

Morphological and Pharmacognostical Evaluation of *Moringa oleifera* Lam. (Moringaceae): A Plant with High Medicinal Value in Tropical and Subtropical Parts of the World

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ABSTRACT

Moringa oleifera Lam. is a very important medicinal plant grown in the Indian subcontinent and it belongs to the family Moringaceae. This is popularly known as drumstick tree and is used as a food delicacy very popularly. This plant is now well known for its various nutritional properties such as rich source of Vitamins (A and C), minerals (Ca, P, K, Fe, Cu, S, Mg) etc. pharmacological properties such as anti-inflammatory, abortifacient, Antioxidant, analgesic, antipyretic, etc. All the parts of the plant are used in one way or the other. There have been no complete records on morphological and pharmacognostical studies of the whole plant. In this research article we have tried to examine the complete morpho-anatomy of the plant *Moringa oleifera* Lam. Simple pharmacognostic studies including macroscopy, microscopy, biostatistical parameters and powder analysis and fluorescent analysis have been performed. The peculiar features observed were the presence of mucilaginous canals in stem and mature petiole; myrosine in all parts of the plant, stellate and rhomboid crystals, reticulate and spiral thickenings in the xylem vessels. The results can be used for further characterization of the plant.

Key words: *Moringa*, Pharmacognosy, Microscopy, Powder microscopy, Standardization.

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INTRODUCTION

Natural products have always gravitated man for its everyday needs and its only recently we have come to terms with the fact that natural medicine if not all, but still has cure to some of our common problems. Herbal drugs have come to light in the view that they are safer and cost effective as against their synthetic counter parts. Plants are the source to most of the natural drugs. In the recent times demand for these medicinal plants has increased enormously as more and more research is being done. The drugs obtained from plant sources are considered safer and have least to almost no side effects when administered in recommended doses. The renewed interest in drugs of natural origin has paved a way for a thorough research in the same as greater the value more is the demand. Also with plants there comes another factor as the closely related species become difficult to differentiate. Therefore, a cascade of extensive research work began in this domain. Therefore, paving a way for pharmacognostical studies which includes wide array of parameters such as organoleptic characters, macroscopic study, microscopic study, powder study, physico-chemical analysis, phytochemical analysis, fluorescence analysis, etc. These studies allow us to authenticate the plants used as drugs properly and thereby, help in ensuring usable quality of these herbal medicines leading to safety and efficacy of natural products. This

study focuses on macroscopic, microscopic, powder and fluorescent analysis of *Moringa oleifera*.

Moringa oleifera Lam. is a monogenous plant belonging to family moringaceae.^[1] It is a deciduous tree with silver grey bark, 10-12 m in height. The leaves are usually tripinnate and fruit is borne mostly in the summers.^[2,3] It is native to India and also widely distributed in tropical and subtropical countries of the world. In India it occurs in various states viz. Andhra Pradesh, Assam, Gujarat, Himachal Pradesh, Punjab, J & K, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Rajasthan, Tamil Nadu, Uttar Pradesh, etc. Distribution in other Asian countries such as Afghanistan, Bangladesh, China, Indonesia, Java, Malaysia, Nepal, Pakistan, Sri Lanka, Vietnam, Taiwan and Thailand has also been reported. It is also spread over to the other continents like Africa, North and South America, Caribbean and Oceania.^[4]

The name *Moringa* finds its origin from a Tamil word 'muringa' meaning 'twisted pods'. While, the name of the genus comes from two Latin words 'oleum' meaning 'oil' and 'ferre' meaning 'to bear'. In French it is known as acacia blanc; ben oléifère; moringa ailé; *Moringa oleifère*; *Mouroungue*; in German *behenbaum*; *Behennussbaum*; *Meerrettichbaum*. Some other common names in different countries viz. quiabo-da-quina (Brazil), la mu (China), shagara al rauwaq (Egypt), mlonge; mlongo; mronge; mzunze

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(Kenya), alim; bagaruwar maka; chigban wawa; danga; halim; idagbo monoye; koraukin zaila; okwe oyibo; rimir nacara; rimir turawa; samarin; zogale; zogalla-gandi (Nigeria), etc.^[5] In India it is commonly called as Sahjan and some of the common Indian names are listed in the Table 1.^[6,7]

The recent development in the field of natural medicine has brought *Moringa oleifera* in the limelight. The plant has become popular due to its multifaceted uses. The plant is of high value as almost every part of it can be used in some way and can single handedly provide a wide array of nutrients such as vitamins, minerals, etc. Research has shown that *Moringa oleifera* contains various nutrients that are required by humans. It is a rich source of Ca, P, K, Fe, Cu, S, Mg etc.^[8] Thus plant may be seen as an alternative to tackle malnutrition in various parts of the world.^[9] Besides full of nutrients it is also rich in antioxidants (vergara) and has properties like anti-diabetic, abortifacient, anti-cancer, anti-microbial, anti-allergic and antipyretic property activities has been reported.^[7,10-12]

The plant *Moringa oleifera* has been used by the human civilization since time immemorial. It was used by the ancient Aryans, Romans, Greeks, Egyptians, etc. the Vedic literature documented about 5000 years ago provides with the first glimpses of use of this plant. The warriors of the great Mauryan Empire were believed to take it as their daily drink.^[13] These men were known to be of great valour and power and *Moringa oleifera* was the key to their fitness.^[14] *Moringa oleifera* oil had great value in ancient Greece, Rome, Egypt and India. It was used in the skin care and personal care regime by these people. *Moringa oleifera* oil was believed to increase skin elasticity, cure wrinkles, rashes, minor wounds, etc.^[6,15]

Moringa oleifera has long been used in the field of medicine. It has historically been used to treat various ailments in humans. Every part of this plant has some or the other medicinal importance. This plant has long been used in homoeopathy by the practitioners. Different parts of the plant have been put to various uses in homoeopathy.^[16,17] Leaves of the plant are used to treat eye diseases, pain, hallucinations and treatment of scurvy. Hot water extract of leaves, root and stem bark is used as an abortifacient in many cultures around the globe. Leaf decoction is used to treat conditions such as nervous shock, rheumatism, galactagogue.^[18] Fruit extract is used to treat diabetes, ascites, edema, spleen enlargement, lumbago and skin diseases.^[19,20] Root bark and root are abortifacient besides root bark also relieves spasm. The root is also used to cure a number of diseases like anodyne paralysis, inflammations, fevers, cough, cold, bronchitis, pectoral diseases, epilepsy, hysteria, etc.^[7,8] Flowers have stimulating effect and are used for the treatment of bile infections.^[20,21] In some cultures in Africa it is used to treat

diseases like weakness, fever, asthma, cough, blood pressure, arthritis, diabetes, epilepsy, wound and skin infection.^[9] Apart from these this plant also been used as tea, soup, vegetable, etc. and as staple by Indian people across India.^[22,23] The flocculent property of the seed makes it a handy tool to purify water therefore its seeds are used as water purifier by some people in areas where water purification facilities are not well developed.^[8-9,24]

Thus, *Moringa oleifera* is an important plant with a multitude of benefits as almost every part of the plant is in some way important. So far regarding study on whole plant has not been done so far and limited research is available on different plant parts. Therefore, it is imperative that substantial work should be done on it. In this study we have made an attempt to present a complete pharmacognostical studies including macroscopy, microscopy, bio statistical parameters, powder analysis and fluorescent analysis of the plant *Moringa oleifera*. A thorough microscopic study has been performed pertaining to different parts of the plant viz. root, stem, leaf, flower, fruit and seed. In case of leaves micrometric analysis like stomata index, vein islet and vein termination including foliar epidermal characters study have been performed.

MATERIALS AND METHODS

Plant collection and identification

Samples were collected from Centre for Medicinal Plants Research in Homoeopathy, Emerald, Indra Nagar, Tamil Nadu. The Good collection practices were undertaken for collection and preservation of the samples. The plant material preserved in FAA solution was used for microscopical study whereas for macroscopical and powder studies the shade dried plant material was used.

Chemicals and reagents

All the chemicals used in the study were of analytical grade and were procured from Fisher scientific, Mumbai, India and E. Merck India Limited.

Macroscopic analysis

The macroscopically characters of the raw drug were studied. These included analysis of the dried whole plant such as size, shape, color, margin, etc. Organoleptic analysis of raw drug was done through sensory based characters like smell, taste, etc. were recorded.

Microscopic analysis

The preserved samples were washed in running water and then samples were processed in the dehydration series followed by embedding series. These specimens were used to cut the section ranging from 30-40 μ m by WESWOX MT 1090A wax microtome. Permanent slides were prepared by double staining procedure using Safranin and fast green and mounted with DPX mountant.^[25,26] These slides were then observed under the microscope and photomicrographs taken. For the qualitative and quantitative analysis of the drug microscopic studies were performed and Trinocular radical RTC S-7 microscope was used to take the photographs.

For the foliar epidermal microscopy the leaves were washed with water and then treated with saturated chloral hydrate solution for clearing. Epidermal peelings of the upper and lower surfaces were taken and temporary slides were prepared by mounting samples in glycerin.^[27] The histochemical analysis of the plant sample were performed where hand sections were cut and treated with different chemicals for the detection of starch, oil globules etc.^[28] The powder analysis was performed by preparing powder of the shade dried material. For powder preparation dried sample was finely powdered using mortar and pestle and powder

Table 1: Common name of *Moringa oleifera* in different languages or area.

Language	Name
English	Horse radish tree, Drumstick tree
Hindi	Sahjan, Saguna, Sainjna
Sanskrit	Subhanjana
Gujarati	Suragavo
Tamil	Mulaga, Munaga
Malayalam	Murinna, Sigru
Punjabi	Sainjna, Soanjna
Unani	Sahajan
Ayurvedic	Haritashaaka, Raktaka, Akshiva
Arabian	Rawag

microscopy was performed using different chemicals.^[25] All the observations were recorded under microscope.

Fluorescent analysis of different part of plant was performed by treating the powdered material with different chemicals and observing the treated samples under three different wavelengths of light viz. visible range (380-800), short wavelength (254nm) and long wavelength (365nm) of UV light.

Quantitative microscopy

Quantifiable characters of the plant such as stomatal index, vein islet, vein termination, palisade ratio (in case of leaves) were recorded. For this analysis the leaves were washed several times with running water followed by clearing using saturated chloral hydrate solution. After clearing leaf peelings were taken for both the surfaces i.e. upper and lower epidermis and stained with safranin. Temporary slides were prepared, mounted in glycerin and observations were recorded.

RESULTS AND DISCUSSION

Moringa oleifera Lam. in the current scenario is being viewed as a very potent plant in the fields of nutraceuticals as well as pharmaceuticals. A number of well established companies are producing and processing different parts of the plant for healthcare. The current trend shows enormous future possibilities for the vigorous use of the plant especially by the third world nations. As it is quite a task for these nations to put in large finances for healthcare, simple methods and techniques used here can be an effective tool to identify and standardize this plant. The present study is mainly based on the morphological and pharmacognostical parameters of *Moringa oleifera* Lam. were examined. In this study plant showed so much peculiar characters for the identification and authentication of the plant from other adulterant.

Morphological description

Moringa oleifera a deciduous, perennial tree, growing up to 10-12 m in height; younger roots tuberous while the older roots branched. The branches spreading and fragile, bark silvery grey with rough texture (Plate 1. A). Leaves tripinnately compound, up to 45 cm in length, leaflets 4 - 6 in pairs, 2.0 - 2.8 × 0.9 - 1.8 cm, ovate, elliptic, upper side dark green, lower side light green and glabrous, margin entire, apex emarginated to round, base round, etiolate, pedicel 0.3 - 0.7 cm in length; pulvinus present at base (Plate 1. B).

Inflorescence axillary panicle, spreading pattern, 10 - 30 cm in length, bracteate, bracts linear, 1 mm (Plate 1. C); flowers fragrant, bisexual, sepals 5, white, polysepalous, lanceolate, 0.7 - 1.6 cm in length (Plate 1. D); petals 5, polypetalous, creamy white and greenish marking on outside at base, spatulate, 0.4 - 1.4 cm in length, descending imbricate aestivated (Plate 1. E); anthers 5, dorsifixed, ditheous, stamens hairy at the base (Plate 1. F); stigma hairy, style slender, ovary superior, syncarpous, tricarpellary, unilocular with parietal placentation (Plate 1. G); fruit capsule with three lobes, green- pale yellow, splitting length-wise upon maturity. Seeds triangular, winged, slimy, olive green to brown.

Macroscopical description

Drug occurs as dried small pieces of stems, roots, leaves, bud, flowers and fruits; roots were brown in colour with rootlets, circular, branched, 4-8 cm in length, rough texture; stem rounded, pale green - light brown, slightly rough texture, 4-7 cm long; leaflets shriveled, shrunked, curled, pale green; flower pale white, shriveled, margins curled; fruit pale green, twisted, deep ridges and furrows present, somewhat rounded; seed pale reddish brown, winged, wings papery thin, shriveled and shrunked (Plate 2. A).

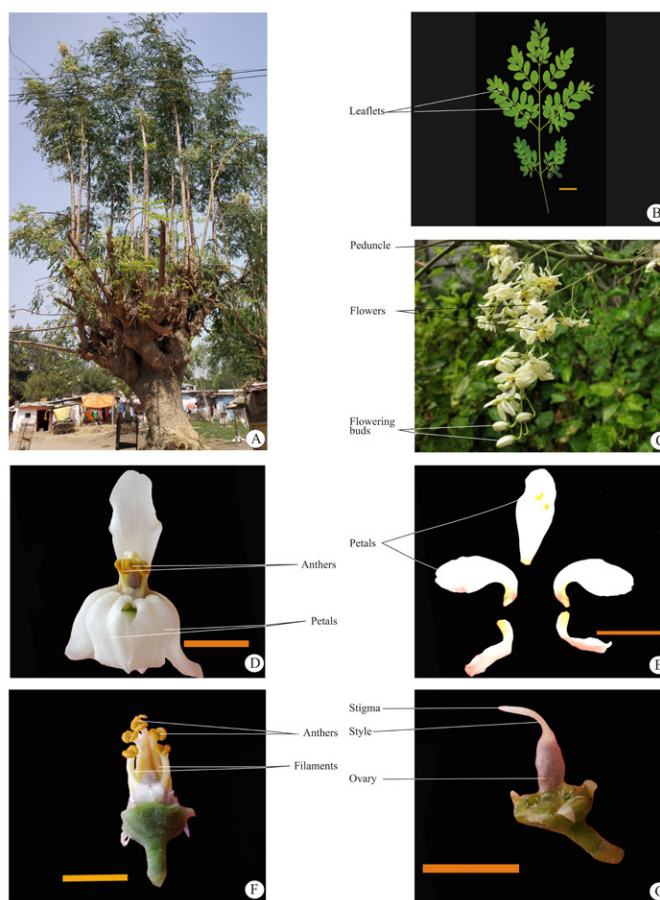


Plate 1: *Moringa oleifera* Lam. A. Habit of the plant; B. Leaf; C. Inflorescence; D. Flower; E. Petals; F. Stamens; G. Style and stigma.

Microscopical description

Young Root

Young root shows circular in outline having elliptical epidermis followed by a zone of cortex. The cortex region divided into two zones, the outer zone composed of small parenchymatous cells often interrupted by patches of sclerenchyma; and inner zone having thin walled large parenchymatous cells. Outer cortical cells often filled with prismatic crystals of varying shape and size. The inner few parenchymatous cells often similar to endodermal cells in shape and size. The endodermis composed of barrel shaped cells showing casparian bands along with a few passage cells. Pericycle clearly not distinguishable below endodermis. Radial vascular bundle present having tetrarch xylem. The pith was absent in the root.

Mature Root

Transsection of the root revealed circular outline. Outermost layer cork, broad approximately 7-12 layered; Cork cells arranged radially and rectangular in shape. The growth of the cork cells were not continuous around the margin but, interrupted at regular intervals. The cortical region broad with thin, isodiametric parenchymatous cells without inter-cellular space; interrupted by zone of sclerenchymatous fibres confined to outer region. Some dark pigmented myrosin cells and few crystals present in this region. These crystals were varying in shape and size, prismatic type ranging from 30-40 × 20-30 μm and stellate type ranging from 38-48 × 42-50 μm; a few oil globules and resinous matter were also scattered in the cortical region. Endodermis and pericycle not quite distinguishable in the mature root. Vascular region containing

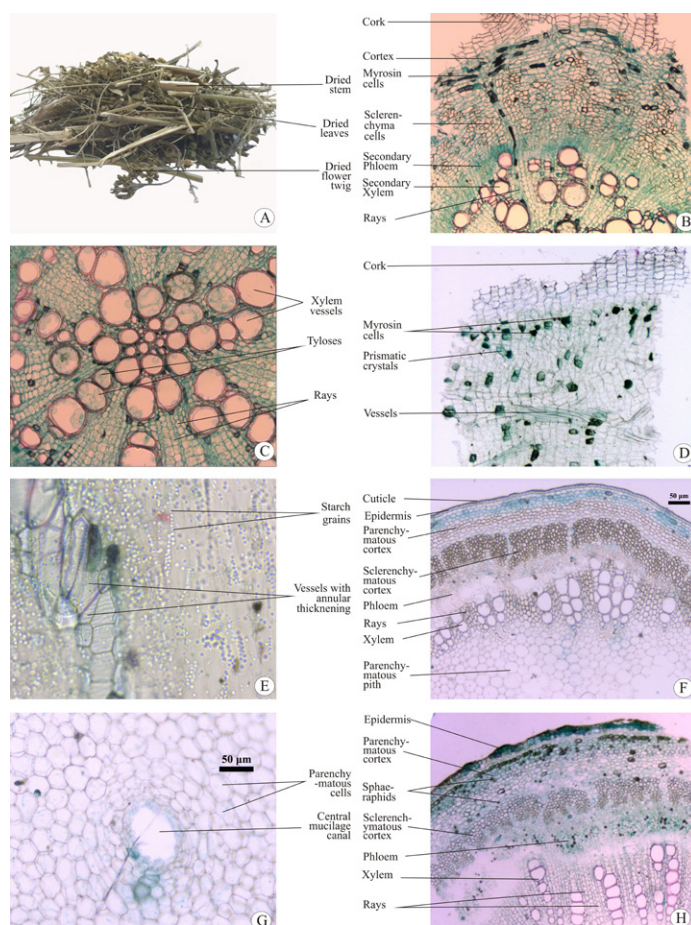


Plate 2: *Moringa oleifera* Lam. A. Raw drug; B. Transverse section of mature root; C. Enlarged view of mature root section showing the secondary xylem, rays, xylem parenchyma and tyloses; D. Longitudinal section of mature root showing myrosin cells and prismatic crystals; E. Longitudinal section of mature root showing starch grains and vessels; F. Transverse section of young stem; G. Transverse section of stem showing mucilage canal in the centre of the stem; H. Transverse section of the mature stem showing epidermis, cortex and vascular region.

secondary phloem towards outer side and secondary xylem towards inner side. Rays mostly unicellular but multicellular rays also present, vessels with reticulate and annular thickening and well developed tyloses also present in the region. A few idioblasts having myrosin cells ranging from 20–26 x 12–17 µm and few starch grains ranging from 3–9 µm present in the cells (Plate 7. G-H). Phloem elements small appeared crushed and aggregated towards upper part of the xylem elements. Xylem vessels exhibited irregular distribution. Some of the larger vessel elements contained tyloses in them. Pith was also absent in the mature roots (Plate 2. B-E).

Young stem

Transection of young stem showed circular in outline with abundant unicellular to 3 celled, non-glandular hairs with blunt tips with broad lumen a few of them have curved apices. The outermost layer epidermal cells were small elliptical followed by long elongated to elliptical parenchymatous hypodermis. Three to four layered chloerenchymatous cells were present. A few layer of parenchymatous cortex present but not differentiated into zones. These cells were filled with starch grains, rosette and prismatic crystals. The endodermis barrel shaped followed by vascular region. Vascular bundles conjoint, collateral and open

and 8 vascular bundles present in a ring. Pith parenchymatous with isodiametric to anisodiametric cells without intercellular spaces. In very early stages of development showed two mucilaginous canal separated by parenchymatous cells. These mucilaginous canals were surrounded by single layered thin walled epithelial cells. A few epithelial cells have protuberance towards inner side. These two mucilaginous canals get fused at the time of maturity and form a large single mucilaginous canal surrounded by epithelial cells without any protuberances in inner side (Plate 2. F and G).

Mature stem

Transection of mature stem exhibited circular outline with a few unicellular to 3 celled, non-glandular hairs, measuring from 40–100 µm with blunt tips and broad lumen, a few of them have curved apices. The cortical region differentiated into two zones viz. outer parenchymatous cortex and inner sclerenchymatous cortex. The cortical parenchymatous cells were anisodiametric, without intercellular space, filled with large amount of starch grains, rosette and prismatic crystals. Ugwoke *et al.*^[29] also reported about the presence of rosette and prismatic crystals in the stem. The prismatic crystals were mostly confined to cortical region only measuring 12–20 x 15–30 µm and rosette type crystals were scattered in all over the region of stem and size varied from 15–40 x 20–30 µm. The starch grains were present in abundance measuring from 4–8 µm. The myrosin cells were randomly distributed throughout the cortex. The inner cortex contained a more or less continuous ring of sclerenchymatous cells having thick wall and broad lumen. These sclerenchymatous patches were more towards the peripheral region and less towards inner region forming a distributed pattern of triangular shape. The patches were with 10–15 layered in thickness. The vascular region consists of broad region of secondary phloem followed by a zone of meristematic cells and secondary xylem. Secondary xylem consists of xylem tracheids, xylem vessels and xylem parenchyma. Xylem vessels contained scalariform spiral and reticulate thickenings with pits. Almost every vessels have thin walled parenchymatous cells towards lumen sided forming tyloses. A large pith with thin walled, isodiametric to anisodiametric, parenchymatous cells without intercellular spaces. A large mucilage canal present in the centre surrounded by thin walled single layered epithelial cells. These cells were without any protuberances as were seen in young stage (Plate 2. H, 3. A-F). Previously in some research studies done by Bones,^[30] El-Emary,^[31] and Metcalfe and Chalk^[32] etc. has also described some characters of the *Moringa oleifera* in the stem was presence of myrosin cells, rosette crystal, sclerenchyma patches only but in this study we found some more peculiar character such as mucilaginous canal, tyloses in the vessels. This study covers the all essential as well as peculiar parameters of the plant which will helpful for diagnosis.

Petiole

Transection of the petiole showed circular in outline covered by small unicellular to multicellular non-glandular hairs with either blunt tips or curved tip with broad lumen, measuring up to 250.5–330.7 µm (multicellular) 70.5 – 110.2 µm (unicellular). In this study petiole section shows two types of hairs but Metcalfe and Chalk^[32] have described only unicellular hairs. The outermost layer was thick walled, single layered epidermis, covered by thick cuticle and often interrupted by stomata. The epidermal layer was followed by single layered hypodermis. The epidermal cells were oval to elliptical cells and hypodermal cells were elliptical to barrel shaped. In young petiole, some of the hypodermal cells were filled by dense content. The cortical region differentiated into three zones; outer chloerenchymatous middle parenchymatous zone and inner sclerenchymatous zone. The outer zone was chloerenchymatous, 3–4 layered and cells were circular, filled with dense chloroplasts and without intercellular spaces. The middle cortical zone was parenchymatous type where cells were thin walled and anisodiametric

type, without any inter-cellular spaces. A few chloroplasts also may be seen in these cells but not similar to upper chlorenchymatous cells. The inner zone showed sclerenchymatous zone and often interrupted pitted parenchyma cells and these cells were also present in pith. In young and upper region vascular bundles were conjoint collateral and open type where as in mature stages these vascular bundles showed secondary growth forming secondary phloem towards outer side and secondary xylem towards inner side. The xylem vessels were arranged radially and have broad lumen and uni to multiseriate medullary rays with annular and reticulate thickenings. The pith region containing thin walled anisodiametric parenchyma cells with very small intercellular space. The idioblasts containing tannin cells confined in hypodermal region, whereas myrosin cells confined to cortical region only, but rosette crystals were present throughout the region. A large mucilage canal present in middle and lower region but absent in upper region of mature petiole and young stage. This mucilaginous canal was surrounded by 1-2 layered thin walled single layered with protuberated epithelial cells (Plate 3. G-H; 4. A-F).

Petiolo

Transverse section of the petiolo showed circular in outline covered by small unicellular, non-glandular hairs with blunt tips and broad lumen, few of

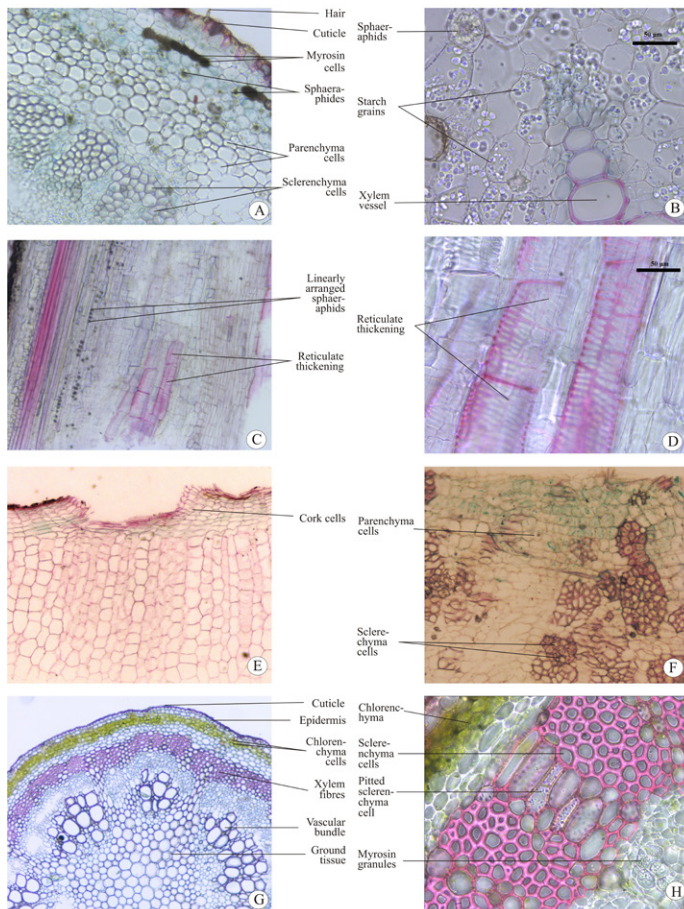


Plate 3: *Moringa oleifera* Lam. A. Enlarged view of stem showing myrosin cells, sphaeraphids and sclerenchyma cells; B. Enlarged view of stem showing xylem vessels and sphaeraphids; C. Longitudinal section of stem showing linearly arranged sphaeraphids and reticulate thickening; D. Enlarged view of longitudinal section of stem showing reticulate thickening; E. Transverse section of outer bark showing cork cells; F. Transverse section of inner bark region showing sclerenchyma cells; G. Transverse section of petiolo; H. Enlarged view of petiolo showing xylem fibers and pitted sclerenchymatous cells.

them have curved apices, measuring from 40–100 μm . The outermost layer was thick walled, single layered epidermis, interrupted by stomata. The epidermal layer was followed by single layered hypodermis but absent below the stomata where air chamber present. The epidermal cells were oval to circular cells forming irregular outer surface. The hypodermal cells were elliptical to oval in shape and some of the cells were filled by dense content. The cortical region differentiated into two zones; outer chlorenchymatous and inner parenchymatous zone. In outer zone 2-5 layered 'palisade like' chlorenchymatous cells were present below the hypodermis. These cells were oval to elongated filled with dense chloroplasts and with intercellular spaces. The inner cortical zone was parenchymatous type where cells were thin walled and anisodiametric type, without any intercellular spaces. The cortical parenchymatous region showed sclerenchymatous patches in mature stage but in young these patches were absent. The meristele is present below the cortical region where secondary phloem and secondary xylem present. The vascular bundles were conjoint, collateral and open type showed uni to multiseriate medullary rays. The pith region containing thin walled polygonal parenchyma cells with intercellular space. The idioblasts containing tannin cells confined in hypodermal region, whereas myrosin cells confined to cortical region only, but rosette crystals were present throughout the region (Plate 4. G and H).

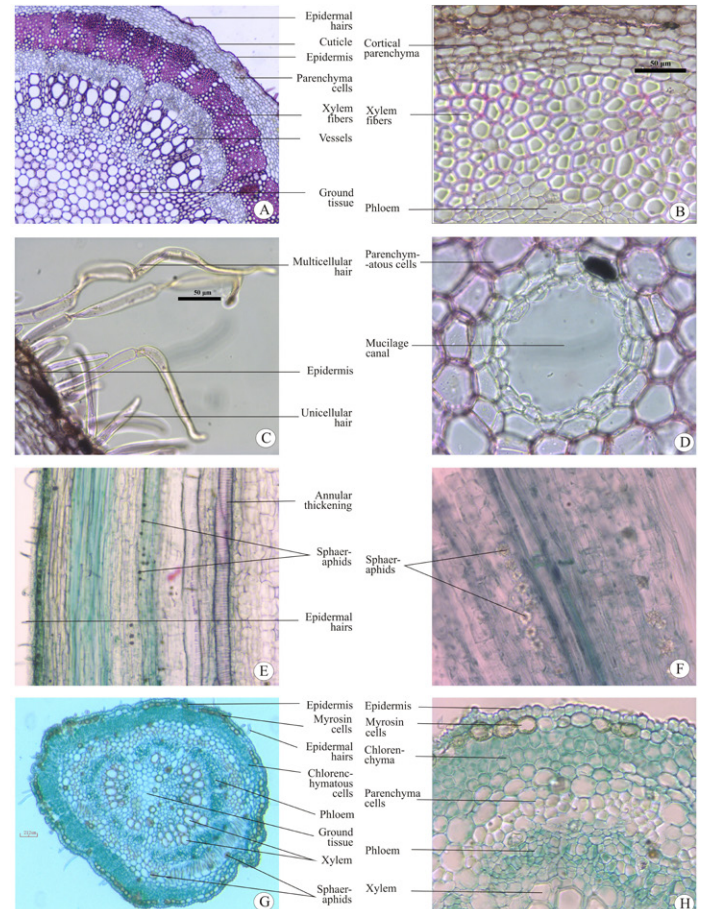


Plate 4: *Moringa oleifera* Lam. A. Enlarged view of petiolo showing xylem fibres arranged in a ring followed by secondary phloem, secondary xylem and pith; B. Enlarged view of petiolo showing cortical parenchyma and xylem fibres; C. Enlarged view of petiolo showing unicellular and multicellular hairs; D. Enlarged view of petiolo showing mucilage canal; E. Longitudinal section of petiolo showing hairs, vessels having annular thickening; F. Enlarged view of petiolo showing linear arrangement of crystals; G. Transverse section of petiolo; H. Enlarged view of petiolo showing chlorenchyma, parenchyma, phloem and xylem.

Leaflets

The vertical section of leaves showed dorsiventral structure. The epidermis was single layered present on both sides and often interrupted by stomata on both side and covered with thin cuticle on both sides. The epidermal cells were barrel shaped on upper sided whereas circular to semicircular and smaller on lower side. The non-glandular, unicellular hairs with blunt tips and often with curved apices were present on both the surfaces of leaves, Metcalfe and Chalk^[31] have also described presence of unicellular hairs. These hairs were arising from the joints of 5-7 epidermal cells, arranged in star shape of fashion. The size of trichome varied from 42-115 μm . The stomata were anomocytic type present on both the surfaces of leaves however these were more scattered on lower surfaces. The mesophyll was differentiated into i.e. palisade and spongy parenchyma. The palisade layer was 2 - 3 celled in thickness and spongy parenchyma was present below this region. The traces of vascular strands also present in this region. The rosette crystals were scattered throughout the region but rarely seen in palisade region (Plate 5. C).

In the midrib region the section showed convex surface on both the sides but more prominent on lower side. The palisade cells were also present in this region. A few idioblasts also present throughout the leaf

which were either filled with rosette shaped crystals or cells filled with starch grains. A few myrosin cells also present throughout the leaves but mainly present in midrib region. The arc shape Merisel present in midrib region where phloem present below the xylem on dorsal side. The parenchymatous ground tissue was present upper and below the vascular region of the midrib. Stomata index on lower surface was 10.84 and upper surface 1.48, vein islet 47.18 per mm^2 , vein termination 31.45 per mm^2 , palisade ratio 6-9 (Plate 5. A-B, D-F)

Sepal

Vertical section of the sepal showed small epidermal cells, covered with minute abundant unicellular, non-glandular hairs^[33] with blunt tips and broad lumen. The hairs measuring from 25 – 90 μm were present on both the surface which were mostly straight and a few of them with curved apices. The loosely arranged, thin walled cortical parenchymatous cells present below the epidermis. The poorly developed vascular bundles were also present in the middle of sepal throughout the region. Few idioblasts containing dark pigmented myrosin cells were present towards the epidermal region on both surfaces but more often on dorsal side and a few rosette crystals ranging from 6-8 x 11-13 μm also present in the cortical region (Plate 5. G-H).

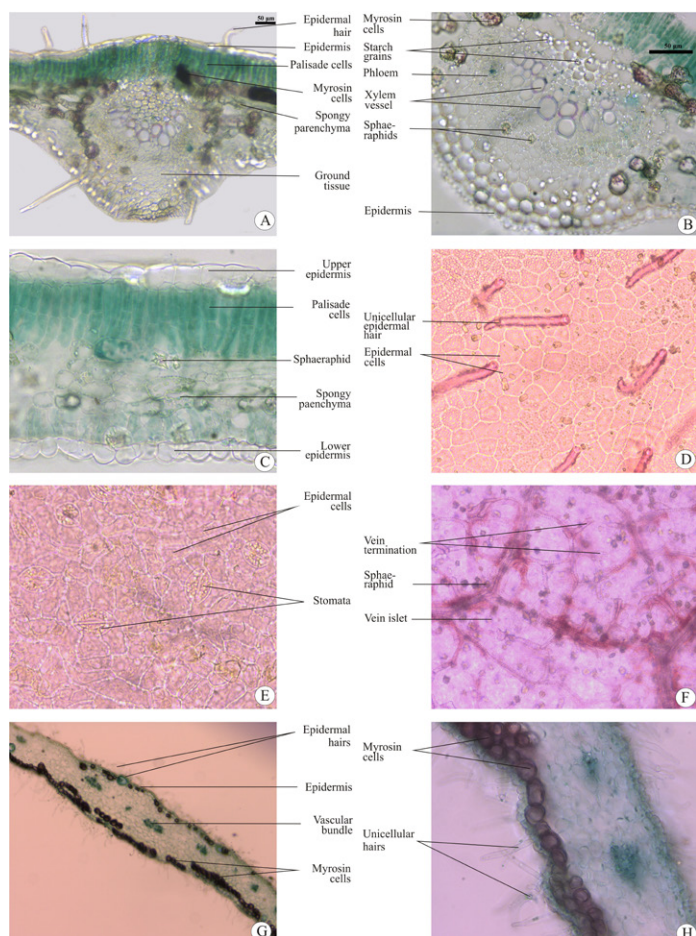


Plate 5: *Moringa oleifera* Lam. A. Vertical section of leaf through midrib showing unicellular hairs, palisade layer, spongy cells and vascular bundle; B. Enlarged view of leaf section showing vascular bundle and myrosin cells; C. Vertical section of leaf lamina showing palisade layer and rosette crystals; D. Leaf peel showing unicellular hairs and epidermal cells; E. Leaf peel showing distribution of stomata on the leaf surface; F. Leaf peel showing vein islets, vein termination and crystal; G. Vertical section of sepal; H. Enlarged view of sepal showing epidermis, unicellular hairs and myrosin cells.

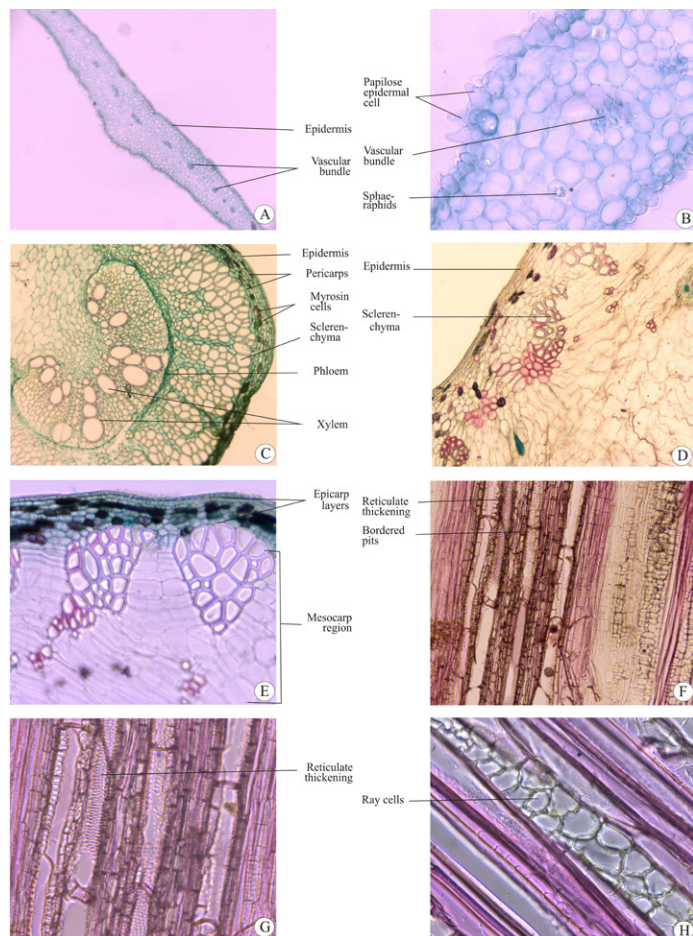


Plate 6: *Moringa oleifera* Lam. A. Vertical section of petal showing unicellular hairs and vascular bundle; B. Enlarged view of section showing papillose epidermis and vascular bundle; C. Enlarged view of fruit from ridges region showing exocarp, mesocarp, endocarp and vascular region; D. Transverse section of fruit through furrow region; E. Enlarged view of fruit showing exocarp, mesocarp and endocarp; F. Longitudinal section of fruit showing annular thickening and bordered pits; G. Longitudinal section of fruit showing reticulate thickening; H. Enlarged view of fruit showing multiseriate ray cells.

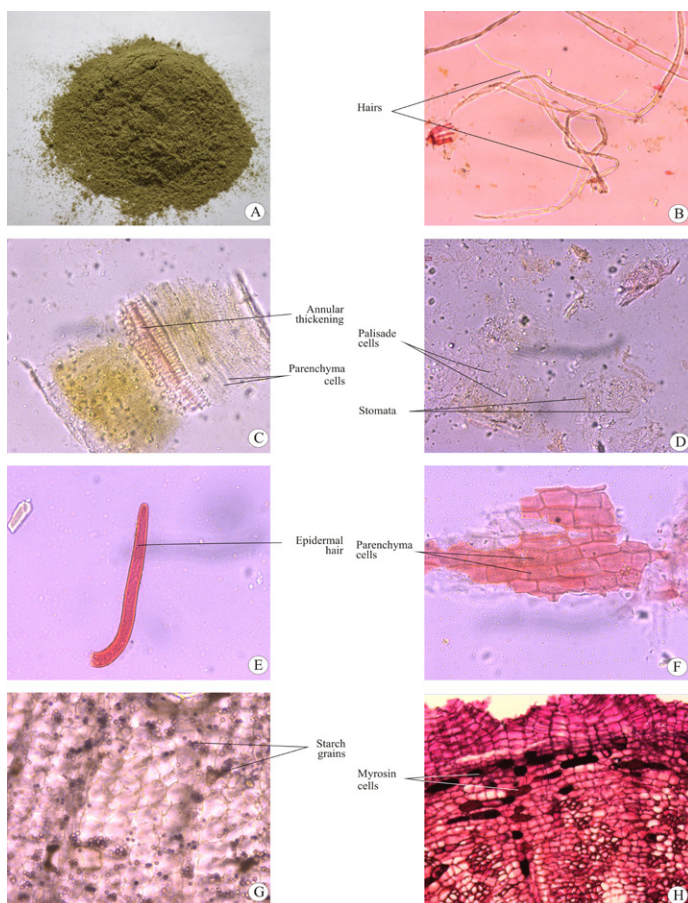


Plate 7: *Moringa oleifera* Lam. A. Powdered raw drug; B. Powdered microscopy showing hairs; C. Powdered microscopy showing fragments of vessels having annular thickening and parenchymatous cells; D. Powdered microscopy showing fragments of parenchymatous cells, palisade cells and stomata; E. Powdered microscopy showing fragments of epidermal hair; F. Powdered microscopy showing fragments of parenchyma cells; G. Histochemical test of root showing starch grain after treating with iodine solution; H. Histochemical test of root showing myrosin cells after treating with basic fuchsin solution.

Petal

Vertical section of the petals showed small papillose epidermal cells on dorsal side and small semi quadrangular to arch shaped ventral epidermis. The loosely arranged, thin walled cortical parenchymatous cells present below the epidermis. The poorly developed vascular bundles were also present in the middle of sepal throughout the region. A few idioblasts containing dark pigmented myrosin cells were present (myrosin acc. To Solereder)^[34] towards the epidermal region on both surfaces, a few rosette crystals also present in the cortical region (Plate 6. A-B).

Fruit

The transection of the fruit was circular in shape having deep ridges and furrows. The fruit can broadly be divided into three layers viz. exocarp, mesocarp and endocarp. The outer exocarp up to 10 layered thick having sparsely distributed non-glandular, unicellular hairs measuring 23-42 μm tapering and blunt tips present. These cells were chlorenchymatous, few pigmented myrosin cells measuring 10 – 20 μm x 10 – 20 μm present in this region. The outer cells were smaller than inner exocarpic cells. The upper layer cells were somewhat rectangular in shape whereas inner cells were anisodiametric type. The exocarp was followed by mesocarp. The mesocarp was parenchymatous type having regular patches of

Table 2: Florescence study of whole plant powder of *Moringa oleifera*.

S. No.	Sample	Visible Light	UV 254 nm	UV 365 nm
1.	Powder as such	Whitish Green	White	Brown
2.	Powder + Aq. NaOH	Light Green	Yellow	Brown
3.	Powder + Alc. NaOH	Light Brown	Light Green	Dark Brown
4.	Powder + 10% NaOH	Light Green	Greenish Yellow	Brown
5.	Powder + 1% Glacial Acetic Acid	Greenish White	White	Light Brown
6.	Powder + Distilled water	Greenish White	White	Light Brown
7.	Powder + Acetone	Greenish White	Light Green	Brown
8.	Powder + Menthol	Greenish White	Light Green	Brown
9.	Powder + Ethanol	Greenish White	Light Brown	Brown
10.	Powder + dil. NH_3	Light Green	Light Brown	Brown
11.	Powder + Chloroform	Light Brown	Light Brown	Brown
12.	Powder + FeCl_3 (10%)	Yellowish Green	Fluorescent Green	Blackish Brown
13.	Powder + Picric Acid	Yellowish Green	Fluorescent Green	Blackish Brown
14.	Powder + conc. HCl	Light Brown	Light Green	Brown
15.	Powder + 50% HCl	Light Brown	Light Green	Brown
16.	Powder + conc. H_2SO_4	Dark Brown	Blackish Green	Black
17.	Powder + 50% H_2SO_4	Light Brown	Light Brown	Light Brown
18.	Powder + conc. HNO_3	Orange	Light Green	Brown
19.	Powder + 50% HNO_3	Light Brown	Light Green	Brown
20.	Powder + Diethylether	Greenish White	White	Light Brown
21.	Powder + Petroleum ether	Greenish White	White	Light Brown

sclerenchymatous cells. These sclerenchymatous patches mostly form an association of triangular type shape or rarely linearly arranged cells. A few sclerotic cells were seen interspersed all over the mesocarp. The endocarp contained vascular bundles present below the ridges. The young vascular bundles were horse-shoe shaped whereas at maturity arranged throughout the region. Vascular bundles were cylindrical and radially arranged. The central region was parenchymatous and containing seeds. The seed covered by thick integument composed of outer epidermal layer papillae like followed by up to two layers of parenchymatous cells of exotesta and anisodiametric small cells of inner integument. The cotyledons parenchymatous cells filled with oil droplets and starch grains present below the integument (Plate 6. C-H).

Powder analysis

The drug occurred as course powder with a rough texture, odorless and tasteless. Powder microscopy analysis showed the presence of fragments of parenchymatous cells, a few fragments of stomata, tracheids with reticulate thickenings, rhomboidal or stellate crystals 40-48 x 37-42 μm , starch grains 7-9 μm , unicellular hairs with blunt tips (Plate 7. A-F).

Fluorescent analysis

The fluorescence analyses of whole plant powder were analysed and results were documented in the Table 2.

CONCLUSION

Our present study mainly based on the morphological, anatomical powder microscopy and fluorescence analysis of the medicinal plant *Moringa oleifera*. This study shows that plants have very important and peculiar characters for the identification of a plant. The morphological and anatomical analysis of *Moringa oleifera* is essential because only few publications are available which are not sufficient for the standardization and authentication as a raw drug. Such peculiar anatomical features of this plant are like presence of sclerenchyma patches in the cortical regions of root, stem and petiole; mature root vessels contained a balloon like outgrowth of parenchyma known as tyloses. Presence of large mucilaginous canal in the center of the pith of mature stem and petiole, this mucilaginous canal were two in young stage of stem. Presence of myrosin cells mainly toward the periphery in all parts of the plant. Abundantly presence of sphaeraphids in root, stem, petiole and leaf. In current study the complete elaborative description of all plant parts including new studies on sepals, petals and petiolules were also preformed. Some peculiar characters like chlorenchymatous cells in petiolule; dorsal papillose epidermal cells in petals; minute unicellular, non-glandular hairs with blunt tips and broad lumen reported covering the epidermis of sepals. Simple, effective and economical techniques have been used for complete identification and characterization of the plant. This can therefore, be an effective article for anatomical and morphological identification of plants by manufacturers, industrialists, researchers, etc.

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CONFLICT OF INTEREST

Authors declare no conflict of interest.

ABBREVIATIONS

cm: centimetre; mm: millimetre; µm: micrometre.

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