

Phytochemical Profile and Pharmacological Insights of *Moringa oleifera* Extracts: A Comprehensive Review

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Abstract- *Moringa oleifera*, commonly referred to as the "drumstick tree" or "miracle tree," is renowned for its rich nutritional and medicinal properties. This review paper presents a comprehensive overview of the phytochemical constituents found in *Moringa oleifera* extracts derived from various parts of the plant—leaves, seeds, bark, and roots. It explores the pharmacological activities including antioxidant, anti-inflammatory, antimicrobial, antidiabetic, hepatoprotective, and anticancer effects, supported by preclinical and clinical studies. Furthermore, the safety and toxicity profile of *Moringa oleifera* is discussed, underlining its significance in phytomedicine and nutraceutical applications.

Keywords: *Moringa oleifera*, Phytochemicals, Pharmacological activity, Antioxidant, Anti-inflammatory, Antimicrobial, Antidiabetic, Hepatoprotective, Toxicity profile, Herbal medicine

1. INTRODUCTION

Moringa oleifera is a fast-growing, drought-resistant tree native to the Indian subcontinent and widely cultivated in tropical and subtropical regions. It is used traditionally for treating inflammation, malnutrition, diabetes, and infections. The plant is a rich source of vitamins, minerals, and phytochemicals, which contributes to its therapeutic applications. The World Health Organization (WHO) recognizes *Moringa* as a valuable source of nutrients and medicine in developing countries.

2. PHYTOCHEMICAL COMPOSITION

Various extracts of *Moringa oleifera*—particularly aqueous, ethanolic, and methanolic—contain a broad spectrum of bioactive compounds such as:

- Alkaloids: Moringine
- Flavonoids: Quercetin, kaempferol
- Phenolic compounds: Gallic acid, chlorogenic acid
- Saponins and tannins

- Glucosinolates and isothiocyanates
- Vitamins and minerals: Vitamin A, C, E, calcium, iron, potassium

The composition varies based on the part of the plant used and the extraction technique employed.

3. PHARMACOLOGICAL PROPERTIES

3.1 Antioxidant Activity

Moringa extracts show significant free radical scavenging activity, reducing oxidative stress in tissues. Studies have demonstrated its effect in reducing malondialdehyde (MDA) levels and increasing antioxidant enzymes like SOD and catalase.

3.2 Anti-inflammatory Effects

Moringa leaf and seed extracts exhibit anti-inflammatory effects by suppressing the production of TNF- α , IL-6, and COX-2. Animal models have shown reduction in carrageenan-induced paw edema, comparable to standard drugs.

3.3 Antimicrobial Activity

Moringa seed and leaf extracts have demonstrated antimicrobial properties against *Escherichia coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and *Candida albicans*, attributed to the presence of pterygospermin and isothiocyanates.

3.4 Antidiabetic Activity

The extracts lower blood glucose levels by enhancing insulin secretion and improving insulin sensitivity. Animal studies show pancreatic β -cell regeneration and decreased HbA1c levels.

3.5 Hepatoprotective and Nephroprotective Effects

Ethanolic extracts protect the liver against CCl₄ and paracetamol-induced hepatotoxicity by restoring liver

enzyme levels. Nephroprotective effects are noted in models of gentamicin-induced renal damage.

3.6 Anticancer Activity

Isothiocyanates and niazimicin from *Moringa* induce apoptosis in cancer cells and inhibit proliferation. Studies support anti-breast, anti-colon, and anti-liver cancer activity in vitro and in vivo.

4. TOXICOLOGICAL PROFILE

Toxicity studies on rodents indicate that *Moringa oleifera* extracts are safe at doses up to 2000 mg/kg. No significant histopathological changes were observed in liver or kidney tissues at therapeutic doses. However, caution is advised during pregnancy due to uterine contraction effects observed in high doses.

5. CLINICAL AND NUTRITIONAL RELEVANCE

Moringa oleifera is widely used as a dietary supplement and in nutraceutical formulations. Leaf powder is consumed in teas, capsules, and food fortification. Clinical trials suggest improvements in lipid profile, glycemic control, and immune modulation. Its GRAS (Generally Recognized As Safe) status supports its safety for human consumption.

6. CONCLUSION

Moringa oleifera is a versatile medicinal plant with a promising future in herbal therapeutics. Its broad phytochemical composition supports a variety of pharmacological actions with low toxicity. Further clinical studies are necessary to validate its efficacy and safety in large populations and explore formulation development for standardized extracts.

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