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THERAPEUTIC POTENTIAL AND PHYTOCHEMICAL PROFILE OF *MORINGA OLEIFERA* LAM. IN ORGAN PROTECTION AND DISEASE MANAGEMENT: A REVIEW

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ABSTRACT

Moringa oleifera Lam. (Moringaceae), commonly known as the drumstick tree, is a medicinal plant widely used in traditional systems of medicine, particularly Ayurveda, for the management of various ailments. Increasing scientific evidence has validated its diverse pharmacological properties, which are largely attributed to its rich content of flavonoids, phenolic compounds, alkaloids, glucosinolates, vitamins, minerals, and other bioactive constituents. Different parts of *M. oleifera*, including leaves, roots, bark, flowers, seeds, and fruits, possess distinct phytochemical profiles and contribute to its broad therapeutic potential. *M. oleifera* exhibits substantial antioxidant and organ-protective effects by scavenging reactive oxygen species, enhancing endogenous antioxidant defenses, reducing lipid peroxidation, and attenuating tissue injury. These properties suggest potential utility against drug-induced hepatic and renal toxicity, including aminoglycoside-associated nephrotoxicity. Overall, *M. oleifera* represents a promising multifunctional medicinal plant with considerable potential for development as a scientifically validated phytotherapeutic agent.

Keywords: *Moringa oleifera*; Phytochemicals; Antioxidant; Hepatoprotective; Nephroprotective; Anti-inflammatory; Pharmacological activities; Medicinal plants; Oxidative stress.

1 INTRODUCTION

Herbal medicine, or phytomedicine, utilizes plant materials (roots, leaves, seeds, barks, flowers) for therapeutic applications. With advancements in quality control, analytical chemistry, and clinical validation, traditional medicinal systems—such as Ayurveda, Siddha, Unani, and Naturopathy—have gained wide acceptance globally. In India, non-allopathic medical systems serve over 70% of the population, backed by growing experimental evidence that supports Observational Therapeutics and Reverse Pharmacology.

A critical clinical challenge in modern pharmacotherapy is drug-induced organ toxicity. Nephrotoxicity and hepatotoxicity often arise because organs like the kidneys and liver are major sites of drug metabolism and excretion.

Renal proximal tubule cells, for instance, are highly susceptible to acute tubular necrosis (ATN) induced by agents like aminoglycoside antibiotics (e.g., gentamicin). Gentamicin administration triggers reactive oxygen species (ROS) generation, lipid peroxidation, lysosomal breakdown, and acute renal failure. Consequently, natural plant-derived antioxidants that scavenge ROS and modulate cellular inflammatory responses present a promising strategy for renoprotection and hepatoprotection.

Moringa oleifera Lam. (family Moringaceae), commonly known as the "drumstick tree" or "horseradish tree," is an indigenous South Asian plant widely cultivated across tropical and subtropical regions. Known in ancient literature such as the *Charaka Samhita*, *M. oleifera* is rich in vitamins, minerals, flavonoids, alkaloids, and phenolic compounds across all plant organs.

2 BOTANICAL CLASSIFICATION AND PHYTOCHEMISTRY

2.1 Taxonomical Classification

- **Kingdom:** Plantae
- **Subkingdom:** Tracheobionta
- **Superdivision:** Spermatophyta
- **Division:** Magnoliophyta
- **Class:** Magnoliopsida
- **Subclass:** Dilleniidae
- **Order:** Capparales
- **Family:** Moringaceae
- **Genus:** *Moringa*
- **Species:** *M. oleifera*

2.2 Chemical Constituents Across Plant Parts

- **Leaves:** Contain *E*-lutein, *n*-hexadecanoic acid, tetradecanoic acid, octadecanoic acid, γ -sitosterol, carotenoids, tocopherols (α, γ, δ), flavonoids, and phenolic acids.
- **Roots and Radicle:** Contain anthonine, spirochin (bactericidal alkaloids), benzylglucosinolate, and 4-(α -*L*-rhamnopyranosyloxy)-benzylglucosinolate.
- **Stem and Bark:** Contain moringine, moringinine, 4-hydroxymellein, octacosanoic acid, and β -sitosterol.
- **Flowers:** Rich in flavonoids (rhamnetin, isoquercitrin, kaempferitrin), sucrose, and essential amino acids.
- **Seeds and Fruits:** High contents of benzylglucosinolate, 4-(α -*L*-rhamnopyranosyloxy)-benzylisothiocyanate, and *O*-ethyl-4-(α -*L*-rhamnopyranosyloxy) benzyl carbamate. **Leaves:** Contain *E*-lutein, *n*-hexadecanoic acid, tetradecanoic acid, octadecanoic acid, γ -sitosterol, carotenoids, tocopherols (α, γ, δ), flavonoids, and phenolic acids.
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3 PHARMACOLOGICAL ACTIVITIES OF *MORINGA OLEIFERA*

3.1 Analgesic, Anti-inflammatory, and Antipyretic Activities

Leaf, seed, and bark extracts show central and peripheral analgesic efficacy in hot-plate and acetic acid-induced writhing models. Paw edema models confirm anti-inflammatory activity comparable to indomethacin and diclofenac, mediated through c-Jun N-terminal kinase pathways, neutrophil regulation, and phenolic/flavonoid constituents.

3.2 Antioxidant and Radical Scavenging Efficacy

M. oleifera pods, leaves, and roots significantly scavenge DPPH, superoxide, and peroxy radicals. Leaf extracts restore endogenous glutathione (GSH) and attenuate malondialdehyde (MDA) production, curbing iron-induced microsomal lipid peroxidation.

3.3 Hepatoprotective and Nephroprotective Potential

Exogenous administration of leaf and root extracts protects against carbon tetrachloride (CCl_4), acetaminophen, antitubercular drugs, and aminoglycoside-induced toxicities. The bioactive constituents (quercetin, kaempferol, alkaloids, ascorbic acid) neutralize ROS, preventing acute tubular necrosis, glomerular congestion, and hepatic architecture distortion.

3.4 Cardiovascular and Metabolic Modulation

Leaf extracts demonstrate hypotensive effects (driven by niazinin A, niazinin B, and niazimicin) and protect against isoproterenol-induced myocardial infarction. Metabolic benefits include reduced body weight, lowering of total cholesterol and triglycerides in hyperlipidemic models, and modulation of adiponectin, leptin, and resistin gene expressions.

3.5 Antimicrobial, Anthelmintic, and Other Properties

M. oleifera extracts inhibit pathogenic bacteria (*S. typhi*, *P. aeruginosa*, *E. coli*) and fungi (*A. niger*, *M. gypseum*). Seed extracts facilitate water purification by coagulating particulates and inhibiting bacterial growth. Anthelmintic efficacy has been confirmed against *Pheretima posthuma* and parasite egg hatching. Furthermore, gastroprotective, antiasthmatic, hematological, antidiabetic, anti-urolithiatic, diuretic, wound-healing, and immunomodulatory properties are well documented.

4 CONCLUSION

M. oleifera represents a versatile botanical entity possessing diverse therapeutic effects. The primary bioactive constituents—flavonoids, phenolic acids, alkaloids, and glucosinolates—synergistically combat oxidative stress and cellular injury. Further standardization, chemical isolation, and targeted clinical trials remain essential to fully leverage its therapeutic value.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

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Disclosure of conflict of interest

The authors declare that they have no conflicts of interest regarding the publication of this article.

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