WISELEAF SCIENTIFIC VENTURES

Chapter 1: Botanical and Pharmacognostic Profile of *Moringa oleifera*

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ABSTRACT:
A member of the Moringaceae family, *Moringa oleifera* Lam. is a tree that flourishes in dry conditions and grows quickly. It is recognized by several names, such as miracle tree, horseradish tree, drumstick tree, and ben oil tree. Each and every component of the plant possesses a stunning variety of nutritional and therapeutic characteristics. It is a perennial with many uses in food production, medicinal, and environmental conservation, and is the most promising tree. With its culinary and positive effects on health, the moringa tree is considered one of the most valuable trees worldwide. This chapter thoroughly analyzes the botanical and pharmacognostic attributes of *M. oleifera*, focusing on its taxonomy, morphology, microscopic features, physicochemical parameters, phytochemical ingredients, and therapeutic applications. The botanical perspective posits that *M. oleifera* is a deciduous, perennial tree that matures to approximately 10 meters in height. It is slender with drooping branches. The leaves are relatively larger, arranged, tripinnate in shape, light green, and feathery. Flowers are aromatic, white or creamy-white, and arranged in clusters. Nearly all parts of this plant have been utilized in the treatment of a variety of diseases. Pharmacognostic profiling emphasizes an abundance of bioactive components and facilitates the assurance of the purity and authentic nature of crude drug derived from *M. oleifera*. In order to determine the active components that are used for ensuring the quality and purity assessment, the chapter also concentrates on the physical, chemical, microscopic, and macroscopic characteristics as well as phytochemical screening. The therapeutic advantages of *M. oleifera* are attributed to the presence of alkaloids, phenolic acids, glycosides, sterols, glucosinolates, flavonoids, terpenes, and fatty acids. Research indicates that the plant's active ingredients can treat several ailments, including cancer, diabetes, obesity, hypertension, and neuropathic pain. The plant is not only employed clinically but also as a cost-effective biostimulant for farmers in their crops. Owing to its considerable medicinal value and nutritive benefits, M. oleifera is a key research topic for its potential use in the pharmaceutical, nutraceutical, and alimentary sectors. As a comprehensive botanical and pharmacognostic profile of *M. oleifera*, this chapter will provide a valuable scientific reference for academicians, researchers, and pharmacognostic professionals who are involved in the research and development of natural medicine.

Keywords: Moringaceae family; Pharmacognostic studies; microscopy; medicinal plant.

1. Introduction: The tree Moringa oleifera Lam. belongs to the family of Moringaceae, which grows quickly and is resistant to drought. It is indigenous to the Himalayas of northwestern India and is presently widespread in India, Ceylon, Singapore, the Philippines, Myanmar, Cuba, Nigeria, Pakistan, the West Indies, Jamaica, Malaysia, and Thailand [1]. It is also in the process of dispersing to other regions. It is a consumable and nutritious plant that possesses a wide range of nutritional and therapeutic attributes. These characteristics have been ascribed to its leaves, seeds, roots, flowers, bark, and fruits [2]. It is commonly referred to by several names, such as moringa, drumstick tree (because of its elongated and slender seedpods), and horseradish tree. (due to the flavour of the roots being similar to horseradish), Ben oil tree (owing to high quantities of behenic acid), and miracle tree (due to the medical benefits) [3]. There are thirteen different species that belong to the Moringa family: *Moringa oleifera, M. stenopetala. M. borziana, M. hildebrandtii, M. peregrina, M. arborea, M. ruspoliana, M. concanensis, M. longituba, M. rivae, M. ovalifolia, M. pygmaea, and M. drouhardii*. In particular, *M. oleifera* has garnered wide acceptance for its numerous applications, which include the production of biogas, fertiliser, and nutritional products [4,5].

Traditional and modern medicine have long recognised M. oleifera for its therapeutic properties, which include the treatment of diabetes, cancer, hypertension, paralysis, respiratory illnesses, helminthiasis, ulcers, and skin infections among its many other uses [6]. Due to its pharmacological characteristics, it has traditionally been utilised in India's holistic system of Ayurveda [7]. The medicinal attributes of M. oleifera are affected by the existence of flavonoids, alkaloids, glycosides, phenolic acids, sterols, fatty acids, glucosinolates, and terpenes. Furthermore, M. oleifera is abundant in elements like vitamins, minerals, and carotenoids, which boost its therapeutic usefulness and make it a nutritional powerhouse [8]. According to reports, it also contains high levels of vitamins, minerals, and carotenoids, making it highly nutritious, offering significantly more vitamin C, A, calcium, protein, potassium, and iron compared to common foods [9]. This book chapter is intended to enhance the comprehensive knowledge of the botanical characteristics and pharmacognostic profile of Moringa oleifera.

2. Plant profile:

2.1 Synonyms: *Moringa pterygosperma* Gaertn., *Guilandina moringa* L., *Hyperanthera moringa* [10].

Language	Common names
Sanskrit	Shigru, shobaanjan
Hindi	Senjana, Munga
English	Drumstick tree, ben tree
Telugu	Mulaga, Munaga, Mochakamu
kannada	Nugge, Guggala, Mochaka
Tamil	Moringa
malayalam	Muringai
Marathi	Shevga
Gujarati	Sajne, sajina
Bengali	Sajne, sojne
Oriya	Sajana, Munigha
Punjabi	Sohanjana
Nepali	Shobhanjan, sohij
Assamese	sohjana
Sinhalese	Murunga

Table 1. Indian common names (vernacular names) of M. oleifera [11]

Kingdom	Plantae
Division (Phylum)	Magnoliopsida
class	Dicotyledoneae (Magnoliopsida)

Order	Brassicales
Family	Moringaceae
Genus	*Moringa*
Species	*Moringa oleifera Lam*

Table 2. Taxonomical or Botanical classification [12]

2.2 Agronomy: The plant thrives in hot, semi-arid, and humid areas with well-drained sandy or loamy soils. For effective germination, the seed has to be kept at a reasonable freshness level. Elevated temperatures are crucial for germination. Wood reptiles and rodents would be prohibited from accessing planted seeds, as they regard them as a delectable morsel due to their nutty flavour. Stem cuttings, about 10-60 cm in length, may also be propagated between spring and summer. Trees are vigorously cultivated in regions with warm temperatures, subtropical climates, and tropical climates [13].

2.3 Geographic distribution: The drumstick tree is native to the Himalayan foothills of South Asia, found in areas from northeastern Pakistan to northern West Bengal in India and northeastern Bangladesh, where it typically grows at elevations ranging from sea level to 1,400 m on recent alluvial soil or adjacent to riverbeds and streams. It thrives at altitudes ranging from sea level to 1400 meters [14,15].

2.4 Macroscopic morphological features: Moringa oleifera is a diminutive, rapidly expanding deciduous or evergreen-growing tree that typically attains a height of up to 9 meters. Its soft, white wood is characterised by corky and gummy bark. Branches and stems exhibit brittleness, accompanied by this corky bark.

- **Leaves:** The leaves are fluffy, pale green, complex, tripinnate (30-60 cm long), with 1.3-2.0 cm long, 0.6-0.3 cm broad, somewhat oval lateral leaves, obovate terminal leaves, and significantly bigger [16].
- **Leaflets:** Leaflets are smooth, entire, and finely hairy, green and nearly hairless on top, paler and hairless underneath, with red-tinged mid-veins, rounded or blunt tips, and short-pointed bases. The twigs are covered in fine hairs and are green in colour.

- **Flowers:** Flowers are white, fragrant, and arranged in big supplementary down panicles; the pods are pendulous, ribbed, and the seeds are triangular. There are nine ribs on each end of the pod, and the seeds have three papery wings and are dark brown in colour. The beginning of flowering occurs within the initial six months following the planting of the plant. Blooming occurs annually between April and June in cool-season locations. In areas with more consistent seasonal temperatures and adequate precipitation, flowering may commence twice annually or even continuously [17]. When dried, the brown, triangular pods break lengthwise into three halves, contain around twenty seeds lodged in the pith, and have yellow stamens.
- **Fruits:** The fruits are typically 20–50 cm long (sometimes reaching 1 m or longer) and 2.0–2.5 cm in diameter; they are linear, three-sided, and pendulous (hanging) pods with nine long lateral ridge-like structures [18].
- **Roots:** Trees grown from seeds possess a robust, deep taproot and an extensive network of massive, tubercular lateral roots that extend broadly. Trees propagated from cuttings do not develop taproots [19].

Figure 1. Images of Moringa oleifera tree, leaves, flowers, and fruits

3. Pharmacognostic profile:

3.1 Organoleptic evaluation:

- **Leaves:** Fresh leaves are deep green, oval-shaped, and are compound leaves; Dried leaves are fine deep green powder or dull green powder. The smell of the fresh leaves

is light and grassy; the dried powder has an earthy, matcha like fragrance. Fresh leaves have a slightly sweet flavor that becomes spinach-like and bitter; dried leaves are earthy and bitter, ending with a peppery or nutty taste. The powder is fine and smooth and fresh leaves are soft and thin, but can also be grainy if not completely dissolved in liquids [20].

- **Flowers:** Small, frail blooms, creamy white or yellowish-white in colour, with a sweet and highly aromatic scent. They are mild-tasting, slightly peppery or spicy, and soft and tender with a slightly velvety texture [21].
- **Fruits or pods:** Green, elongated, ridged pods up to 45 cm long, that turn brown when mature. When cooked they have a fresh and slightly pungent smell. The young pods are crudely called "drumsticks" and have a mild taste, like green beans or asparagus, but with a slight nutty flavor. They are crisp and fleshy at young age, and woody and tough when mature [22].
- **Seed:** Seed is round or triangular, papery, winged, and when mature is pale white to cream colored, then dark brown. They are usually free of odours; the pressed oil is neutral. The flavor of fresh seeds is mild, sweet and nutty, but it quickly turns bitter and astringent. The mature seeds are hard, firm and oily inside [23].
- **Roots and bark:** The plant has a thick, whitish-grey corky bark and a fleshy taproot, like horseradish. It has a strong spicy, bitter flavor, a pungent smell, and bitter and biting roots. It has a rough and woody exterior, and a juicy, fibrous interior [21].

3.2 Microscopic characteristics: Moringa oleifera displays unique microscopic features in its different portions, extensively employed for pharmacognostical scrutiny. The anatomical characteristics of the leaves, roots, and flowers disclose certain cellular structures, crystals, and tissues that delineate the plant.

- **Leaves:** The polygonal epidermal cells have either linear or gently arched walls. Stomata are predominantly anomocytic, encircled by cells indistinguishable from adjacent epidermal cells, and are generally located on the lower epidermis. The mesophyll or parenchymal cells are characterised by the presence of rosette (and

occasionally clustered) calcium oxalate crystals. An occasional presence of unicellular or glandular trichomes is also observed [24].

- **Flowers:** Numerous unicellular trichomes adorn the sepals and petals, which are coated by a unique cuticle. Along with small starch grains, the parenchyma cells are loosely arranged, and the anthers have a huge number of tricolpate pollen grains [25].
- **Roots:** The root has a multiseriate cork, different parenchyma cell layers, and sieve tubes in transverse sections. Long, slender fibres and dense vessels characterise mature root tissues. Calcium oxalate crystals, in prismatic and rosette forms, are abundantly concentrated in the cortical regions [26].
- **Stem:** a ring of vascular bundles that generate secondary wood, a cortex full of calcium oxalate crystals, a pith with secretory ducts, and a protective periderm [27].

3.3 Powder microscopy: General powder microscopic diagnostic characteristics comprise: -

- Typically found on the lower surface, epidermal cells are characterised by their wavy walls and anomocytic stomata.
- Crystals of calcium oxalate that present themselves in the shape of rosettes or clusters.
- Simple trichomes that can be either unicellular or occasionally glandular.
- Vessel elements that have thickenings that are either annular or spiral in shape.
- Palisade cells and remnants of spongy parenchyma are present in the tissue [28].

3.4 Physico-chemical and Quantitative parameters: Moringa oleifera's standardised quantitative and phytochemical characteristics (whole plant and leaf extracts) serve as baseline data for quality control and pharmaceutical formulation. Due to variations in precise values based on the plant section, cultivation site, and extraction technique, the subsequent ranges illustrate standard pharmacognostic observations [29].

Physico-chemical parameters indicate the moisture limits, inorganic mineral composition, and soluble substances found within the plant.

- **Moisture Level:** Ranges from 4.42% to 14.6% (contingent upon drying techniques and storage conditions).
- **Total Ash Content:** Ranges from 8.00% to 11.50% (signifying a substantial presence of inorganic mineral constituents such as Calcium and Potassium).

- **Acid-Resistant Ash:** Ranges from 0.02% to 7.50% (quantifies siliceous content).
- **Water-Soluble Ash:** Ranges from 1.20% to 9.64%.
- **Foreign organic matter:** Not less than 2.5%
- **Alcohol-Soluble Extractive:** Ranges from 10.22% to 18.32%.
- **Water-soluble extractive content**: Ranges from 11.20% to 57.50%, contingent upon the specific plant portion and solvent concentration [30,31].

Moringa oleifera has undergone qualitative phytochemical analysis and a large number of secondary metabolites have been detected. These metabolites are the main reasons for the great nutritional and therapeutic value of the plant. In order to identify certain bioactive chemicals, screening mostly entails making crude extracts (using solvents like water, methanol, or ethanol) and employing conventional colorimetric or precipitative assays [32].

Alkaloids can be detected by Wagner's or Mayer's reagents, resulting in a yellowish-white or brown precipitate. The alkaline reagent test is used to confirm flavonoids, which give a strong yellow colour in alkaline solution and turn colourless in acid. The ferric chloride test gives positive results with tannins and phenolic compounds, producing a bluish-black or brownish-green color. The froth test is used to identify saponins, which form a persistent and stable foam layer. Salkowski test is used to detect the presence of terpenoids and steroids which can be detected by a reddish-brown interface. Lastly, cardiac and anthraquinone glycosides can be detected with Bornträger's or Keller-Kiliani tests [33,34].

3.5 Phyto-chemistry of Moringa oleifera:

It has been documented in the literature that Moringa oleifera is a rich source of various chemical components such as alkaloids, flavonoids and other compounds with beneficial effects in different parts of the plant. The wide variety of phytochemicals highlights its health-promoting and nutritional properties [35].

It has characteristic features of its high rhamnose and glucosinolates content and the presence of moringinine and moringinine in its stem bark. The stem contains various compounds like vanillin, β-sitosterol and octacosanoic acid [36]. The whole-gum exudate comprises sugars like L-arabinose and mannose, while mild hydrolysis of the gum yields a polysaccharide of L-galactose and L-mannose. The flowers contain high levels of the amino

acids, sucrose and are also rich in trace amounts of alkaloids, and the ash is rich in potassium and calcium. The ethanol extract of Moringa pods has been reported to contain a number of antihypertensive compounds such as thiocarbamate and isothiocyanate glycosides [37]. Moreover, the seeds are rich in a number of bioactive compounds, such as O-ethyl-4-(α-L-rhamnosyloxy) benzyl carbamate and β-sitosterol [38]. Leaves have been reported as being rich in omega-3 and omega-6 polyunsaturated fatty acids, with palmitic acid being the main saturated fatty acid. The immature pods and flowers contain more monounsaturated fatty acids and less polyunsaturated fatty acids than leaves [39]. On the other hand, Moringa seeds and moringa oil have high oleic acid content, and have fatty acid profile that is comparable to olive oil with the exception of content of linoleic acid [40].

3.6 Nutritional composition:

Moringa oleifera is known for its nutritional and medicinal properties, providing a high concentration of essential nutrients including vitamins, minerals, amino acids and fatty acids. It surpasses other food sources in vit. leaves. C, vit. A, Ca, Fe, and K content [41]. Protein quality is comparable to that of milk and eggs, and immature pods are rich in fiber, protein and amino acids. The leaves of Moringa are especially rich in vitamins C, β-carotene and B vitamins, essential for metabolism and antioxidant properties [42]. Furthermore, Moringa is rich in essential minerals such as calcium, potassium and magnesium, and its seeds contain beneficial fatty acids, which makes it a potential source of food and an alternative to control cholesterol [43].

3.7 Moringa oleifera's chromatographic profile and fluorescence characteristics: The intrinsic fluorescence of Moringa oleifera and its complex chromatographic profile can also be used for fingerprinting of bioactive compounds, a crucial step for the quality control and standardization of the plant in nutritional and pharmaceutical applications [44].

The chromatographic analysis of Moringa using High-Performance Liquid Chromatography (HPLC) and Gas Chromatography-Mass Spectrometry (GC-MS) gives insight to its complex chemical composition. The identified key components are phenolic acids and flavonoids; the chromatograms reveal significant peaks of antioxidant compounds including chlorogenic acid, ellagic acid, gallic acid, rutin and quercetin [45]. Furthermore, the

seeds and leaves from Moringa have exceptional glucosinolate and isothiocyanate profiles, such as moringin. Moreover, the analysis shows that considerable amounts of organic acids, such as citric, succinic, and malic acids, as well as essential amino acids, such as tryptophan [46] are present. This comprehensive profiling highlights Moringa's nutritional and therapeutic benefits. The autofluorescence of Moringa extracts, especially the seeds and leaves, exhibit two prominent fluorescent peaks, one at mid-visible (450–600 nm) and the other at longer red/far-red (650–775 nm) range. Under UV 366 nm light, the powdered extracts from the leaves yield about eight fluorescent bands ranging from bluish to yellow and green, corresponding to the presence of various phytochemicals such as polyphenols and flavonoids including rutin and quercetin [47,48].

4. Pharmacological investigations: It is well known that the M. oleifera tree is used in traditional medicine, both in Ayurvedic and Unani medicine [49]. It has been known for its wide pharmacological properties and used as a medicinal plant and functional food. A variety of parts of the tree namely leaves, roots, seeds, pods, fruits and flowers have been used in the treatment of various common health ailments such as skin infection, anemia, asthma, cough and diarrhea [50]. In recent times, several pharmacological actions have been identified with different extracts of M. oleifera, such as antibacterial, antifungal, anti-inflammatory, anti-oxidant, anti-cancer, fertility and wound healing properties [51].

5. Concluding remarks and perspective points: Moringa oleifera, also known as the miracle tree or drumstick tree, is a quick-growing, drought-resistant plant that is native to the Himalayas. It is known for its wide range of nutritional and medicinal benefits, which are found in all its parts: roots, bark, leaves, flowers, fruits and seeds. The plant has a wide range of beneficial nutritional, medicinal, and bioactive properties. It is used for various medicinal purposes, including the treatment of diabetes, skin infections, respiratory diseases, and cancer. The pharmacognostic profile of Moringa oleifera shows a complex composition of phytochemicals such as alkaloids, flavonoids, and glucosinolates that are responsible for its health benefits. Overall, Moringa oleifera offers promising potential for future research and use in the fields of health and nutrition, thanks to its nutritional and therapeutic benefits. It has demonstrated adaptability to different climatic and soil conditions and is a promising species

to be grown in different parts of the world, contributing to food security and health improvement. Incorporating moringa into the diet may have benefits for public health, especially in developing nations where access to a variety of nutrition is limited.

Conflict of interest: The authors declare no conflicts of interest.

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