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Moringa oleifera: A Comprehensive Review of Its Nutritional Value and Medicinal Potential

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ABSTRACT

Moringa oleifera is a versatile, nutritionally rich plant that has attracted global attention for its exceptional nutritional value and wide range of medicinal applications. Commonly known as the drumstick tree, horseradish tree, or miracle tree, *M. oleifera* is widely distributed across tropical and subtropical regions of the world. The plant is highly adaptable, capable of withstanding severe drought and mild frost, which has contributed to its extensive cultivation. *Moringa oleifera* is a small to medium-sized tree, typically growing 5–10 m in height, and almost every part of the plant is utilized for nutritional or medicinal purposes. This seminar paper is a narrative review based exclusively on secondary data obtained from published scientific literature and other reliable sources. Beyond being a rich source of proteins, vitamins, essential oils, fatty acids, macro- and micro-minerals, and phenolic compounds, *M. oleifera* has been reported to exhibit a broad spectrum of pharmacological activities, including anti-inflammatory, antidiabetic, antimicrobial, antioxidant, anticancer, cardioprotective, anti-ulcer, diuretic, and antiurolithiatic effects. These diverse therapeutic properties underpin its extensive use in traditional medicinal systems for the management of various diseases. The accumulated evidence highlights *M. oleifera* as a promising medicinal plant with significant potential for incorporation into modern healthcare systems. Further scientific investigation, including clinical and pharmacological validation, is warranted to fully elucidate its therapeutic efficacy and safety. This review underscores the need for a systematic and evidence-based appraisal of *M. oleifera* to establish its pharmaceutical potential in contemporary medicine.

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Introduction

Shajna, scientifically known as *Moringa oleifera*, is an herbal remedy that goes by various names such as the horseradish tree, drumstick tree, ben oil tree, miracle tree, and mother's best friend. It is renowned for its versatility, ability to thrive in various conditions, and straightforward cultivation (Fakir et al., 2017). Moringa, with its nutrient-rich leaves, pods, and flowers, offers benefits to both humans and animals, making it a valuable resource for addressing malnutrition. It is referred to be a miracle tree due to its many health benefits, such as having 15 times more potassium than bananas and 15 times more calcium than milk. It also has 7 times more vitamin C than oranges and 10 times more vitamin A than carrots,4 times more protein than found in eggs, and 9 times more protein than contained in yogurt (Islam et al., 2021). It serves as a reservoir of medicinal compounds and contains highly nutritious elements, including protein, amino acids, carbohydrates, minerals, vitamins, and organic acids. Moringa leaves are anti-bacterial and anti-inflammatory. Leaf tea can be used to alleviate gastric ulcers and diarrhea, while Moringa leaves are excellent dietary options for individuals dealing with malnutrition because they are rich in protein and fiber (Oduro et al., 2008). *Moringa oleifera* is utilized in various forms as vegetable, herbal tea, and processed foods due to its nutritional value, providing proteins and vital amino acids such as cysteine, methionine, lysine, and tryptophan (Stadtlander & Becker, 2017). Additionally, *Moringa oleifera* contains significant amounts of flavonoids, carotenoids, and ascorbic acid. Furthermore, this herbal product has shown health advantages that extend beyond its exceptional nutritional content (Anwar et al., 2005).

Millions of patients are hospitalized each year due to adverse drug reactions throughout the world. In contrast, when it comes to natural herbal products, despite their long history of use, there have been very few reported instances of such adverse reactions. Plants stand out as one of the most valuable resources for medications, food supplements, and nutraceuticals (Tiwari *et al*., 2011). Therefore, in traditional medicine, historical guidelines have recommended the use of *Moringa oleifera* leaves for their advantageous effects on mental well-being and maintaining healthy skin. Furthermore, *Moringa oleifera* has been associated with a wide range of therapeutic uses in both laboratory and living organism experiments, including antibacterial, antifungal, antiviral, cytotoxic, antihyperglycemic, antioxidant, anti-inflammatory, antiparasitic, and heart-protective properties (Dhakad et al., 2019). Additionally, numerous clinical investigations have explored the pharmacological impact of *Moringa oleifera* in the treatment of conditions such as metabolic syndrome, type 2 diabetes mellitus, osteoporosis, anemia, and dyslipidemias. Nevertheless, despite its significant nutritional and therapeutic benefits, *Moringa oleifera* leaves have not gained as much popularity as other leafy greens, and there remains untapped potential in exploring its pharmacological properties, especially regarding its potential as a neuroprotective agent. It exhibits notable effects in lowering blood lipid levels, reducing blood pressure, promoting weight loss, aiding in digestive regulation, safeguarding the liver against the effects of alcohol, and boosting overall immune system function (Liang et al., 2019). This remarkable plant possesses extraordinary medicinal attributes that have the potential to address healthcare requirements in various scenarios. Its ability to thrive in challenging environmental conditions and its widespread accessibility make it a noteworthy candidate for both economic and health-related opportunities in resource-constrained developing nations. This review focuses on the pharmacological properties of *Moringa oleifera* and its medicinal applications in traditional and modern healthcare systems.

Topographical Sources and Distribution of *Moringa oleifera*

Moringa oleifera (MO) belongs to a plant family called Moringaceae and comprises 14 different species of flowering plants. Among these, *Moringa oleifera*, also commonly referred to as the "immortal tree," stands out for its significant therapeutic properties and has been extensively studied. Moringa is one of the most valuable medicinal plants that can be used as a source of micronutrients to treat various illnesses (Swati et al., 2018). *Moringa oleifera* is a perennial tree that thrives in tropical and subtropical regions, including Bangladesh. In

this country, it is not typically grown as a primary agricultural crop. Instead, numerous households choose to cultivate a few to several moringa trees in the vicinity of their residences. Additionally, moringa trees are commonly planted alongside roads, in backyard spaces, and on unused land that is not dedicated to rice cultivation (Fakir et al., 2017). *Moringa Oleifera* (MO) is originally from the Himalayas in North-Western India, specifically in the Sub-Himalayan region extending from the Chenab River to the Sarda River in the east, and into Uttar Pradesh, India. Over time, this plant has been introduced and cultivated in various parts of the world, including Bangladesh, Malaysia, the Philippines, Singapore, Sri Lanka, Cuba, Burma and Africa. (Swati et al., 2018).

Figure 1. Topographical distribution of *Moringa Oleifera*

Table 1. Moringa Nutrition Content

Nutrition analysis	Pods (per 100g)	Fresh leaves (per 100g)	Dried Leaves (Per 100g)
Moisture %	86.9	75	7.5
Calories	26	92	205
Protein (g)	2.5	6.7	27.1
Fat (g)	0.1	1.7	2.30
Carbohydrate (g)	3.7	13.4	38.2
Fiber (g)	4.8	0.9	19.2
Minerals (g)	2	2.3	-
Calcium (mg)	30	440	2003
Magnesium (mg)	24	24	368.0
Phosphorous (mg)	110	70	204.0
Potassium (mg)	24	24	1324

Table 1. Moringa Nutrition Content (contd.)			
Copper (mg)	3.1	1.1	0.6
Iron (mg)	5.3	0.7	28.2
Oxalic acid (mg)	10	101	0.0
Sulfur (mg)	137	137	870

Source: Abrams et al., 1993

Moringa as a nutrient source:

Moringa oleifera is a plant where every component contains significant nutrients and also some compounds that can affect nutrient absorption. The leaves of *M. oleifera* are abundant sources of essential minerals such as calcium, potassium, zinc, magnesium, iron, and copper (Table 1) (M. N. Somchit, 2012). *Moringa oleifera* contains a variety of vitamins, including beta-carotene (a precursor to vitamin A), various B vitamins like folic acid, pyridoxine, and nicotinic acid, as well as vitamin C, D, and E (Mbikay, 2012). Phytochemicals found in the substance include tannins, sterols, terpenoids, flavonoids, saponins, anthraquinones, alkaloids, and reducing sugars. Additionally, there are anti-cancer substances such as glucosinolates, isothiocyanates, glycosides, and glycerol-1-9-octadecanoate in the mixture (Berkovich et al., 2013). Its leaves also have a low calorific value and can be used in the diet of the obese.

Moringa as a source of vitamins and minerals

Moringa oleifera contains a variety of vitamins, including vitamin A (in the form of beta-carotene), vitamin B (comprising folic acid, pyridoxine, and nicotinic acid), vitamin C, vitamin D, and vitamin E. Vitamins and Minerals are required for everything from building our physical bodies to blood coagulation and energy production (Table 2) (Mbikay, 2012b).

Table 2. Vitamin and mineral Content of Moringa

Vitamin Content (per 100 g)	**Fresh leaves**	**Dried leaves**
Carotene (Vit. A) (mg)	6.78	18.9
Thiamin (B1) (mg)	0.06	2.64
Riboflavin (B2) (mg)	0.05	20.5
Vitamin C (mg)	220	17.3
Calcium (mg)	440	2003
Copper (mg)	0.07	0.57
Iron (mg)	0.85	28.2
Magnesium (mg)	42	368
Potassium (mg)	259	1324
Zinc (mg)	0.16	3.29

Soure: Anwar & Bhanger, 2003

Moringa as a source of protein

Moringa trees are known to overcome protein deficiency in developing countries as the leaves and other parts of the tree contain a high amount of crude proteins and amino acids compared with soybeans. Moringa leaves contain all of the essential amino acids, which are the building blocks of proteins (Table 3) (T. Lockett, 2000; Chandra Babu, 2000).

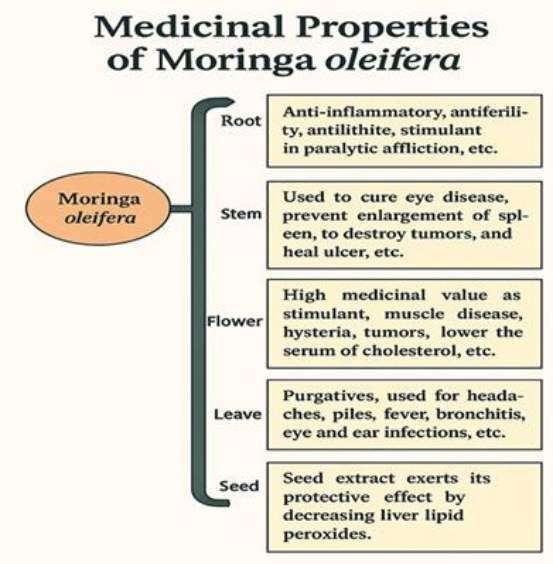
Table 3. Moringa protein content

Amino acid content (per 100 g)	Pods	Fresh leaves	Dried leaves powder
Arginine (mg)	360	406.6	1325
Histidine (mg)	110	149.8	613
Lysine (mg)	150	342.4	1325
Tryptophan (mg)	80	107	425
Methionine (mg)	140	117.7	350
Theroine (mg)	390	117.7	1188
Leucine (mg)	650	492.2	1950
Isoleucine (mg)	440	299.6	825
Valine (mg)	540	374.5	1063

Source: Abrams et al., 1993

Medicinal Applications of *Moringa Oleifera*:

Every part of the *Moringa oleifera* tree finds valuable applications in traditional medicine and nutrition worldwide. Various ailments have been effectively addressed using different components of the tree. For instance, rubbing Moringa leaves on the forehead can alleviate headaches, while applying fresh leaf poultices can stem bleeding from minor cuts, thanks to their inherent antibacterial and anti-inflammatory properties. Extracts derived from Moringa are useful in treating bacterial and fungal skin issues. Consumption of Moringa as a dietary supplement is especially beneficial for those grappling with malnutrition due to its rich protein and fiber content. In traditional medicine, the bark is boiled with potash to alleviate toothaches, and the seeds, when ground and ingested, are believed to have potential benefits against HIV. Moringa seeds are further employed for their antibiotic and anti-inflammatory attributes to address conditions such as arthritis, rheumatism, gout, cramps, sexually transmitted diseases, and boils. Roasted and pounded seeds, when mixed with coconut oil, can be topically applied to problem areas for relief (Bashir & Mohammed, 2014).



Source: Swati et al., 2018

Figure 2. Widespread therapeutic applications of different components of *Moringa oleifera*

Moringa Oleifera as an Anticancer Agent

Cancer is a prevalent ailment, with one in seven fatalities linked to inadequate treatment. Multiple factors, including smoking, insufficient physical activity, and exposure to radiation, can contribute to the onset of this condition (Nair, 2015). Cancer therapies, such as surgery, chemotherapy, and radiation, come with high costs and potential side effects. *Moringa oleifera* presents a natural, dependable, and safe alternative for anticancer purposes when used at established concentrations. Many anticancer agents work by inducing Reactive Oxygen Species (ROS) to target cancer, but it's crucial that these substances are also capable of inhibiting antioxidant enzymes (Liou & Storz, 2010). The compounds responsible for the anticancer properties in the leaves include glucosinolates, niazimicin, and benzyl isothiocyanate (Table 4) (Hermawan et al., 2012).

Table 4. *Moringa oleifera* content as anti-cancer

No	Content	Function
1	Glukosinolate	Slows carcinogenesis and promotes detoxification from carcinogens, antiinflammatory, anti-tumor.
2	Three bioactive components: • 4-(α-L-rhamnosyloxy) Benzyl isothiocyanate • Sitosterol-3-O-β-D-glucopyranoside • Niazimicin	Preventing the development of cancer cells and proliferation.
3	ITC type MIC-1	MIC-1 can leads to the failure of numerous transcription factors to prevent the onset and development of inflammation when they are activated.
4	Quinic acid, octadecanoic acid, hexadecanoic acid (palmitic acid), α-tocopherol (vitamin E) and G-sitosterol	Potentially inhibits tumor development as a cancer therapeutic drug, without altering normal bodily physiology and function.

Source: Adam et al., 2023

Moringa Oleifera as an Antidiabetic Agent:

Moringa has demonstrated potential in the management of both Type 1 and Type 2 diabetes. In Type 1 diabetes, patients face a deficiency in insulin production, a hormone crucial for regulating blood glucose levels. Type 2 diabetes, on the other hand, is linked to insulin resistance and can also be attributed to Beta-cell dysfunction, where these cells fail to effectively sense glucose levels, leading to reduced insulin signalling and elevated blood glucose levels (Cerf, 2013).

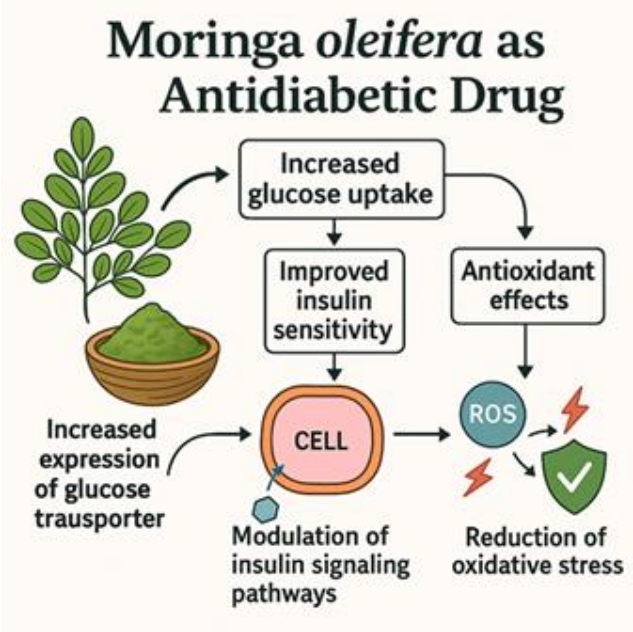


Figure 3. Moringa as an antidiabetic drug and it's mode of action

Effect on Antioxidant Enzymes Activities

The vital defense system against free radical hinges on antioxidant enzymes. This system primarily involves three enzymes: catalase (CAT), superoxide dismutase (SOD), and glutathione peroxidase (GPx). SOD is responsible for converting the superoxide anion radical into hydrogen peroxide. Meanwhile, CAT and GPx facilitate the breakdown of hydrogen peroxide, with GPx transforming it into water and CAT into both water and oxygen (Weydert & Cullen, 2010). In Figure 8 of the study conducted by González-Burgos et al. in 2021, it was observed that the activity of antioxidant enzymes underwent a significant decline, with a 53% decrease for CAT, 51% for SOD, and 65% for GPx when compared to cells with no extract (considered as 100%). However, prior treatments with Moringa extracts successfully reversed this decline in the body's defense system. Notably, for catalase, a substantial increase was noted at concentrations of 10 and 25 µg/mL, showing a boost of 82.9% and 81.2%, respectively. As for SOD and GPx, all three tested concentrations substantially enhanced the activity of these enzymes. The ability of Moringa to enhance the activity of antioxidant enzymes strongly suggests that its polyphenols directly exert antioxidant effects (Almeida et al., 2016).

***Moringa Oleifera* as an Anti-Inflammatory Agent:**

Inflammation is a natural bodily reaction that serves to safeguard against infections and facilitate the healing of damaged tissues (Ariel & Serhan, 2007). Nevertheless, prolonged and persistent chronic inflammation can give rise to the emergence of conditions and illnesses linked with chronic inflammation, including diabetes, cancer, autoimmune disorders, cardiovascular diseases, sepsis, colitis, and arthritis (Bhatelia et al., 2014) (Aggarwal, 2004). Inflammatory cytokines such as interleukin-1 beta (IL-1β) and tumor necrosis factor alpha (TNF-α) have the ability to elevate the synthesis of nitric oxide (NO) and prostaglandin E2 (PGE-2), thereby promoting the expression or intensifying the activity of inducible nitric oxide synthase (iNOS), cyclooxygenase-2 (COX-2), and microsomal PGE synthase-1 (mPGES-1) in target cells (Kou et al., 2011). Moringa oleifera has been shown to reduce the production of TNF-α, IL-6, and IL-8 in human monocyte-derived macrophages (MDM) stimulated by lipopolysaccharide (LPS) (Kooltheat et al., 2014)

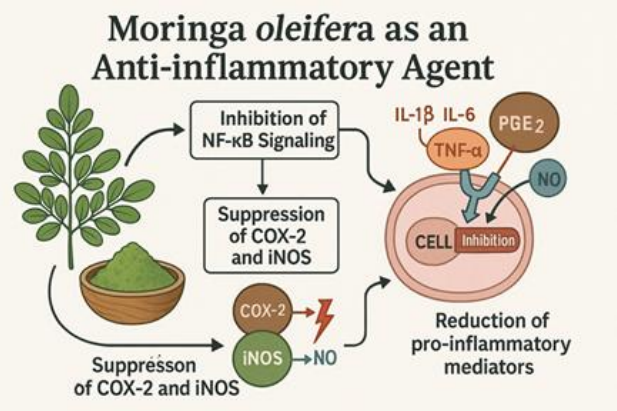


Figure 4. The anti-inflammatory mechanisms of *Moringa oleifera* are illustrated in a schematic diagram.

These pathways include Toll-like receptor 4 (TLR4), Nicotinamide adenine dinucleotide phosphate (NADPH), Inhibitor of kappa B (IB), Kelch-like erythroid cell-derived protein with cap'n'collar (CNC) homology (ECH) associated protein 1 (KEAP1), Lipopolysaccharide (LPS), mitogen-activated protein kinases (MAPKs), c-Jun N-terminal kinase (p-JNK), extracellular signal-related kinase (ERK), nuclear factor (erythroid-derived 2)-like 2 (Nrf2), nuclear factor-kappa B (NF-κB), inducible nitric oxide synthase (iNOS), cyclooxygenase-2 (COX-2), tumor necrosis factor alpha (TNF-α), interleukin-1 beta (IL-1β), interleukin-6 (IL-6), quinone oxidoreductase 1 (NQO1), and heme oxygenase 1 (HO-1).

Moringa Oleifera as an Antimicrobial Agent

The leaves, roots, bark, and seeds of *Moringa oleifera* have demonstrated in vitro antimicrobial properties against a wide range of microorganisms, including bacteria (such as *Bacillus cereus, Candida albicans, Streptococcus faecalis, Staphylococcus aureus, Staphylococcus epidermidis, Bacillus subtilis, E. coli, and Aspergillus niger*), yeast, dermatophytes, and helminths using a disk diffusion method. Additionally, *Moringa oleifera* has shown antifungal activity in both dilution and agar plate methods against *Trichophyton rubrum, Trichophyton mentagrophytes, Epidermophyton xoccosum, Microsporum canis, Fusarium solani, and Rhizopus solani*. The active chemical constituents responsible for its antibacterial effects include 4-(-L-rhamnopyranosyloxy) benzyl isothiocyanate, 4,4-(-L-rhamnopyranosyloxy) Benzylglucosinolate, and Pterygospermin (Manikandan et al., 2016; Shukla et al., 1988)

Moringa Oleifera as an Analgesic Agent

The methanolic extract obtained from the root bark of *Moringa oleifera* demonstrated analgesic effects in a mouse model, specifically in the acetic acid-induced writhing test. (Mishra et al., 2011).

Moringa Oleifera as a Cardiovascular Agent:

The ethanolic extract derived from *Moringa oleifera* leaves exhibited hypotensive or antihypertensive effects. These promising hypotensive properties were attributed to the presence of thiocarbamate and isothiocyanate glycosides. Furthermore, the water extract of *Moringa oleifera* leaves displayed in vitro and ex vivo antioxidant characteristics, along with beneficial effects on hyperlipidemia and anti-atherosclerosis activities (Chumark et al., 2008).

Moringa Oleifera as an Antiasthmatic Agent

The alcoholic extracts obtained from *Moringa oleifera* seed kernels demonstrated spasmolytic effects in response to bronchospasms induced by acetylcholine, histamine, BaCl2, and 5HT. In the same study, these extracts exhibited protective properties against mast cell degranulation triggered by egg albumin and compound 48/80. Additionally, pretreatment with the alcoholic extract of *Moringa oleifera* seed kernels resulted in a reduction of paw edema induced by carrageenan (Goyal et al., 2009).

Moringa Oleifera as an Anti-urolithiasis Agent

The bark's aqueous extract from *Moringa oleifera* demonstrated a reduction in stone weight in a urolithiasis model induced by 1% ethylene glycol. The study established that this extract possesses both preventive and curative qualities. Additionally, the diuretic activity was observed in rats through a hot water infusion of *Moringa oleifera's* flowers, leaves, seeds, and bark, resulting in increased urine output (Fahad et al., 2010).

Moringa Oleifera as an Anthelmintic Agent

Ethanolic extract of *Moringa oleifera* leaves showed more anthelmintic activity against Indian earthworm Pheritimaposthuma, compared to Vitexnegundo. The time for paralysis and time for the death of worms with *Moringa oleifera* leaves were less compared to the roots of Vitexnegundo (Rastogi, 2009).

Moringa Oleifera as an Antiulcer Agent

Mishra et al., conducted research demonstrating that the aqueous extract obtained from *Moringa oleifera* leaves showcases antiulcer properties in different animal models, using adult Holtzman albino rats of both genders.

Conclusion

Moringa oleifera is a plant that boasts rich nutrients in every part, and it also contains certain compounds that can influence the absorption of these nutrients. With its nutrient-dense leaves, pods, and blossoms, Moringa provides advantages for both human and animal nutrition, making it a valuable resource in the fight against malnutrition. Often referred to as a "miracle tree," Moringa offers numerous health benefits and it has fewer side effects than conventional synthetic drugs. For this reason, moringa should be used widely in healthcare industries.

Competing interest

The authors declare that they have no competing interests.

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