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Moringa oleifera: A review on its pharmacognosy, phytochemistry and pharmacological potential

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Abstract :
Moringa oleifera, commonly known as the drumstick tree, is a widely used medicinal plant with a rich history in traditional healing practices. This review explores its pharmacognostic features, key phytochemical compounds, and various pharmacological activities. Almost every part of the plant—leaves, seeds, bark, and roots—holds therapeutic value. It is rich in bioactive compounds such as flavonoids, alkaloids, tannins, and saponins, which contribute to its antioxidant, anti-inflammatory, antimicrobial, antidiabetic, and hepatoprotective properties. The plant is also known for its high nutritional content, making it valuable both medicinally and nutritionally. By compiling available scientific data, this review aims to provide a clear understanding of *Moringa oleifera*'s potential for future pharmaceutical use. The findings highlight the need for more in-depth studies and clinical trials to fully utilize its benefits and ensure safety and effectiveness in modern medicine.

IndexTerms - Moringa oleifera, Pharmacognosy, Phytochemistry, Medicinal plant, Pharmacological activity

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Introduction:

Moringa oleifera, commonly known as the drumstick tree or "miracle tree," is a fast-growing deciduous tree native to the Indian subcontinent. It belongs to the family Moringaceae and is now cultivated in many tropical and subtropical regions across Asia, Africa, and Latin America due to its nutritional and medicinal importance. (1)
Traditionally, Moringa oleifera has been deeply rooted in Ayurveda, where it is believed to cure over 300 diseases. Its leaves, pods, seeds, bark, and roots have all been used in folk medicine for centuries. In rural communities, the leaves are often used to treat malnutrition, while its seeds are known for purifying water. Decoctions from various parts of the plant are used to manage ailments like fever, joint pain, infections, digestive issues, and skin diseases. (2)
Phytochemically, the plant is rich in bioactive compounds such as flavonoids, alkaloids, glucosinolates, tannins, saponins, and phenolic acids. These constituents are primarily responsible for its diverse pharmacological properties, including antioxidant, anti-inflammatory, antimicrobial and antidiabetic effects. The nutritional value of Moringa leaves, with high levels of vitamins, minerals, and proteins, further enhances its significance in both traditional medicine and modern health applications. (3)

Fig. 1. *Moringa oleifera* linn

Fig. 2. Flower of *moringa oleifera*

Pharmacognostic Profile of *Moringa oleifera*

Synonym:

- Drumstick tree
- Horseradish tree
- Ben oil tree
- Sajna (Hindi)
- Shevaga (Marathi)
- Murungai (Tamil)
- Sahjan (Sanskrit)

Taxonomical Classification: (4)

1. Kingdom: Plantae
2. Sunkingdom: Tracheobionta
3. Super division: Spermatophyte
4. Division: Magnoliophyta
5. Class: Magnoliopsida

6 Subclass: Dilleniidae

7. Order: Capparales
8. Family: Moringaceae
9. Genus: Moringa
10. Species: Oleifera

Biologica lSource (5)

Moringa oleifera Lam. consists of the dried or fresh parts of the plant, including leaves, seeds, bark, roots, and flowers. All parts are used for medicinal and nutritional purposes.

Geographical_Source

Moringa oleifera is native to northwestern India, particularly the sub-Himalayan regions of Uttar Pradesh and Bihar, but it is now widely cultivated in Africa, Sri Lanka, Indonesia, Thailand, the Philippines, South America, and tropical parts of the USA.

Collection and Harvesting: (6)

- **Leaves** are collected during the early morning hours, preferably in the growing season (spring/summer), when they are tender and nutrient-rich.
- **Pods** (drumsticks) are harvested when young for consumption and when fully mature for seed extraction.
- **Seeds** are collected from dry pods after full maturation.
- **Roots** are harvested during the second or third year of plant growth.

Collected parts are usually shade-dried at low temperatures to preserve volatile constituents and then stored in airtight containers.

Cultivation:

Climate: Moringa thrives in tropical and subtropical climates with temperatures ranging from 25°C to 35°C. It is drought-tolerant and can grow in poor soil conditions.

Soil: Well-drained sandy or loamy soils with a pH of 6.5–8.0 are ideal.

Propagation: Generally propagated by seeds or stem cuttings. Seeds germinate within 7–10 days.

Irrigation: Requires minimal watering after establishment; overwatering should be avoided.

Spacing: Plants are usually spaced at 2–3 meters apart.

Harvest Time: Leaves can be harvested within 60–90 days after planting; seeds and pods are harvested after 6–8 months.

Phytochemical Constituents of Moringa oleifera (7) (8) (9) (10)

1. Alkaloids
Moringine
Moringinine
Spirochin
Quinine
Niaziminin
Niazimicin
Pharmacological relevance: Many of these alkaloids show hypotensive, antimicrobial, and antitumor properties.

2. Flavonoids
Quercetin
Kaempferol
Rutin
Myricetin
Isorhamnetin
Apigenin
Pharmacological relevance: Flavonoids are potent antioxidants, anti-inflammatory, and cardio-protective agents.

3. Phenolic Compounds
Gallic acid
Ferulic acid
Chlorogenic acid
Caffeic acid
p-Coumaric acid
Ellagic acid
Pharmacological relevance: These compounds exhibit strong antioxidant, hepatoprotective, and antimicrobial activities.

4. Tannins
Condensed tannins
Hydrolysable tannins
Pharmacological relevance: Tannins help in wound healing, antimicrobial action, and astringency.

5. Saponins
Oleanolic acid-type saponins
Triterpenoid saponins
Pharmacological relevance: Saponins have cholesterol-lowering, antimicrobial, and immune-boosting effects.

6. Glucosinolates and Isothiocyanates
4-(α-L-rhamnopyranosyloxy) benzyl isothiocyanate
Benzyl isothiocyanate
Niazimicin
Niaziminin A and B
Methyl p-hydroxybenzoate
Pharmacological relevance: Known for anti-cancer, antimicrobial, and detoxification effects.

7. Vitamins
Vitamin A (beta-carotene)
Vitamin C (ascorbic acid)
Vitamin E (tocopherol)
Vitamin B1 (thiamine), B2 (riboflavin), B3 (niacin), B6 (pyridoxine)
Pharmacological relevance: These contribute to immune support, antioxidant defense, and metabolic function.

8. Minerals
Calcium
Magnesium
Potassium
Phosphorus
Iron
Zinc
Selenium
Pharmacological relevance: Essential for bone health, oxygen transport, enzyme activation, and immune modulation.

9. Amino Acids (Essential and Non-essential)
Leucine
Isoleucine
Valine
Lysine
Methionine
Phenylalanine
Threonine
Tryptophan
Histidine
Glutamic acid
Aspartic acid
Pharmacological relevance: Important for protein synthesis, immune defense, and energy production.

10. Fatty Acids (from seeds)
Oleic acid
Palmitic acid
Stearic acid
Linoleic acid
Arachidic acid
Behenic acid
Pharmacological relevance: These fatty acids contribute to anti-inflammatory and cardioprotective actions.

11. Other Notable Compounds
Zeatin (a plant hormone with anti-aging potential)
β-sitosterol (anti-cholesterol activity)
Campesterol
Stigmasterol
Pharmacological relevance: These sterols have anti-inflammatory, lipid-lowering, and anticancer effects.

Pharmacological activities:

Antioxidant Activity of Moringa oleifera and Its Use in Detanning Soap (11) (12)
Reactive oxygen species (ROS) are unstable molecules that are naturally produced in the body, mainly through the mitochondrial electron transport chain. While ROS play some roles in normal cellular processes, excessive levels can damage cells and are known to contribute to various chronic conditions like cancer, diabetes, high cholesterol, heart diseases, and neurodegenerative disorders.
Several studies have shown that plant-based antioxidants can help neutralize these harmful free radicals. Moringa oleifera, particularly its leaves, has been found to be rich in antioxidant compounds, mainly polyphenols and phenolic acids. In 2009, research highlighted that the polyphenols in Moringa leaves significantly contribute to its antioxidant activity. A year later, scientists measured the free radical-scavenging capacity of Moringa root, leaf, and stem bark extracts, reporting IC_{50} values of 8, 15, and 19 mg/mL, respectively—indicating strong antioxidant potential.

Further studies confirmed that Moringa leaf extracts showed the highest antioxidant activity when extracted with 90% ethanol, making it an ideal solvent choice. In models of oxidative stress like erectile dysfunction in mice, Moringa leaves were found to effectively neutralize hydroxyl (OH^-) and nitric oxide (NO^-) free radicals with IC_{50} values of 0.52 mg/mL and 1.36 mg/mL, respectively. The extract also showed iron-chelating activity and inhibited lipid peroxidation, mechanisms that help protect cells from oxidative damage.

Interestingly, Moringa seed extracts outperformed even velvet bean in antioxidant assays, scavenging OH and DPPH radicals with IC_{50} values around 50 mg/mL, and also inhibited iron-induced lipid oxidation.

Application in Detanning Soap Formulation
When exposed to sunlight, pollution, and environmental stressors, the skin undergoes oxidative stress, which leads to hyperpigmentation, tanning, dullness, and premature aging. Incorporating Moringa oleifera extracts—especially its leaf extract—into a detanning soap can help combat these effects by:
• Neutralizing free radicals on the skin surface
• Inhibiting melanin overproduction, reducing pigmentation
• Protecting against UV-induced damage
• Reducing lipid peroxidation, preserving skin cell membranes
• Restoring brightness and an even tone to sun-damaged skin
The ethanol-based leaf extract would be ideal in soap formulation due to its high polyphenol content and proven antioxidant efficacy. This can be combined with other skin-beneficial ingredients like glycerin, aloe vera, or essential oils to create an effective, natural detanning soap.

Anti-inflammatory Activity of Moringa oleifera (13)
Inflammation is a natural defense mechanism of the body in response to injury, infection, or harmful stimuli. However, chronic inflammation has been linked to serious health issues like cancer, heart disease, and metabolic disorders. Moringa oleifera, especially its seeds and fruits, has shown promising anti-inflammatory properties in both traditional use and modern research.
Traditionally, Moringa seeds have been used for purifying water, but scientific studies have now confirmed their biological effects on inflammation. For instance, in immune-stimulated mouse cells, Moringa seed extracts were found to reduce the production of key inflammation markers such as nitric oxide (NO), tumor necrosis factor-alpha (TNF-α), and interleukin-1β

(IL-1β)—all of which play a central role in promoting inflammation.

In 2010, researchers discovered that specific compounds from Moringa fruit were able to suppress nitric oxide production and block the expression of the iNOS enzyme, a key driver of inflammation. Later studies supported this by identifying active compounds—like isothiocyanates derived from rhamnose-containing molecules—which can act at the genetic level to reduce inflammation.

Further investigations using rat models of colitis (an inflammatory condition of the colon) demonstrated that both hydro-alcohol and chloroform extracts of Moringa had significant anti-inflammatory effects. Moreover, two unique compounds isolated from the roots—aurantiamide acetate and 1,3-dibenzyl urea—showed the ability to lower inflammatory markers like TNF-α and IL-2.

Another interesting compound from Moringa seeds, called GMG (4-(α-L-rhamnosyloxy)-benzylerucate), gets converted into an active form (GMG-ITC) after enzymatic hydrolysis. This active form has been shown to regulate NF-κB, a master switch for inflammation in the body, helping to reduce inflammatory mediators.

These findings support the traditional use of Moringa oleifera in treating inflammation-related conditions, including skin infections, and indicate its potential as a natural alternative for managing inflammation.

Antiurolithiatic and Diuretic Activity (14) (15)

Urinary stones (kidney stones) have troubled people since ancient times, and many herbs have been used traditionally to treat this painful condition. Research has shown that Moringa oleifera has diuretic properties, meaning it can increase urine output and help flush out toxins. A study in 1992 reported that giving Moringa extract at a dose of 100 mg/kg led to noticeable diuretic effects.

Later, in 2010, researchers studied the aqueous bark extract of Moringa at doses of 400 and 800 mg/kg in rats and found it significantly reduced the size of kidney stones. These results suggest that Moringa may help prevent or treat kidney stones. However, more detailed research in other animal models or human clinical trials is still needed to confirm its full potential.

Anthelmintic Activity (16) (17)

Moringa oleifera leaves also show promise as a natural anthelmintic, which means they can help get rid of parasitic worms. In lab studies, Moringa leaf extracts were found to be more effective than those of Vitex negundo, a known medicinal plant. The extract worked by stopping worm eggs from developing, preventing hatching, and even killing the early larval stages (L1 and L2) of the worm Haemonchus contortus.

Although these studies suggest strong anthelmintic effects, the exact active compounds responsible haven't yet been clearly identified. Future research could focus on isolating these compounds and testing their safety and effectiveness through toxicity and pharmacokinetic studies, to help develop plant-based worm treatments.

Hepatoprotective Activity (18) (19)

Certain medications, such as anti-tuberculosis drugs and painkillers like paracetamol, can cause serious liver damage. Interestingly, Moringa oleifera has shown potential to protect the liver from such harmful effects. In one study, liver damage was experimentally induced in albino rats using paracetamol. When these rats were treated with root and flower extracts of Moringa oleifera, significant liver protection was observed.

The protective effect was largely linked to β-carotene, a natural antioxidant found in Moringa leaves. It likely works by reducing the levels of liver enzymes in the blood such as SGOT (serum glutamic oxaloacetic transaminase), SGPT (serum glutamic pyruvic transaminase), and alkaline phosphatase, which are commonly elevated during liver injury.

In another study using a model of chemically induced liver fibrosis (with CCl_4), Moringa seed extract showed liver-protective effects by reducing oxidative stress, lowering inflammation, and blocking the activation of liver stellate cells, which are involved in scarring and liver damage.

These findings indicate that Moringa oleifera may help safeguard the liver against damage caused by toxic substances. However, more studies, especially in humans, are needed to confirm these promising results.

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