

# Moringa oleifera: A Nutraceutical Powerhouse with Multifunctional Pharmacological and Nutritional Potentials

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**Abstract-** *The miracle tree Moringa oleifera, has a great commercial importance, and is known for its nutritional and medicinal values. An indigenous plant of the Indian subcontinent stretching from the western desert region of India, Pakistan, Afghanistan and Bangladesh as well as east to the Himalayan foothills, cultivated in tropical and sub-tropical area, Moringa has become recognized as an important source of essential nutrients and bioactive molecules. Its parts such as leaves, seeds, and pods, have been used in food, traditional medicine, cosmetic products and water treatment. The plant is a rich source of protein, vitamins, minerals, and phytochemicals including flavonoids, phenolic acids, alkaloids, and glucosinolates, which together impart its antioxidant, anti-inflammatory, antimicrobial, antidiabetic, and anticarcinogenic activities. Because of its drought resistance and rapid growth, Moringa oleifera has also proven to be a valuable weapon in the fight against malnutrition and food insecurity in impoverished areas. This review provides an overview of the therapeutic properties, nutritional values, and diverse uses of Moringa oleifera which render it crucial in traditional and modern health systems.*

**Indexed Terms-** *Moringa oleifera, Phytochemicals, Nutraceuticals, Medicinal Plants, Pharmacological Activities, Functional Foods*

## I. INTRODUCTION

Plants have been historically used as a cornerstone of traditional medicine and indigenous health care throughout the world, particularly in developing countries where the availability of allopathic drugs is scarce. It is estimated that more than 80% of the world population depends on medicinal plants as their main source of healthcare indicative of the value of these plants in traditional culture and therapeutic applications [1-3]. Of these, *M. oleifera* has been growing in interest because of its potential uses in nutrition, medicine and environmental management.

*Moringa oleifera* is commonly referred to as the drumstick tree, horseradish tree, or the miracle tree, and it is a member of the family Moringaceae. Native to India, the acai palm tree is commonly grown in tropical climates throughout the world, including Africa, Asia and Latin America. The plant's exceptional drought tolerance and tolerance of poor soils, along with a rapid growth rate, qualify it as a good candidate for marginal agricultural lands [4].

The leaves, seeds, pods, flowers, roots, and bark of the *Moringa* have been used in ethnomedicine as a remedy against inflammation, infections, anemia, diabetes, and gastrointestinal ailments, among others traditions [4]. The plant has also been applied to water treatment and animal feed as a consequence of such multifunctionality [5].

Such studies have shown that *Moringa oleifera* is a nutrient-rich edible tree, containing significant

amounts of essential amino acids, vitamins (including vitamin A, C and E), minerals (including calcium, potassium and iron). Its phytochemical composition contains flavonoids, phenolic acids, alkaloid s, glucosinolates, tannins, and saponins that contribute to its pharmacological activities carcinogenesis, antioxidant, antimicrobial, and anti-inflammatory [6].

*Moringa oleifera*, with its wide spectrum of medicinal utility and tolerance to diverse agro-climatic conditions, is a potential botanical panacea to tackle malnutrition, immune health and integrated healthcare interventions. The present review is an effort to provide a detailed and comprehensive analysis of the botany, traditional uses, phytochemistry, pharmacology as well as nutritional and medicinal and nutritional value of *Moringa oleifera* with special emphasis on various parts of the moringa tree as of exceptional source of bioactive components for modern drug discovery and development as well as the status of *Moringa oleifera* as a “miracle tree” in traditional folk medicine.

## II. BOTANICAL DESCRIPTION

*Moringa oleifera* Lam. is a fast-growing deciduous tree that is usually found in the foothills of the Himalayas of northern India. It is a member of the family Moringaceae, and consists of 13 species known so far, of which *M. oleifera* is the most commonly cultivated for nutritional and therapeutic purposes [7].

The tree grows to a height of 5 to 10 meters, and is identified by its softwood stem, low crowns and profuse branching. It has tripinnate leaves, compound in alternate syllables, having leaflets that are oval and have a high protein and micronutrient content. They are white to cream in colour, sweet smelling, bisexual, oriented in lax clusters that attract pollinators bees [8].

The tree bears long, green slender pods (fruits) which is commonly known as “drumsticks” and the pods can grow up to 45 cm long. The pods have many round seeds that are covered in a triangular wing. These seeds are oily and coagulant, and, therefore, can be used in water treatment applications [9].

*Moringa* is a drought tolerant species that prefers loose soil with good drainage, sandy or loamy, a friable and a good loamy to loose soil type and it can grow in soils that will range in acidity from neutral to slightly acidic. It is also heat tolerant and needs little additional watering once it is established. These characteristics make it the perfect crop for semi-arid and marginal resource areas [10].

The adaptability, fast biomass production and year-long leafing of *Moringa oleifera* have facilitated integration of the tree system in different agro-ecological zones, e.g., agroforestry systems, home gardens and re-afforestation projects aimed at fostering food and environmental security.

## III. NUTRITIONAL COMPOSITION

*Moringa oleifera* is considered as one of the most nutrient-rich plants yet discovered because it contains a unique combination of numerous essential elements needed by human beings. Its leaves, seeds, and pods are particularly rich in macronutrients and micronutrients, rendering it an important supplement for the treatment of malnutrition, particularly in low-income countries [11].

Its leaves, eaten fresh or dried and ground into a powder, are powerhouses of protein, with all the essential amino acids. They also provide substantial levels of vitamins A, B-complex, C, D, and E, and minerals like calcium, potassium, magnesium, iron, zinc, and phosphorus [12]. *Moringa* leaves are most surprisingly rich in: 7 times more vitamin C than oranges, 4 times more vitamin A than carrots, 4 times more calcium than milk, 3 times more potassium than bananas, and 2 times more protein than yogurt per gram of dry weight [13].

The pods, which are most frequently consumed although they are also used in traditional medicine, are also of nutritional interest, though some micronutrient concentrations are lower in the pods than in the leaves. But they are a great source of fiber and Vitamin C.

The seeds of *moringa* have 30–40% and it is rich in oleic acid, a mono-unsaturated fatty acid that has been recognized for good effect on cardiovascular health.

The oil, commonly known as “ben oil” is of the same quality as olive oil and is employed as cooking oil, in cosmetic, medicated preparations, traditional medicine [14].

Not just the macronutrients and vitamins, Moringa is a powerhouse of antioxidants including quercetin, chlorogenic acid and beta-carotene. They are also crucial for scavenging free radicals, defending against oxidative stress, and maintaining cellular health [15].

Owing to its well-balanced nutritional composition, Moringa oleifera has been used for making functional foods, nutraceuticals, and therapeutic nutrition programs especially in food-insecure countries facing micro-nutrient deficiencies.

#### IV. PHYTOCHEMICAL COMPOSITION

Moringa oleifera is one of the most popular medicinal plants prized for its phytochemical content, which include variety of bioactive components that are responsible for majority of its therapeutic and health preventive properties. These secondary metabolites are found in different parts of the plant such as leaves, seeds, bark, pod, root in the form of alkaloids, flavonoids, tannins, saponins, glucosinolates, phenolic acids, terpenoids etc [16].

Among these, flavonoids play an important role, in particular quercetin, kaempferol and myricetin, which have a significant antioxidant, anti-inflammatory, and anticancer effect. These derivatives contribute to neutralizing reactive oxygen species and attenuating oxidative stress in biological systems [17].

The plant also contains phenolic acids including chlorogenic acid, caffeic acid and gallic acid that maximizes its antioxidant potential. These phenolics have been related to cardioprotective, neuroprotective and anti-diabetic effects [18].

Glucosinolates and its degradation products (especially isothiocyanates, e.g.w.glucosinolates glucosinolates isothiocyanates...mcsa glucosinolates seed-storage source of aliphatic nitrogen containing compounds and are toxic to pests) are present in leaves and seeds as a source of aliphatic

nitrogen containing compounds and toxic to pests and they display antimicrobial, anticancer and detoxifying activities. These compounds have structural resemblance to those present in cruciferous vegetables and are found promising in chemopreventive investigations [19].

Alkaloids, including moringinine, are concentrated in the roots and produce sympathomimetic effects. While for the saponins and tannins found in the leaves and bark have anti-microbial, antidiabetic, cholesterol lowering and anti-parasitic effects [20].

Furthermore, the plant also encompasses amino acids, fatty acids and sterols such as  $\beta$ -sitosterol that have made significant impact as a nutraceutical and functional food product. Taken together, these phytochemicals interact synergistically to generate several health benefits.

With improved analytical methodologies, new phytochemicals continue to be discovered in Moringa oleifera and these may aid drug discovery and the propagation of herbal formulations in modern pharmacology.

#### V. PHARMACOLOGICAL ACTIVITIES

It was reported for a long time that Moringa oleifera possesses a variety of pharmacological effects that could be attributed to its multi-component phytochemical contents. The bioactive principles in the seeds, leaves, bark, and roots possess anti-inflammatory, antimicrobial, antioxidative, antidiabetic, antiulcer, anticancer, and hepatoprotective activities [21].

##### 5.1 Antioxidant Activity

The antioxidant capacity of Moringa is mostly ascribed to its richness in flavonoids, phenolic acids, and carotenoids. These molecules function as antioxidants that scavenge free radicals, preventing deterioration of cell structures and slowing ageing and the process of developing degenerative diseases [22]. Both aqueous and ethanolic leaves extracts have exhibited remarkable in vitro radical-scavenging activity.

## 5.2 Antimicrobial Properties

*Moringa oleifera* has been found to be active against a wide range of bacteria and fungi, including *Escherichia coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and *Candida albicans*. Seeds and leaves are also particularly rich in antimicrobial compound such as isothiocyanates and pterygospermin which cause perturbation of the microbial cell membrane [23].

### 5.3.1 Anti-Inflammatory and Analgesic Drug-Loading with $\alpha$ -LA Mitigation of inflammation and pain have been of great concern to the medical community for centuries, but until now, they have not been fully cured or treated effectively [16, 69].

It has been reported that *Moringa* leave and bark extracts reduced inflammation and pain via controlling inflammatory mediators including COX-2, TNF- $\alpha$ , and IL-6. These effects have been confirmed in animal models with paw edema and tail-flick assays [24].

## 5.4 Antidiabetic Activity

Hypoglycemic effects of *Moringa* have been evident in experimental and clinical conditions. The leaf and seed extracts lower blood glucose and enhance insulin sensitivity and  $\beta$ -cell protection. Compounds such as chlorogenic acid and quercetin are thought to be responsible for this antidiabetic effect [25].

## 5.5 Anticancer Potential

The anticancer activity could be attributed to its bioactive compounds such as niazimicin, benzyl isothiocyanate and quercetin. These molecules are cytotoxic towards multi-forme human cancer cell lines by apoptotic cell death, inhibition of cell proliferation, and angiogenesis inhibition [26].

## 5.6 Hepatoprotective and Cardioprotective Action

*Moringa oleifera* has been reported to be hepatoprotective against paracetamol-induced changes in levels of liver enzymes and regeneration of hepatocytes. It is cardioprotective through lipid

lowering and the regulation of blood pressure by virtue of its antihypertensive and antioxidative effects [27].

## 5.7 Other Activities

Furthermore, *Moringa* also possesses immunomodulatory, neuroprotective, antiulcer, antihelminthic and diuretic properties. These pharmacological effects render *Moringa oleifera* as a broad flexible candidate for integrative medicine and development of phytomedicine [28].

## CONCLUSION

*Moringa oleifera* is among the most versatile and promising medicinal plants in traditional and complementary alternative medicine. Its rich nutritional profile as well as a wide variety of bioactive phytochemicals allows it for varied health supporting potential. The plant is replete with well documented antioxidant, antimicrobial, antidiabetic, anti-inflammatory, anticancer and hepatoprotective properties and has huge therapeutic prospect.

Apart from its therapeutic utility, *Moringa* has ecological and economical significance because of its rapid growth even in drylands and marginal soils. Proper cultivation of the crop has potential to contribute to food security, help fight malnutrition and promote sustainable agriculture, especially in developing countries.

Due to its abundant phytochemicals and nontoxic nature, *Moringa oleifera* is now incorporated in nutraceuticals, herbal medicines, and functional foods. But, further clinical trials, toxicological investigations, and standardization guidelines are required to completely utilize the medicinal properties of the plant and also to apply safely in current healthcare practice.

To conclude, *Moringa oleifera* continues to be an attractive natural resource—aptly also called a “miracle tree”—providing panoply of opportunities for health, nutrition, and sustainable development.

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