragr. J. 21: 304-305, 2006.
- Nazimuddin, S., & Qaiser, M. Apocynaceae. In E. Nasir & S. I. Ali (Eds.), Flora of Pakistan (pp. 11-13). Karachi: Department of Botany, University of Karachi, 1983.
- Pushpangadan P. (2003), Karanda: Rural india's rich fruit. *Down to earth*, Thomson Press India, New Delhi, 12, 52-53.
- Jabeen, A., Khan, M. A., Ahmad, M., Zafar, M. and Ahmad, F. Indigenous uses of economically important flora of Margallah Hills National Park, Islamabad, Pakistan, African Journal of Biotechnology, 2009, 8(5), p. 777.
- Parmar, C. and Kaushal, M. K. Wild Fruits. Kalyani: New Delhi, 1982.
- Sharma P.C., Yelne M.B. and Dennis T.J. (2001), *Database on Medicinal Plants Used in Ayurveda*. Central Council for Research in Ayurveda and Siddhha, Ministry of Health & Family Welfare, Govt of India, 369-377.
- Vohra M.M. and De N.N. (1963), Comparatively cardiotonic activity of *Carissa carandas* Linn. and *Carissa spinareum* A. Indian J. Med. Res., 51, 937-940.
- Chunekar K.C. (1982), *Bhavaprakasa Nighantu*. Chaukhambha Bharti Academy, Varanasi, India., 564 - 575.
- Trivedi, K., Garg, D., Agrawal, J. and Gard, D. 1663. *Dhanvantari. Vanaushadhi Vishaheanke* 37(2): 164-166.
- Cooke, T. 1957. *Flora of Presidency of Bombay*. Vol. II. Govt. of India.
- Talbot, W.A. 1909-1911. *Forest Flora of Bombay Presidency and Sind*. Vol. I & II. Govt. Press. Pune.
- Ghate, V.S., Kulkarni, D.K. and Upadhye, A.S. 1997. Karvanda (*Carissa* L): an underutilized minor fruit of India. *Plant Genetic Resources Newsletter* 109: 20-21.
- Ghate, V.S., Kulkarni, D.K. and Upadhye, A.S. 1999. Screening of natural diversity in Karvanda (*Carissa* L): Commercially potential wild fruit in Maharashtra. *Indian J. Pl. Genet. Resources* 12(1): 10-15.
- Almeida, M.R. 2001. *Flora of Maharashtra*. Vol. III. Blatter Herbarium, Mumbai. Almeida, S.M. and Almeida, M.R. 2005. *Dictionary of Generic Names of Flowering plants and ferns in Maharashtra*. Blatter Herbarium, Mumbai.
- Haines, H.H., 1919. Indian Species of *Carissa*. *Indian Forester* 45:375-388.
- Johansen, D.A. 1940. *Plant Micro-techniques* First Ed., McGraw Hill Book Company. Inc., New York.
- Trease, G.E. and Evans, W.C. 1983. *Pharmacognosy*. 12<sup>th</sup> Ed., English Language Book Society. Baillere and Tindall, London.
- Chauhan, M. G. and Pillai, A.P.G. 2004. *Microscopic profile of powdered drugs used in Indian systems of medicine - Bark Drugs*. Vol. I. Institute of Ayurvedic Medicinal Plants Sciences. Gujarat.
- Anonymous, 2005. *Quality standards of Indian Medicinal Plants*. Vol III. Indian Council of Medical Research.
- Patel, K.P. 2005. Structure and ontogeny of stomata in the cotyledons of the seedlings of some Apocynaceae. *J. Econ. Taxon. Bot.* 29(2): 414-418.
- Bhatnagar, J.K. and Raina, M.K. 1970. Pharmacognostic studies of indigenous drug I. Microscopic characters of the roots of *Carissa*

- spinarum* Linn. *Res. Bull. Punjab Univ.* 21: 317.
24. Hegde, K., Thakker, S.P., Joshi, A.B., Shastry, C.S. and Chandrashekhar, K.S. 2009. Anticonvulsant activity of *Carissa carandas* Linn. Root extract in experimental mice. *Tropical Journal of Pharmaceutical Research* 8(2): 117-125.
25. Bhaskar, V.H. and Balakrishnan, N. 2009. Analgesic, anti-inflammatory and antipyretic activities of *Pergularia daemia* and *Carissa carandas*. *DARU* 17(3): 168-174.
26. Vaghasiya, Y. and Chanda, S.V. 2007. Screening of Methanol and Acetone extracts of fourteen Indian medicinal plants for antimicrobial activity. *Turk J. Biol.* 31: 243-248.
27. Hasnain, A. and Ali, R. 1990. Studies on amino acids of *Carissa carandas*. *Pak. J. Sci. Ind. Res.* 33(8): 318-320.
28. Singh, V.K. and Zaheer, A.A. 1998. *Herbal Drugs of Himalaya*. Survey of Medicinal Plants unit Regional Research Institute of Unani Medicine. Today and Tomorrow's Printers and Publishers, New Delhi.

**Table II: Commonness and variables between the species**

Characters	<i>C. car</i>	<i>C. con</i>	<i>C. opa</i>	<i>C. spi</i>
Roots	Woody, mucilaginous, yellowish white; surface rough, wrinkled	Woody, pliable, mucilaginous; pale brown in colour; surface rough, wrinkled	Cylindrical, long and slender, pliable mucilaginous, woody; brown, surface smooth to shallow wrinkled	Long and slender, woody, mucilaginous; reddish brown, surface, wrinkles on root bark
Leaves	5x3cm; broadly elliptic or oblong, rounded at base, retuse apiculate at apex; Veins prominent, lateral nerves 4-8, looping towards margins and connected with intermediates.	5.5x2.5 cm, broadly ovate, subacute or obtuse, mucronate at apex or slightly emarginate; rhomboid rounded subacute at base; shining above slightly glaucous beneath, veins looping but not conspicuous except mid-vein.	2.8 X 1.8 cm, ovate to elliptic, coriaceous, shining glossy green, glabrous; rhomboid at base; obtuse and mucronate at apex; petiole short. Venation not very conspicuous except mid vein, secondary veins 2-3, neither looping nor reticulate.	3.2X1.6 cm, coriaceous, densely pubescent, elliptic-lanceolate to ovate, rounded to slightly cordate base and acute apex; petiole short, 2-5 mm long, pubescent. Venation prominent reticulate and looping at margins
Flowers	Flower white, mild fragrant, terminal and axillary cymes; peduncles up to 2.5 cm puberulous; corolla tube 1.7 cm, pink red, swollen and pubescent slightly above middle; Flowers February to April	Flowers white, mild fragrant, terminal corymbose many flowered cymes; peduncles puberulous, up to 1.2-2.5 cm; corolla tube 2.5 cm, green, swollen slightly above the middle; Flowers February to March	Flowers small star like, white, mild fragrant in terminal and axillary lax pubescent cymes; peduncles puberulous; corolla tube greenish white, longer than spreading lobes, swollen closer to top; Flowers-June onwards till August	Flowers small, white, fragrant, in terminal or axillary shortly peduncled cymes; peduncles pubescent; corolla tube cylindrical, 1.8 cm, swollen slightly above the middle, green; Flower-May-June
Fruits	Berry oval ellipsoid, 1.5 to 2 cm, pink and yellow in when unripe becomes dark purple when ripe, 8- seeded	Berry oval ellipsoid or spherical shaped, 1.2-2.5 cm, green sour when unripe and sweet, pulpy, black purple when ripe, 4- seeded.	Pea sized berry, ellipsoid 0.7 X 0.5 cm, less fleshy, turns black when ripe, 2 seeded.	Pea sized berry 0.8X0.7 cm, ovoid or ellipsoid, red and green when young and purple to black on ripening, 4 Seeded.
Seeds	0.8X0.4, dark brown in colour. Hilum brown, bulging on one side and a notch is present on the other side at the centre, pointed at the tip, two ends curved upwards.	1X0.6, light brown in colour. Hilum light brown, bulging at one side and the notch is not very prominent.	0.5X0.3, brown in colour. Hilum yellowish white in colour, pointed at both ends	0.5X0.3, dark brown in colour, Hilum brown, bulging on one side and a notch is present on the other side at the centre, pointed at the tip, two ends curved.

Table III: Comparative details of powder

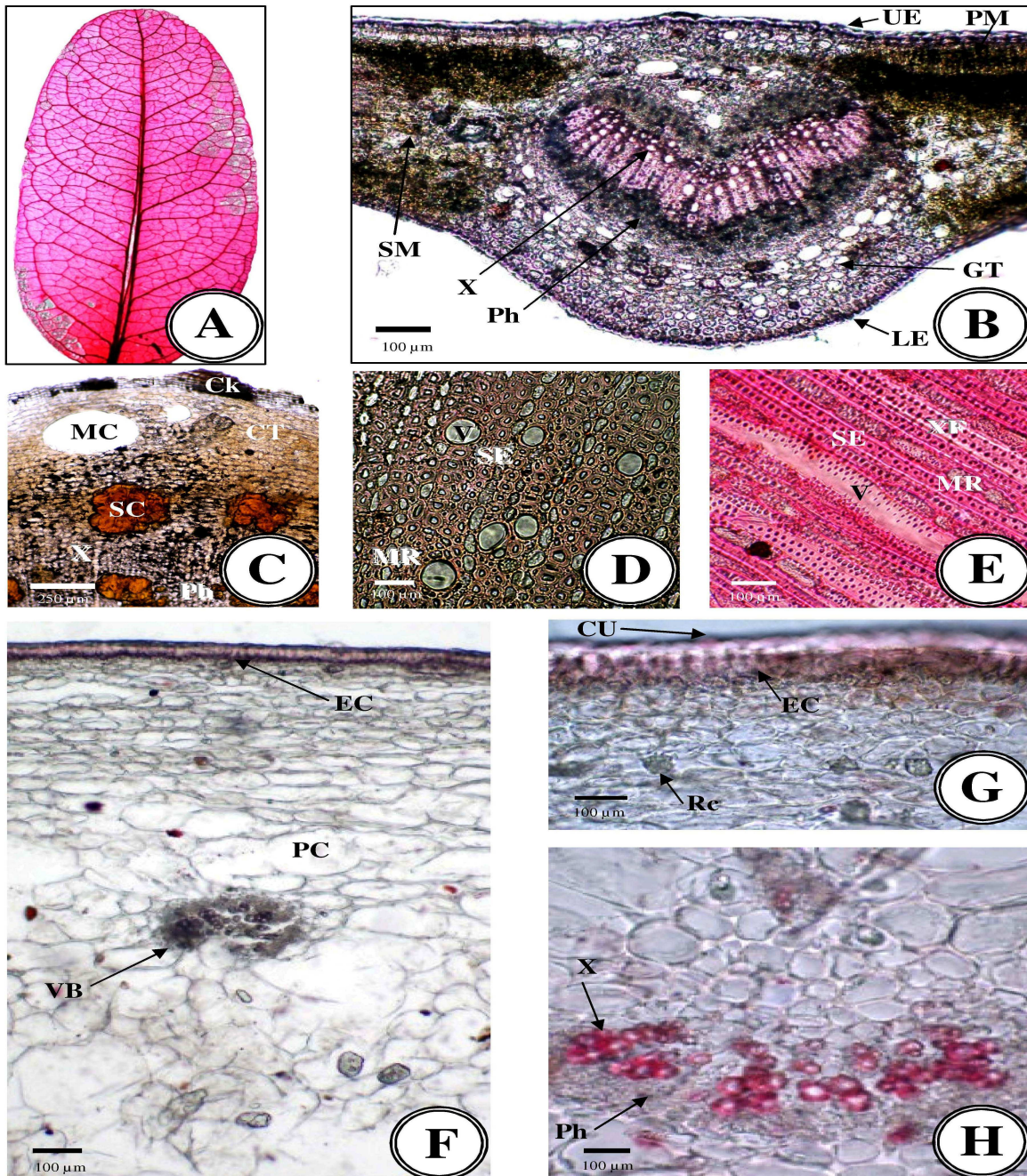
Parts	Cell types	<i>C. car</i>	<i>C. con</i>	<i>C. opa</i>	<i>C. spi</i>
<b>Roots</b>	Cork cells	20X 30 µm	22X 30 µm	20X40 µm	20X25 µm
	Parenchymatous cells	40 µm dia	57 µm dia	33 µm dia	30 µm dia
	Trachids	30 µm dia	38 µm dia	25 µm dia	30 µm dia.
	Vessels	25 µm dia	20 µm dia	50 µm dia	13-30µm dia
	Fibres	20 µm dia	21 µm dia	21 µm dia	21 µm dia.
	Starch grains	10 µm	08-10 µm	10 µm	10 µm
	Crystals	20.5X15µm	11X20 µm	20X12 µm	12X20 µm
	Stone cell	50 µm	60 µm	50 µm	50 µm
<b>Leaves</b>	Epidermal cells	28 µm	40 µm	25 µm	20 µm
	Palisade cells	55 µm	34 µm	90 µm	45 µm
	Spongy cells	20 µm	31 µm	22 µm	12 µm
	Trachids	85X40 µm	92X28 µm	111X30 µm	117X26 µm
	Vessels	17 µm	21 µm	15 µm	11 µm
	Fibres	16 µm	11 µm	10 µm	12 µm
	Starch grains	9 µm	11 µm	9 µm	11 µm
	Crystals	Prismatic 30µm, roset crystal 27 µm	Prismatic 15 µm, roset crystal 19 µm	Prismatic 26 µm, roset crystal 43 µm	Prismatic 21 µm, roset crystal 18 µm
	<b>Fruits</b>	Epidermal cells	140X60 µm	160X95 µm	120X60 µm
Laticiferous cells		11 µm dia	25 µm dia	17 µm dia	18 µm dia
Crystals		20 µm	13 µm	26 µm	20 µm
Vessels		10 µm	8 µm	10 µm	10 µm

Table IV: Qualitative phytochemical characterization in roots, leaves and fruits (Histochemical analysis)

Parameters	<i>C. con</i> roots	<i>C. car</i> roots	<i>C. spi</i> Roots	<i>C. opa</i> roots	<i>C. con</i> leaves	<i>C. car</i> leaves	<i>C. spi</i> leaves	<i>C. opa</i> leaves	<i>C. con</i> fruits	<i>C. car</i> fruits	<i>C. spi</i> fruits	<i>C. opa</i> fruits
Alkaloids	+	+	+	+	+	+	+	+	-	-	-	-
Anthraquinones	-	-	-	-	-	-	-	-	-	-	-	-
Aminoacids	+	+	+	+	+	+	+	+	-	-	-	-
Carbohydrates	+	+	+	+	+	+	+	+	+	+	+	+
Fats	+	+	+	+	+	+	+	+	+	+	+	+
Flavonoids	+	+	+	+	+	+	+	+	+	+	+	+
Glycosides	+	+	+	+	+	+	+	+	+	+	+	+
Mucilage	+	+	+	+	+	+	+	+	+	+	+	+
Pentoses	-	-	-	-	-	-	-	-	-	-	-	-
Proteins	+	+	+	+	+	+	+	+	+	+	+	+
Reducing sugars	+	+	+	+	+	+	+	+	+	+	+	+
Saponins	+	+	+	+	+	+	+	+	+	+	+	+
Starch	+	+	+	+	+	+	+	+	-	-	-	-
Steroids	+	+	+	+	+	+	+	+	+	+	+	+
Tannins	+	+	+	+	+	+	+	+	+	+	-	-



PLATE – 4. 1. 2

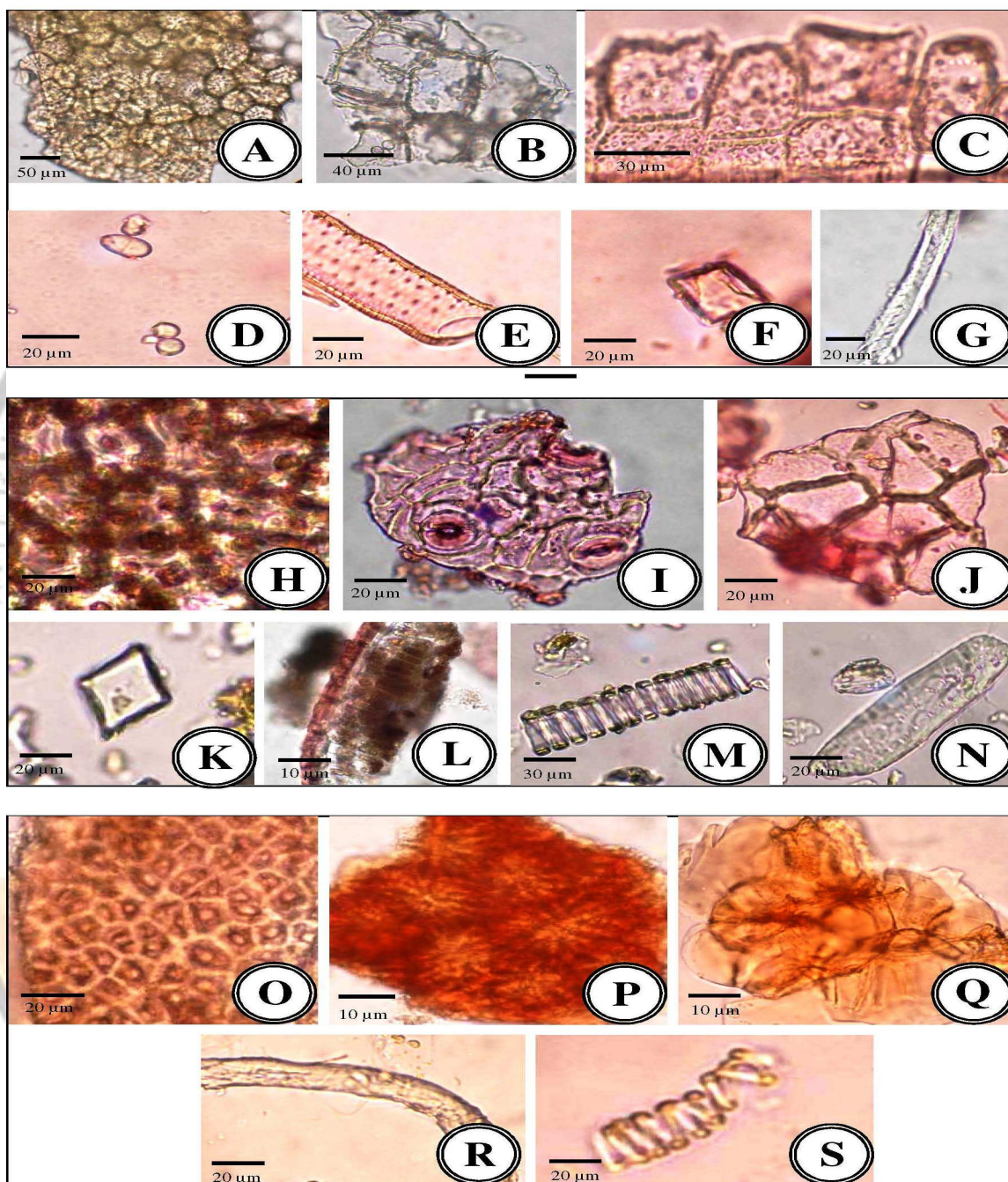


**A** - Leaf venation pattern of *Carissa carandas* L.; **B** - Transverse section of leaf; **C** - Transverse section of root showing large number of stone cells; **D** - Transverse section of wood; **E** - Longitudinal section of root; **F** - Transverse section of fruit; **G** - Transverse section of fruit showing crystal; **H** - Transverse section of fruit showing vessels

[CK - Cork, CT - Cortex, CU - Cuticle, EC - Epicarpic cells, GT - ground tissue, LE - lower epidermis, MC - Mucilage cells, MR - Medullary Rays, PC - Parenchyma cells, Ph - Phloem, PM - Palisade mesophyll, RC - Rosette crystals, SC - Stone cells, SE - Sieve element, SM - Spongy mesophyll, UE - Upper epidermis, V- vessel, VB - Vascular bundles, X - Xylem, XF - Xylem fibre]



PLATE – 4. 1. 3

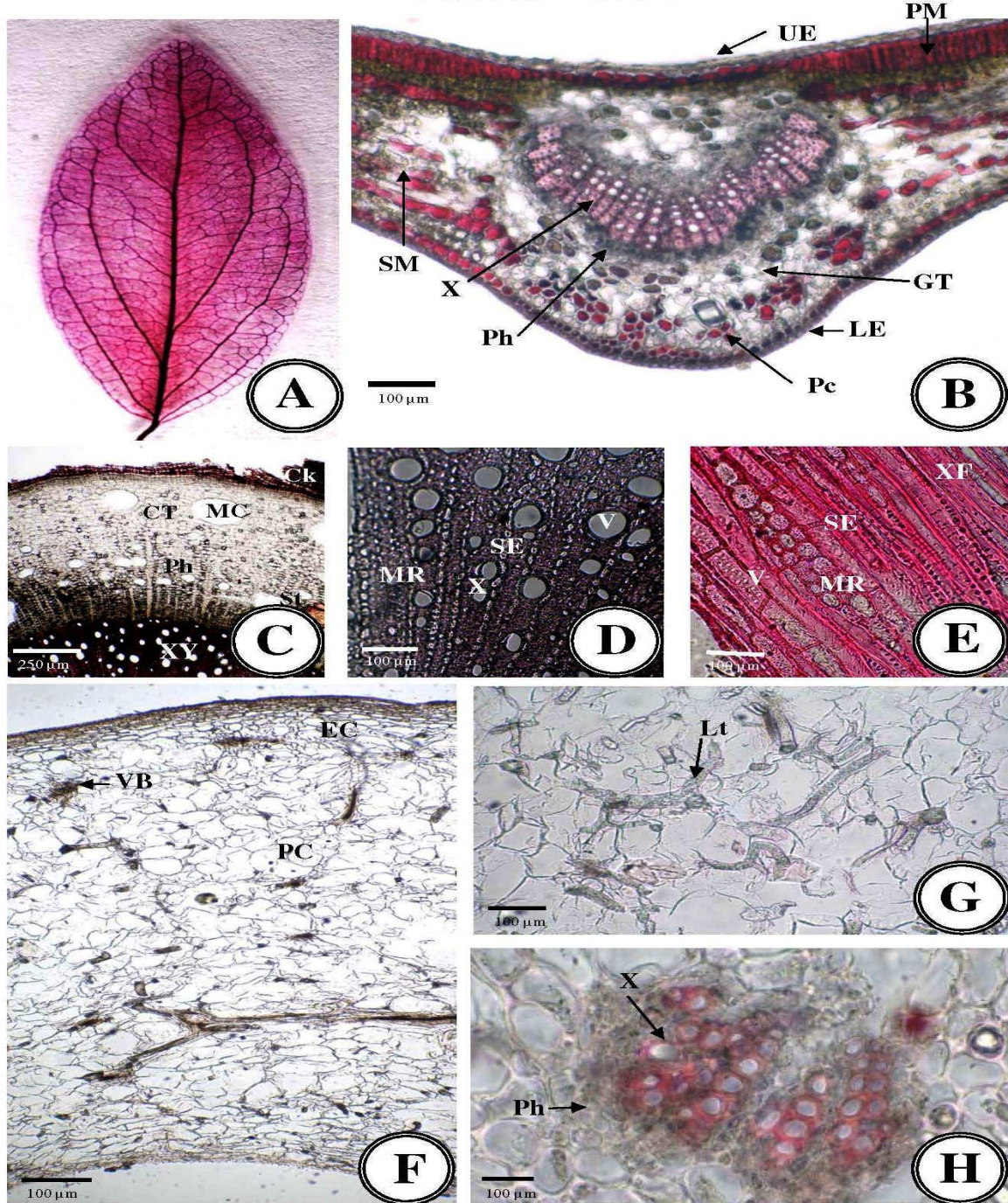


Root powder A-G, Leaf powder H-N, Fruit powder O-S (400X)

A - Stone cells; B - Parenchymatous cell, C - Cork cell; D - Starch grains; E - Vessel; F - Prismatic crystal; G - Fibre; H - Starch grain; I - Stomata; J - Parenchymatous cell; K - Prismatic crystal; L - Vessel; M - Tracheid; N - Sclerified cell; O - Epicarp cells in surface view; P - Cell filled with brown deposition; Q - Parenchyma cell; R - Laticiferous tube; S - Vessel



PLATE – 4. 2. 2

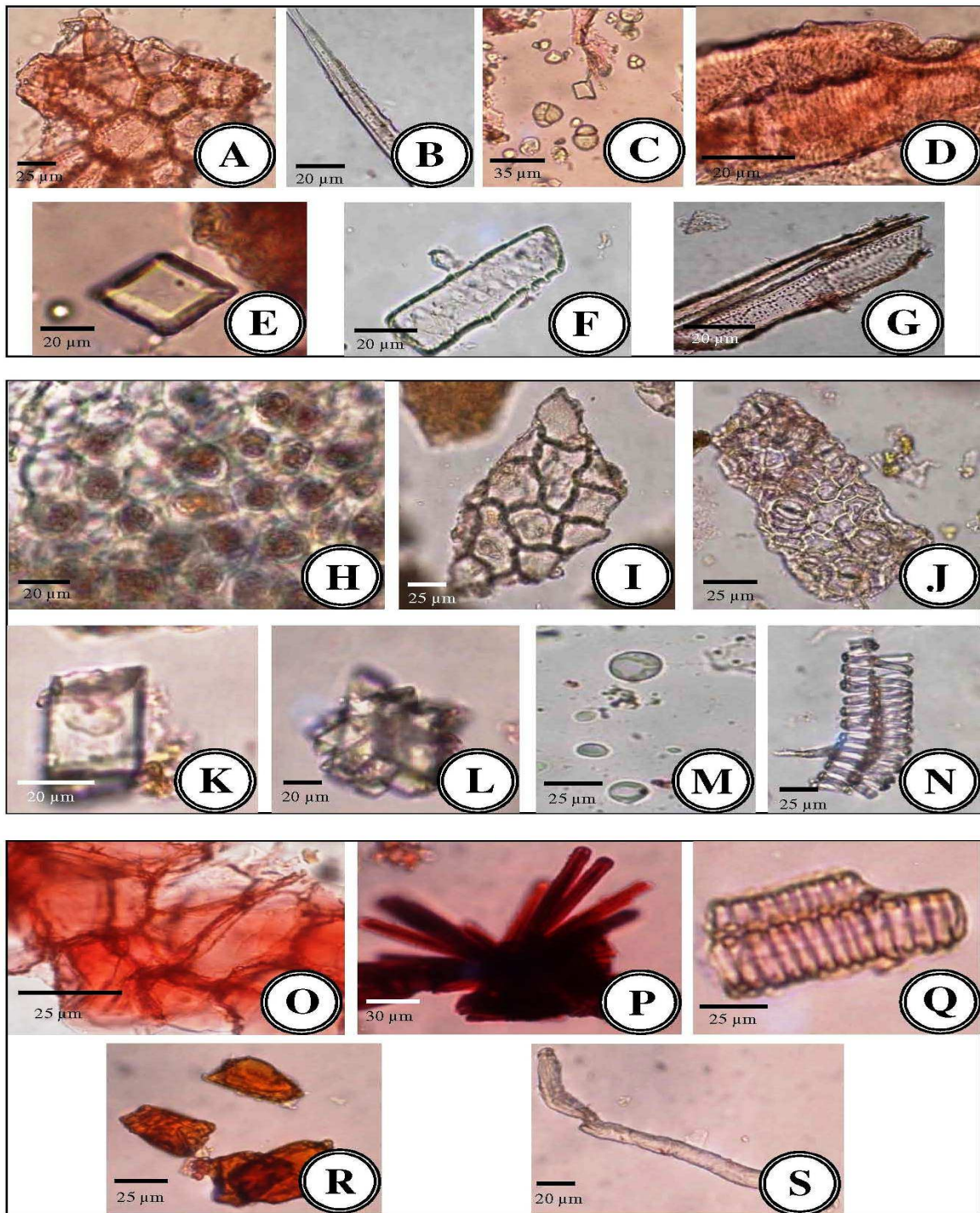


**A** - Leaf venation pattern of *Carissa congesta* Wight; **B** - Transverse section of leaf; **C** - Transverse section of root showing large number of stone cells; **D** - Transverse section of wood; **E** - Longitudinal section of root; **F** - Transverse section of fruit; **G** - Transverse section of fruit showing laticiferous tube; **H** - Transverse section of fruit showing vessels

[CK - Cork, CT - Cortex, CU - Cuticle, EC - Epicarpic cells, GT - ground tissue, LE - lower epidermis, Lt - Laticiferous tube, MC - Mucilage cells, MR - Medullary Rays, PC - Parenchyma cells, Pc - Prismatic crystals, Ph - Phloem, PM - Palisade mesophyll, SC- Stone cells, SE - Sieve element, SM - Spongy mesophyll, UE - Upper epidermis V- vessel, VB - Vascular bundles, X - Xylem, XF - Xylem fibre, XV- Xylem Vessel]



PLATE – 4. 2. 3

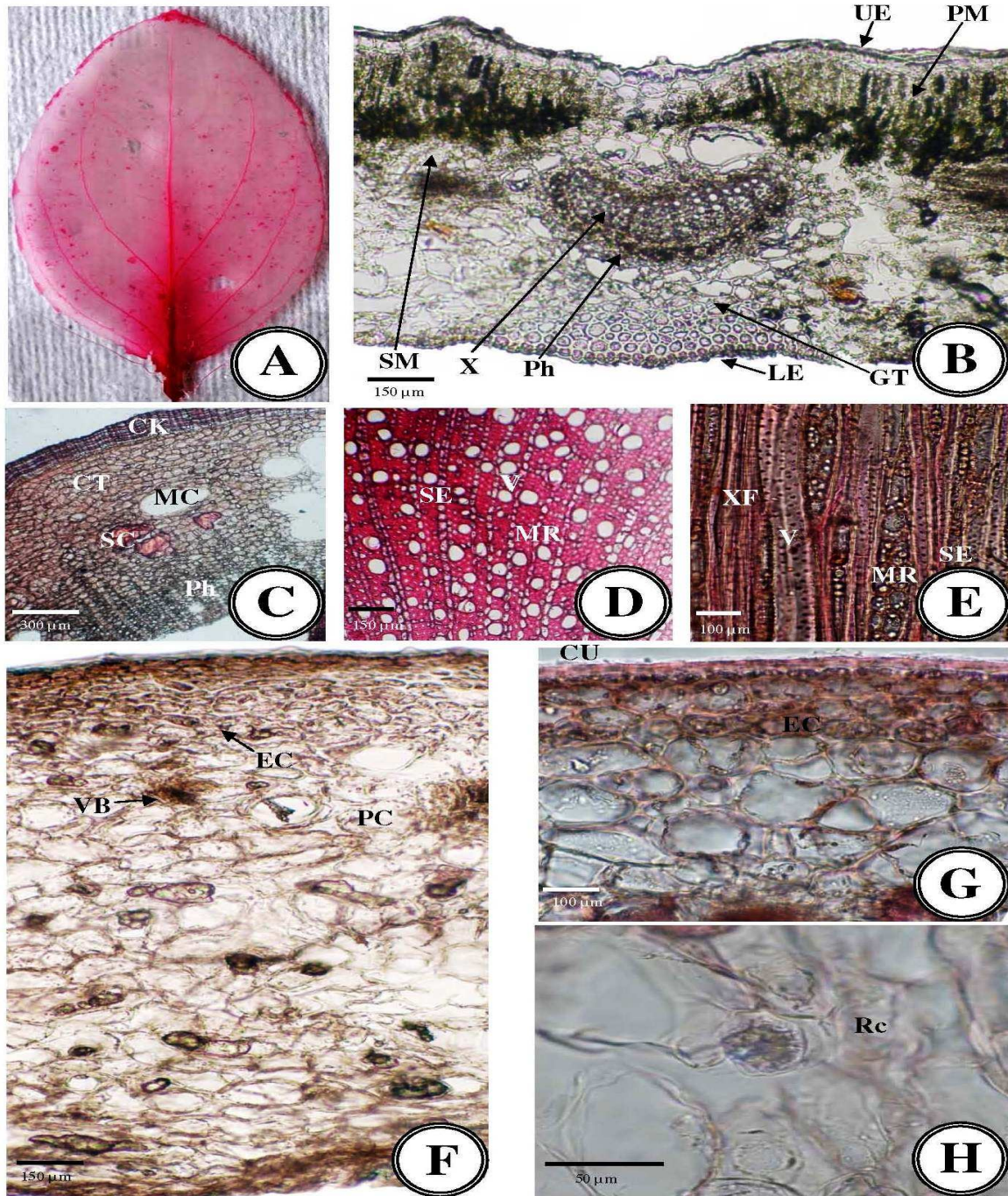


Root powder A-G , Leaf powder H-N, Fruit powder O-S (400X)

A - Parenchymatous cell; B - Fibre; C - Starch grain; D - Stone cell; E - Prismatic crystal; F - Tracheid; G - Vessel; H - Starch grain in groups; I - Parenchymatous cell; J - Stomata; K - Prismatic crystal; L - Rosette crystal; M - Starch grain; N - Vessel; O - Parenchyma cell; P - Resin; Q - Vessel; R - Cell filled with brown deposition; S - Laticiferous tube



PLATE – 4. 3. 2

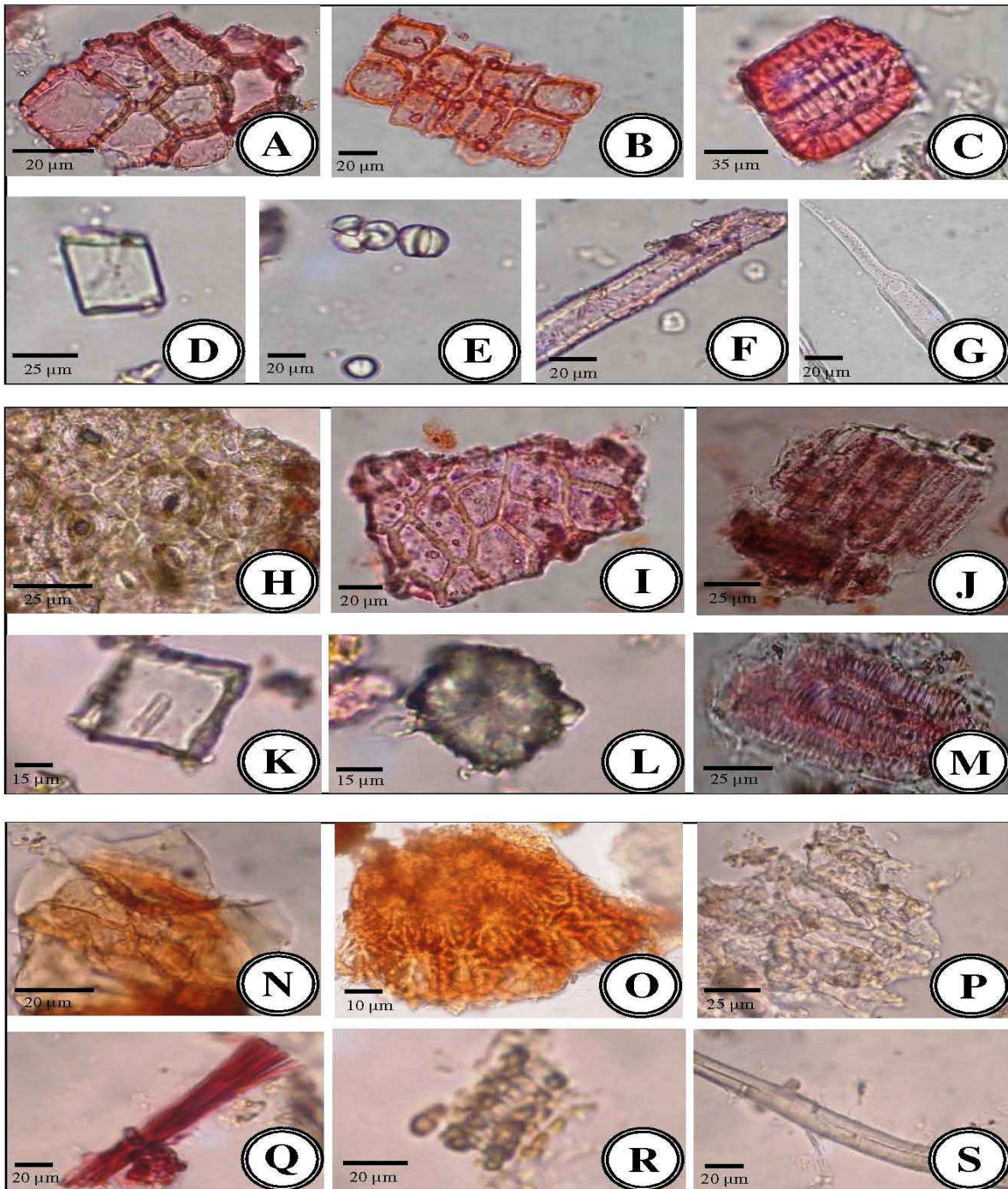


**A** - Leaf venation pattern of *Carissa opaca* Stapf ex Haines; **B** - Transverse section of leaf; **C** - Transverse section of root showing large number of stone cells; **D** - Transverse section of wood; **E** - Longitudinal section of root; **F** - Transverse section of fruit; **G** - Transverse section of fruit showing details; **H** - Transverse section of fruit showing crystal

[CK - Cork, CT - Cortex, CU - Cuticle, EC - Epicarpic cells, GT - ground tissue, LE - lower epidermis, MC - Mucilage cells, MR - Medullary Rays, PC - Parenchyma cells, Ph - Phloem, PM - Palisade mesophyll, RC - Rosette crystals, SC - Stone cells, SE - Sieve element, SM - Spongy mesophyll, UE - Upper epidermis, V - vessel, VB - Vascular bundles, X - Xylem, XF - Xylem fibre]



PLATE – 4. 3. 3

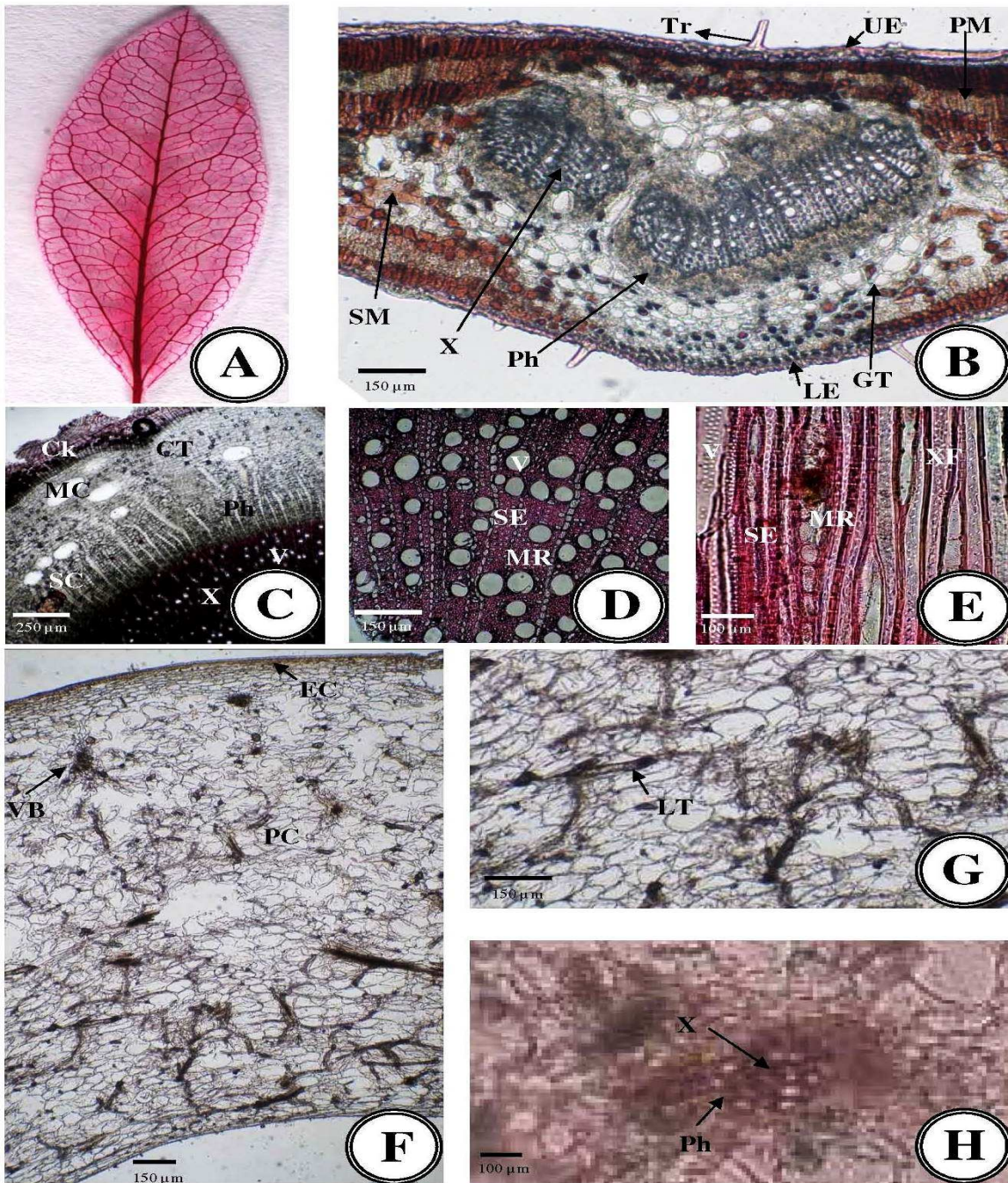


Root powder A-G , Leaf powder H-M, Fruit powder N-S (400X)

A - Parenchymatous cell; B - Cork cell; C - Stone cells; D - Prismatic crystal; E Starch grains; F - Fibre; G - Vessel; H - Stomata; I - Parenchymatous cell; J - Palisade cell; K - Prismatic crystal; L - Rosette crystal; M - Vessel; N - Parenchyma cell; O - Cell filled with brown deposition; P - Parenchyma containing Starch grain; Q - Resin; R - Vessel; T - Laticiferous tube



PLATE – 4. 4. 2

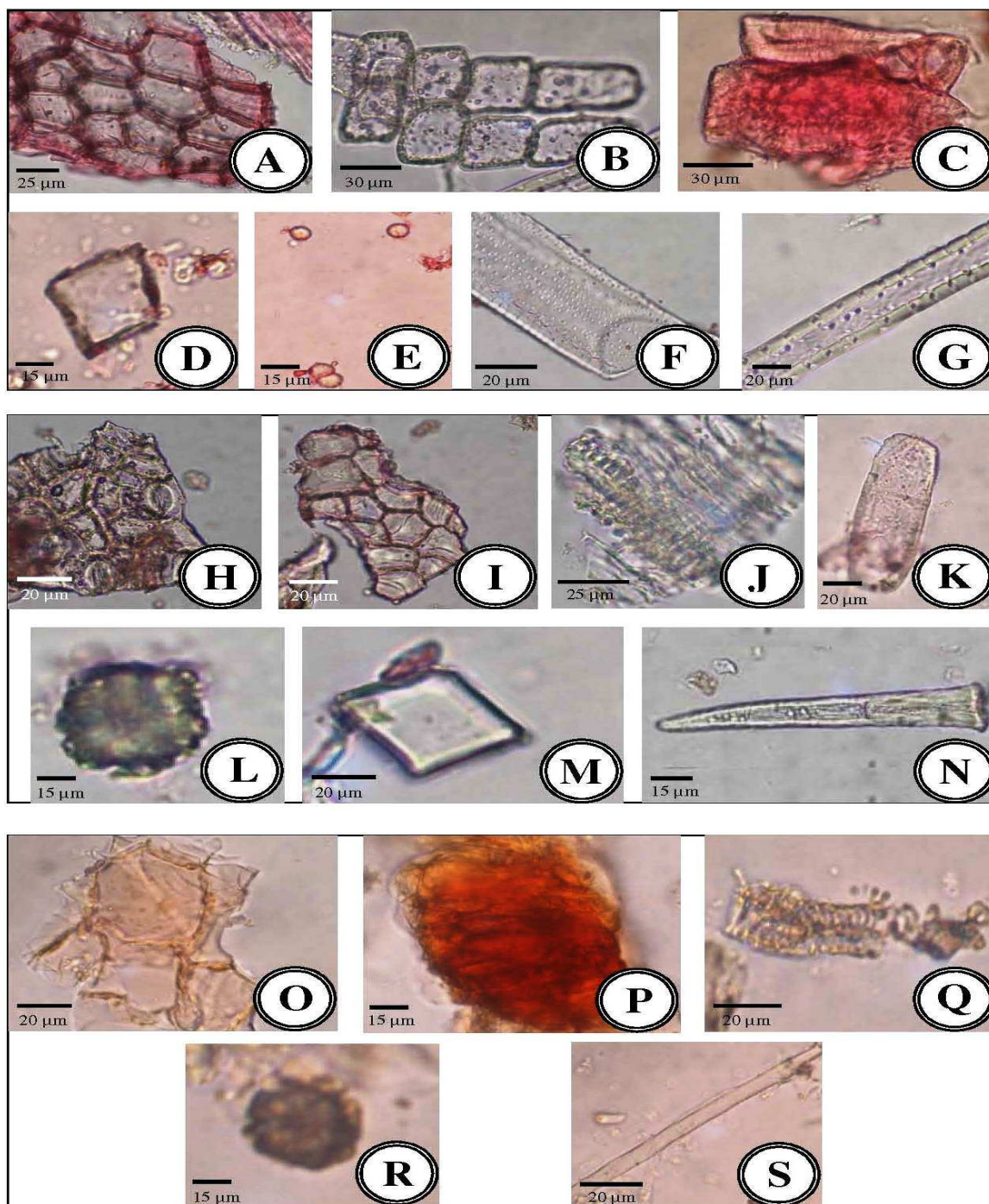


**A** - Leaf venation pattern of *Carissa spinarum* L.; **B** - Transverse section of leaf; **C** - Transverse section of root showing large number of stone cells; **D** - Transverse section of wood; **E** - Longitudinal section of root; **F** - Transverse section of fruit; **G** - Transverse section of fruit showing Laticiferous tubes; **H** - Transverse section of fruit showing vessels

[CK - Cork, CT - Cortex, CU - Cuticle, EC - Epicarpic cells, GT - ground tissue, LE - lower epidermis, LT- Laticiferous tube, MC - Mucilage cells, MR - Medullary Rays, PC - Parenchyma cells, Ph - Phloem, PM - Palisade mesophyll, SC- Stone cells, SE - Sieve element, SM - Spongy mesophyll, Tr- Trichome, UE - Upper epidermis, V- vessel, VB - Vascular bundles, X - Xylem, XF - Xylem fibre]



PLATE – 4. 4. 3



Root powder A-G , Leaf powder H-N, Fruit powder O-S (400X)

A - Cork cell; B - Pitted parenchymatous cell; C - Stone cells; D - Prismatic crystal; E - Starch grains; F - Vessel; G - Fibre; H - Stomata; I - Parenchymatous cell; J - Vessel; K - Tracheid; L - Rosette crystal; M - Prismatic crystal; N - Trichome; O - Parenchyma cell; P - Cell filled with brown deposition; Q - Vessel; R - Rosette crystal; S - Laticiferous tube