



Review Article

Moringa Oleifera: A Nutraceutical Resource with Multifunctional Health Benefits

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Moringa oleifera has numerous common names across regions where it is cultivated, with drumstick tree, horseradish tree, or simply moringa use in English. The genus *Moringa* means “twisted pod” and the specific name *oleifera* derived from Latin words *oleum* “oil” and *ferre* “to bear”. It is short-lived, fast-growing tree belongs to the 13 species of family Moringaceae, it is native to northern India and extensively in South and Southeast Asia. *Moringa* having long, slender, triangular seed pods. It is widely cultivated for its young seed pods and leaves, used as vegetables and for traditional herbal medicine. It used to cure wounds, pain, ulcer, liver diseases, heart diseases, cancer and inflammation and as antioxidant, antimicrobial, anticancer, antihypertensive, hepatoprotective, and nutritional effects. It can a height of 10-12 m (33-39), it tolerates a soil condition as sandy and loamy soil. *Moringa* powder is available in market which use in a place of iron pills to treat anaemia. *Moringa* having high nutritional content which gives most of the health benefits. The phytochemical present in its leaves include flavonoid, alkaloids, tannins, reach phenolic acid and saponins. Its fresh leaves contain high amount of carotenoids.

Keywords: Miracle tree, Tree of Life, Nutritional powerhouse, Natural nutrition for tropics.

INTRODUCTION

The 13 species that make up the *Moringa* family are *M. oleifera*, *M. arborea*, *M. rivae*, *M. ruspoliana*, *M. drouhardii*, *M. hildebrandtii*, *M. concanensis*, *M. borziana*, *M. longituba*, *M. pygmaea*, *M. ovalifolia*, *M. peregrina*, and *M. stenopetala*. Of these, *M. oleifera* has gained notoriety. ^[1] *Moringa oleifera* is nutrient-dense due to the presence of various essential chemicals in its leaves, flower, pods, seeds and root ^[2] Because of its high protein level, vital amino acid, minerals, and fibres content, *Moringa oleifera* is a nutritional powerhouse. Food matrices are improved, but sensory qualities may change ^[3]. *Moringa* is abundant in phytochemicals, bioactive substances, and vital nutrients that have a number of health advantages ^[4]. Comprehensive research on the bioavailability and bioaccessibility of these advantageous moringa leaf constituents is lacking ^[5]. The seeds were employed for medical purposes by the

Indians, who were aware that they contained edible oil. It's likely that the general public was also aware of its potential as a vegetable or fodder ^[6]. This tree grows well at elevations from sea level up to approximately 1,400 m above sea level. It can be found naturally at elevations up to 1,000 m in its native Himalayan foothills. *Moringa* is a fast-growing tree and has been found to grow to 10-12 m height in one year, in areas receiving less than 400 mm mean annual rainfall (Odee, et al., 2001) ^[7] *Moringa* has been used to combat malnutrition, especially among infants and nursing mothers. Trees for Life, Church World Service, and Educational Concerns for Hunger are three nongovernmental groups that have promoted moringa as "natural nutrition for the tropics." Without refrigeration, leaves can be consumed raw or cooked, or they can be kept as a dry powder for several months without losing their nutritious content. Because the tree is in full leaf near the end of the dry season, when other crops are usually in short supply, moringa is

particularly promising as a food source in the tropics (Fahey)^[8]. Treating water and wastewater is arguably the most creative and daring application for this species, which is already multipurpose. Silt and other impurities can be settled using the protein in moringa seeds. According to research conducted in Africa, it can take the place of alum, a costly and typically

imported substance. Although the water still requires a final filter, the seeds prolong the life of water filters and make the procedure simpler and more thorough. Where water-borne illnesses are common and central water treatment facilities are sluggish or non-existent, this could be extremely important (National Research Council)^[9].



Fig 1: Moringa

MORPHOLOGY

The tree prefers a height of 1,400 meters above sea level and grows quickly in loamy, well-drained sandy soils.^[10] The tree is typically modest to medium in size, with naturally trifoliate leaves and blooms that are born on inflorescences that are 10 to 25 cm long.

^[11] The fruits are often called "pods" and are often trifoliate.^[12] Each tree can produce between 15,000 and 25,000 seeds annually, with the brown seeds having a semi-permeable hull, the branches being generally haphazard, the canopy being umbrella-shaped, and the stem being straight although occasionally badly formed.^[13]

1. Leaves



2. Seeds



3. Flowers



4. Pods (Drumstick)



Fig 2: Structure of plant Moringa oleifera

1. Geographical and Botanical Distribution

As a member of the Moringaceae family, moringa is distinguished by its deciduous habit and rapid growth. It usually has tiny, fragrant flowers in groups and has compound leaves with several oblong or elliptical leaflets. The dark-brown seeds inside the long, cylindrical pods, called "drumsticks," are encased in fibrous pulp. This multipurpose tree is an important resource in tropical and subtropical places



Fig 3: Geographical and Botanical Distribution

However, owing to its remarkable adaptability, it is progressively extending its presence to other regions, particularly tropical and subtropical areas affected by drought [16] It grows well in tropical and subtropical climates with temperatures between 25 and 35 °C. [10] Deciduous trees like *M. oleifera* are commonly found in tropical and subtropical climates worldwide.

across the world because it can adapt to a variety of environmental conditions. [14] It is a deciduous tree that grows quickly and comes from Northern India's sub Himalayan highlands. *M. oleifera* is the most widely spread of the 13 species in its genus, especially in tropical and subtropical areas with elevations up to 2000 m. [15] *M. oleifera* is currently mostly found in the Middle East, as well as in a number of African and Asian nations.

[17,18]. It thrives in soil that is slightly acidic to alkaline, in indirect sunshine, and without waterlogging. The tree starts to produce fruit between six and eight months of age. [17] Commercially, it is grown in a variety of nations, including South America, Mexico, Hawaii, and Africa; however, the nutrient content differs from nation to nation due to varying soil conditions. [12]

Table 1: Taxonomical Distribution [12,19,20]

Kingdom	Plantae
Sub kingdom	Tracheobionta
Super division	Spermatophyta
Division	Magnoliophyta
Class	Magnoliopsida
Sub class	Dilleniidae
Order	Capparales
Family	Moringaceae
Genus	<i>Moringa</i>
Species	<i>oleifera</i>

2. Nutritional Properties

M. oleifera is also referred to as the "Miracle Tree" or the "Tree of Life" due to its exceptional nutritional

and health value as well as its favorable environmental effects. Nutrients and antinutrients are present in every part of the plant. Among the minerals found in *M. oleifera* leaves are Ca, K, Zn, Mg, Fe, and

Cu^[21]. Furthermore, beta-carotene contains vitamins C, D, and E along with pyridoxine, nicotinic acid, and folic acid.^[22] Because moringa leaves have a low calorie content, eating them can help lower obesity. Fiber-rich pods can help prevent and treat colon cancer.^[21] The fiber content of immature pods is estimated to be 46.78%, and the protein content is around 20.66%. 30 percent of the amino acids are found in the pods, 44 percent in the leaves, and 31 percent in the flowers. The levels of palmitic, linolenic, linoleic, and linoleic acids did not alter between immature pods and flowers.^[23] Calcium is one of the most crucial elements among the numerous that support moringa growth. Moringa powder has 4000 mg of calcium, more than twice as much as 8 ounces of milk, while moringa leaves might supply 1000 mg. Moringa powder can be used in place of iron pills to treat anemia. Compared to beef's 2 mg of iron, moringa leaf powder has 28 mg. According to a recent study, moringa has more iron than spinach does.^[24] For sperm cells to continue growing properly and for DNA and RNA to be synthesized, zinc must be consumed in adequate amounts. *M. oleifera* leaves contain between 25.5 to 31.03 mg of zinc per kilogram, which is about what an individual needs each day.^[25] According to a recent study, moringa seed oil has around 76% PUFA, which makes it a perfect alternative to olive oil.^[26] Drumstick leaves provide around 252% and 235% of the daily requirements for vitamin A and ascorbic acid, respectively. Compared to the control group, malnourished children who were given 10 g of dry leaf powder of moringa every day reported much higher weight gain and shown indications of healing much more quickly. An excellent source of *M. oleifera*'s anticancer qualities are the phytochemicals present in its leaves, which include flavonoids, alkaloids, tannins, phenolic acids, and saponins.^[27] It was found that whereas vitamin C and iron were abundant during the cold, dry season, vitamin A was abundant during the hot, humid season.^[28] In addition to location and temperature, environmental variables have a considerable impact on trees' nutritional value.^[29] Fresh leaves contain high amounts of carotenoids, including trans-zeaxanthin (about 6%), trans-lutein (30%), and trans-beta-carotene (18%).^[30] Significant amounts of carotenoids, tocopherol (36.9 mg/100 g), and vitamin C (271 mg/100 g) are found in leafy greens. The nutritional content of *M. oleifera*

contains a number of trace antinutrients, including oxalates, tannins, saponins, and phytates.^[31] They are not harmful or poisonous. High dosages may make it difficult to take some supplements, including those containing zinc, iron, calcium, and magnesium. Its seeds and leaves have lower levels of phytate and saponin than those of the majority of legumes, including soybeans. Eating leaves is safer and higher in nutrients because of these features.^[32,33]

3. Moringa Leaves Applied to Food Items For Nutrition

Because of their high nutritional content and inherent antioxidants, moringa leaves can be employed as nutraceuticals to address the challenges of worldwide malnutrition.^[34,35] The addition of moringa leaves considerably raised the nutritional content of a number of baked items. When 5% moringa leaves were added to wheat flour bread, the loaf's protein and crude fiber levels rose dramatically to 54% and 56%, respectively. Other research, however, indicated that the fortified bread's rise in crude fibre was greater (88%) than its increase in protein (17%). The addition of 1%, 3%, and 5% moringa leaf flour increased the fat and protein content of tortilla chips by 50%.^[36] Oleic and linoleic acids made up the majority of the fatty acids in the upgraded tortilla chips. The TPC and antioxidant qualities were significantly increased by adding moringa leaves.^[37] Additionally, studies on microbial food preservation employing fermented foods and moringa leaves have produced positive outcomes. Moringa seed and leaf extract has been demonstrated to have antifungal qualities against strains of *C. gloeosporioides*, *A. alternative*, and *L. theobromae* when added to an edible coating formulation for avocados.^[38] The best-tasting beverages were fortified with 2%. Moringa's health benefits are mostly due to its high nutritional content, which contains protein and antioxidant components composed of vitamins and polyphenols. For these reasons, moringa leaves are vital for a healthy diet and can be used as functional foods.^[39]

4. Pharmacological Uses

According to recent pharmacological research, distinct *M. oleifera* extracts have various pharmacological actions.

Example: Antifungal^[40], Anticancer^[41], antioxidant, antidiabetic, anti-inflammatory^[42], wound healing and antimicrobial^[43].

5. Medicinal Properties

M. oleifera is frequently referred to as a panacea because it may cure over 300 ailments. Moringa is a traditional herbal remedy used by Africans and Indians. The phytochemicals in this medication make it effective. This section reviews the effects of moringa on conditions like cancer and diabetes.

5.1. Antioxidant

Reactive oxygen species damage DNA, proteins, carbohydrates, and cell membranes by oxidizing biological components and suppressing the antioxidant defense system of the cell. This oxidative stress is brought on by a small number of illnesses, including diabetes, heart failure, and hypertension.^[44] Because natural antioxidants are superior to manufactured ones, consumers consistently pick them.^[45] It has been discovered that a variety of organic solvents, including leaf extracts and acetone, chloroform, dichloromethane, diethyl ether, methanol, water, and ethyl acetate, has antioxidant qualities.^[46,47,48] The hydroalcoholic fraction of moringa leaves was used to generate topical formulations (gel and nanoparticles) by Alvarez-Roman and colleagues, and the phytochemical profile's moisturising and antioxidant qualities were evaluated. The formulations were deemed eligible for usage as formulations due to their appropriate viscosity, pH, and particle size. Seven different compounds, including flavonoids and phenolic acids, were found. Also, the enhanced antioxidant activity of this formulation and the favorable skin biophysical evaluation outcomes may be leveraged to create a unique approach to administering skin treatments.^[49] Their study examines three distinct diets: goat fodder at 25%, *M. oleifera* leaves at 25%, and alfalfa alone. Ten goats participated in each trial, which included two weeks for adaption and six weeks for data collecting. Goats fed either variety of drumstick leaves exhibited increased content of fat that was free of total phenols and nitrogen extract when compared to goats fed only alfalfa. Saleem et al. (2020) investigated the in-silico antioxidant potential of

several moringa leaf extracts at doses ranging from 0.1563 to 5 mg/ml.^[50]

5.2. Antimicrobial activity

Because disease-resistant strains are becoming more common and causing more fatalities worldwide, more and better antimicrobial drugs need to be developed.^[51,52] This is why there has been a rise in the usage of medicinal plants because of their superior health philosophy and lack of adverse drug reactions. *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*, *B. subtilis*, *S. typhi*, *P. vulgaris*, *K. pneumonia*, *Micrococcus* species, and *Helicobacter pylori* have all been investigated for their antibacterial efficacy against *M. oleifera* leaf extracts^[53-56] *P. aeruginosa* has outstanding antibacterial activity in all other situations, but *P. oleifera* is the only pathogen that aqueous leaf extract is unable to eradicate. Numerous phytochemicals give leaves their antimicrobial qualities.^[53] In contrast, *Staphylococcus aureus*, *E. coli*, and *Bacillus subtilis* were all susceptible to the aqueous extract of moringa leaves (MIC: 0.78, 0.78, and 1.56 mg/mL, respectively). Strong antibacterial action against these illnesses was also demonstrated by ethanol and acetone extracts from the leaves. In order to test the antibacterial properties of several solvents, including methanol, water, acetone, ethanol, and ethyl acetate,^[57] *Fusarium oxysporum* (9.4, 0.71 mm), *Aspergillus flavus* (12.4, 0.55 mm), *Penicillium italicum* (10.5, 0.26 mm), *Anternaria* sp. (6.6, 0.26 mm), *Aspergillus niger* (15.2, 0.52 mm), and *Rhizopus stolonifera* (13.2, 0.58 mm) were all successfully eliminated by an aqueous extract of moringa leaves. According to some research, *M. oleifera* leaf extract inhibits or evades the disease's defense mechanisms, which halts microbial development and aids in its eradication.^[29]

5.3. Anticancer properties

Every year, seven fatalities from the common disease cancer are ascribed to inappropriate medicine. There are 2.4 million incidences of cancer in India, yet no known cause has been identified. The condition is caused by a number of causes, including smoking, radiation exposure, and inactivity.^[58] Surgery, radiation, and chemotherapy are costly procedures with unintended consequences. *M. oleifera* is a safe, dependable, and natural anticancer drug at known

concentrations. Moringa is a strong antiproliferative that stops the growth of cancer cells. When leaves are soluble or solvent extracted, they work well as anticancer agents. The emission of reactive oxygen species from malignant cells may be a key factor in the antiproliferative effects of cancer. Cells undergo apoptosis as a result of reactive oxygen species. Furthermore, two crucial pathways—caspase 3 and caspase 9—are activated during apoptosis. [59-61] However, it has been shown that extracts from moringa leaves have both anti-cancer and antioxidant qualities that produce ROS. Regarding the leaves' contradicting traits, there are still unanswered concerns. The precise interaction between the leaves' two opposing characteristics is still unknown. The leaves also contain benzyl isothiocyanate, which is known to have anticancer effects in addition to glucosinolates and niazimicin.[62] Cancer is considered a major cause of mortality worldwide, accounting for one in six fatalities.[63]

5.4. Antidiabetic properties

In another study, the antidiabetic benefits of moringa leaves were tested in male albino rats' parotid glands. A dose of 200 mg/kg body weight of moringa extract was administered orally for three weeks. After receiving a moringa treatment, rats were given a large dose of halothane to induce sleep, and many parotid gland examinations were performed. Blood sugar levels were significantly reduced. Through the use of optical microscope, it was possible to see that after being damaged by diabetes, which also resulted in inner vacuolization and pyknotic nuclei, acinar cells had started to proliferate and regain their previous morphologies. Rats treated with *M. oleifera* had lower vesicles and significantly more simultaneous cisternae than control rats, which had irregular rough endoplasmic reticulum topologies and many vacuoles. In the comet experiment, rats given moringa exhibited a much lower tail moment, indicating less DNA damage. [64,65] The primary factors influencing the hypoglycemia index are bioactive substances and a high fiber content. The increased amount of fiber slowed down the absorption of glucose in the intestine and the time it took for the belly to empty, in contrast to secondary metabolites, which are responsible for the metabolism of

carbohydrates and inhibit the enzymes b-glucosidase and amylase.

6. Formulation of Moringa Oleifera

Researchers discovered that raw and germinated moringa seed flours had greater levels of phytochemicals, while fermented and germinated moringa seed flours had higher levels of amino acids. Most plants lose nutrients when they are treated. [66,67] Microbial, biochemical, and germination processes can all play a part in this. In order to determine if nutrients were maintained after boiling, simmering, and blanching moringa leaves, this study was conducted. Except for boiling, which decreased them more than the other two methods, there was no change in the amounts of cyanide, oxalate, or phytate between the two methods. When phytate and other antinutrients are present, plants can often absorb more nutrients from their seeds and leaves. [68,69] According to Yang et al. [70], boiling raises the amount of iron and antioxidants. Therefore, moringa seed flour can be used to address nutritional issues. Some studies have found that children avoid eating moringa because of its somewhat bitter taste. Therefore, moringa seed flour can be used to address nutritional issues. Some studies have found that children avoid eating moringa because of its somewhat bitter taste. [71] There are three methods for cooking moringa noodles: boiling, steaming, and sautéing. Kiranawati and Nurjanah suggested three ways to make noodles. [72] Rats were used in the study to examine the effects of these noodles on their mammary glands. When rats ate sautéed noodles, their mammary glands generated more milk. The lactogogum properties were enhanced by sautéing the noodles because of the oil's high insterol concentration. Chocolates manufactured from *M. oleifera* have also been produced. A research that examined various percentages of moringa inclusion revealed that 20% was the ideal amount to use to strengthen cocoa powder. The nutrients in halawa tahinia are comparable to those in Omoringa. Researchers have shown that high protein and mineral content chocolate and Halawa tahinia can be produced (Abou-zaid & Nadir, 2014) [73]. There are many moringa fortifications available to ensure youngsters are getting enough nutrients. Following figure 1 shows processing of *M. oleifera*. [74-84]

1. Harvesting and Selection**2. Drying****3. Grinding of dry leaves****4. Sieving****5. Final product/ Extra****CONCLUSION AND FUTURE PERSPECTIVES**

Phytochemistry, phytopharmaceutical formulations, clinical investigations, toxicity, ethnopharmacology, pharmacology activities, global research, and other unspecified factors are all summarized in the review. The therapeutic properties of *M. oleifera* are caused by the presence of alkaloids, phenolic acid, glycosides, sterols, glucosinolates, flavonoids, terpenes, and fatty acids. Furthermore, *M. oleifera* is abundant in substances like vitamins, minerals, and carotenoids, which boost its therapeutic potential and popularity as a superfood. According to pharmacological research, the plant's active ingredients have successfully treated a number of illnesses, including cancer, neuropathic pain, diabetes, hypertension, and obesity. However, the potential therapeutic advantages of a number of phytochemicals have not yet been investigated. Apart from its clinical application, the plant is also utilized by farmers as a successful bio-stimulant in their fields and has shown itself to be an affordable substitute. According to a review of the literature, a lot of preclinical research has been done recently. The effectiveness of the plant in treating serious illnesses including coronavirus epidemics, AIDS, and different types of cancer will need to be further studied in clinical settings. Additionally, more mechanism-based research is suggested to investigate the plant's

mechanistic strategy for locating and isolating active or synergistic chemicals. All things considered, *M. oleifera* lives up to its moniker as the "Miracle tree" and seems to be a phytopharmaceutical and functional food that, if taken regularly, may help treat a number of chronic illnesses in people. It may also be utilized by doctors as a safer option to treat a number of conditions.

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Cite: Nitin Mahale, Santosh Ghule, Ajay Bhagwat, Virendra Phatekar*, Nandini Shinde, Sujal Yadav, Swapnil Auti, Moringa Oleifera: A Nutraceutical Resource with Multifunctional Health Benefits, *Int. J. Med. Pharm. Sci.*, 2025, 1 (11), 132-143. <https://doi.org/10.5281/zenodo.17656574>