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THE "MIRACLE TREE": A REVIEW OF MORINGA OLEIFERA'S EXTENSIVE USEFULNESS

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ABSTRACT

Herbal drug treatments are believed to have advantages over conventional medicines and interest in them is increasing again in contemporary studies. Moringa oleifera, additionally called the "drumstick tree" or the "miracle tree", is identified as an important herbal plant because of its numerous medicinal and non-medicinal advantages. Traditionally, the plant has been used to heal wounds, ache, ulcers, liver ailment, coronary heart ailment, cancer and infection. It contains vital amino acids, carotenoids in the leaves and components with nutraceutical effects. The significant factor for the medicinal use of Moringa oleifera is the very wide variety of vitamins it carries, along with vital antioxidants, antibiotics and nutrients and minerals. Each part of Moringa has useful components that may serve mankind. But, many conventional uses are still to be explored scientifically. Therefore, still more studies are proposed to discover the mechanistic method of the plant to discover and isolate the active or synergistic compounds which makes the plant therapeutically useful.

KEYWORDS: Moringa oleifera; Miracle Tree; Nutritional; Traditional Medicinal uses.

INTRODUCTION

Moringa oleifera is a tree with strong antioxidant properties, commonly known as the moringa tree, miracle tree, bane oil tree, or horseradish tree. Humans have used moringa for centuries because of its wide range of health benefits. Native to India, Pakistan, Bangladesh, and Afghanistan, "Moringa oleifera" is a fast-growing, drought-resistant species now found

throughout tropical and subtropical regions worldwide, including Africa, Southeast Asia, and parts of Latin America. It has long been utilized in Ayurvedic and folk medicine to treat conditions such as hypertension, toothache, and stomach ulcers. Its antihypertensive, antimicrobial, and anti-inflammatory activities are believed to arise from the abundance of bioactive compounds present in its leaves, pods, seeds, and roots, including flavonoids, glucosinolates, phenolic acids, and alkaloids. Moringa may offer numerous health benefits, ranging from promoting wound healing to helping manage blood sugar levels, although further research is needed to fully validate its medicinal uses.

Medicinal parts of M. Oleifera

"Moringa oleifera" is a highly bioactive plant in which every major part—leaf, fruit pod, fruit, seed, flower, root, and even stem—contain compounds with important therapeutic potential.

Leaves are rich in polyphenols, flavonoids, phenylpropanoids, terpenoids, fatty acids, sterols, minerals, and nutrients, making them valuable for health-promoting applications.

Seeds contain high levels of proteins, essential amino acids, fatty acids, and flavonoids. Their "isothiocyanates" exhibit anti-inflammatory, antioxidant, antibacterial, and anticancer properties. Seed oil also shows coagulant activity beneficial for wound healing.

Stems, though less studied, yield compounds such as cholest-5-en-3-ol, stigmasterol, γ-sitosterol, and trichocyanic acid through methanol reflux extraction and chromatography. These stem extracts demonstrate strong antifungal activity against "Rhizoctoniasolani" and "Fusariumoxysporum".

Flowers and fruits are rich in carbohydrates, proteins, organic acids, flavonoids, and phenols. Antioxidants including tocopherols, ascorbic acid, carotenoids, and flavonoids help neutralize reactive oxygen species (ROS).

Overall, "M. oleifera" contains diverse bioactive compounds across its plant parts, supporting its wide-ranging medicinal and nutritional applications.

THERAPEUTIC APPLICATIONS

Antimicrobial and Antifungal effects of Moringa oleifera

Moringa oleifera contains multiple compounds with antimicrobial and antifungal activities:

Alkaloids

Amino acids

Cardio glycosides

Flavonoids

Saponins

Steroids

Terpenoids

Tannins

Pterigospermin (an antibiotic compound from flowers)

Antimicrobial Effects

Bacteria

Gram-negative: E. coli, Pseudomonas aeruginosa (root extract, leaves)

Gram-positive: Bacillus cereus, Staphylococcus aureus (seed kernel extract, leaves)

Mechanisms:

Denaturation of proteins

Inhibition of spore germination (especially via steroid ring structures)

Antifungal Effects

Fungi affected

Candida albicans (alcoholic extract of leaves, fruits)

Aspergillus flavus, Aspergillus niger, Aspergillus terreus, Aspergillus nidulans (leaves, stems, seeds)

Trichodermaharzianum, Mucor species, Fusariumsolani (various extracts)

Mechanisms

Direct inhibition of fungal growth.

Prevention of spore germination.

Possible disruption of fungal cell walls and protein functions.

Anti-inflammatory activity

Moringa oleifera exhibits significant anti-inflammatory and antimicrobial properties across its various parts, including leaves, pods, flowers, and roots. Both in vitro and in vivo studies have demonstrated its potential in treating infections. Notably, the compound "4-[2-O-acetyl-α-L-rhamnosyloxy] phenyl thiocyanate" has been shown to suppress "iNOS, COX-2, and NF-κB" expression while enhancing "IκBα" levels, highlighting its therapeutic potential for inflammation-related disorders.

Active constituents such as "tannins, phenols, alkaloids, flavonoids, carotenoids, β-sitosterol, vanillin, and moringin" contribute to these anti-inflammatory effects. Experimental studies in mice suggest that "M. oleifera" leaf extract may serve as an effective treatment for "atopic dermatitis". Moreover, bark extract has demonstrated efficacy in "urinary tract infections", achieving a "66.7% complete cure rate within three weeks".

Neuroprotective and Antioxidant Effectsin Neurodegenerative Disorders

Moringa is widely acknowledged for its neuroprotective effects, primarily attributed to its ability to improve cerebral blood flow, which is essential for preventing cerebral ischemia and reducing the formation of reactive oxygen species (ROS). The plant significantly decreases ROS levels, inducing an "antioxidant response" that protects the brain. Studies have shown that Moringa treatment notably reduces the size and number of brain infarcts in both cortical and subcortical regions. Additionally, it enhances the activity of "superoxide dismutase (SOD)" in the hippocampus and striatum of rats, further contributing to its antioxidant effects.Beyond its antioxidant properties, Moringa seed extract has been shown to

"manage cognitive impairment" by enhancing the cholinergic system and promoting neuron synthesis in the hippocampus. Administration of Moringa reverses scopolamine-induced decreases in key signalling pathways, including "phosphorylated extracellular signal-regulated protein kinase (ERK1/2)", "Akt", and "cAMP" response element-binding protein (CREB) in the hippocampus. Long-term Moringa treatment has been demonstrated to improve "spatial memory", reduce "escape latency", restore acetylcholine levels, mitigate oxidative stress, and slow the progression of "Alzheimer's disease (AD)". Its neuroprotective effects extend to dementia, where Moringa treatment reduces levels of "malondialdehyde (MDA)", "cholinesterase", "nitric oxide (NO)", and amyloid proteins, while increasing "glutathione" levels. Additionally, Moringa promotes "neuronal health" by supporting neurite outgrowth and overall neuronal function."Parkinson's Disease (PD)" is characterized by the degeneration of dopaminergic neurons in the substantia nigra. Moringa has shown potential in PD management by reducing oxidative stress, ROS formation, mitochondrial dysfunction, and apoptosis. "Sulforaphane", an active compound in Moringa, has been reported to protect dopaminergic neurons by activating the transcription factor "Nrf2", which enhances neuronal survival. Furthermore, Moringa exerts "anti-inflammatory effects" by reducing proinflammatory cytokines in PD models, contributing to its neuroprotective profile. Moringa demonstrates "multifaceted neuroprotective actions" through antioxidant, anti-inflammatory, and cholinergic system-enhancing mechanisms, offering potential therapeutic benefits in neurodegenerative disorders such as Alzheimer's and Parkinson's diseases.

Antidiabetic Activity

Several studies suggest that consuming moringa leaves in powdered form may help reduce blood sugar levels, particularly in individuals with diabetes. Observational data indicate that diabetic patients who consume moringa leaf powder may experience a decrease in blood glucose levels. However, it is crucial to consult a healthcare provider before incorporating moringa leaves into a diabetes management plan. In animal models, moringa leaves have been shown to enhance glucose uptake by muscles and the liver while reducing hepatic glucose production. These mechanisms could potentially help manage hyperglycaemia in diabetic patients. Nonetheless, further clinical studies in humans are necessary to confirm these effects and establish safe and effective dosages.

Anticancer Activity

Moringa has demonstrated notable anticancer properties in both in vitro and in vivo studies. Research indicates its effectiveness against a variety of cancers, including “lung, liver, and breast cancer”, often resulting in “significant tumour growth reduction” and “improved survival rates” in animal models.

The anticancer effects of Moringa are attributed to multiple mechanisms.

1. “Induction of Apoptosis” – Moringa promotes programmed cell death in cancer cells, helping to eliminate abnormal cells.
2. “Inhibition of Cancer Cell Proliferation” – It prevents the rapid multiplication of cancer cells, slowing tumor progression.
3. “Cell Cycle Regulation” – Active components of Moringa can arrest the cell cycle at various phases, reducing uncontrolled cell division.
4. “Reduction of Oxidative Stress” – Its antioxidant compounds help neutralize free radicals, which can damage DNA and promote cancer development.
5. “Inhibition of Signalling Pathways” – Moringa interferes with molecular pathways that are critical for cancer cell survival and metastasis.

The bioactive compounds responsible for these effects include “glucosinolates, isothiocyanates, and phenolic compounds”, which together contribute to Moringa’s multi-targeted anticancer activity.

Analgesic and Antipyretic Activity

Scientific studies using animal models have confirmed that various extracts of “Moringa oleifera” possess significant analgesic and anti-inflammatory activities. These effects are largely attributed to the plant’s rich phytochemical composition and support its traditional use in folk medicine for the management of pain and inflammatory conditions such as arthritis. Key phytochemicals, including flavonoids, alkaloids, tannins, saponins, and steroids, contribute to its pain-relieving properties. These bioactive compounds exert analgesic effects through mechanisms such as inhibition of inflammatory mediators, antioxidant activity, and modulation of pain pathways.

Several studies conducted on rats have documented the analgesic effects of “Moringa”, noting reductions in inflammatory markers. Alcoholic extracts of “Moringa” seeds and leaves have demonstrated analgesic efficacy comparable to commonly used pharmaceutical agents

like aspirin and indomethacin. This suggests that "Moringa" may offer a natural alternative for pain relief.

Additionally, "Moringa" leaf extract has shown strong antipyretic activity, effectively reducing fever induced by yeast in experimental albino mice. The extract demonstrated a dose-dependent response, maintaining normal body temperature in the treated animals.

Overall, these findings support the traditional use of "Moringa oleifera" as a natural analgesic and antipyretic agent, with potential applications in managing pain, inflammation, and fever.

Immunomodulatory Activity

Moringa has significant immunomodulatory effects, primarily by boosting both humoral and cell-mediated immunity. It increases antibody levels, enhances T and B cell activity, and modulates the production of cytokines like IL-10 and TNF-α. These effects are mediated by its rich content of bioactive compounds and may help regulate chronic inflammation, support immune responses against pathogens, and potentially aid in managing autoimmune and other immune-related disorders. Moringa leaves extracts shows immunomodulatory effects by following ways.

- Increases antibody production: Moringa extracts significantly increase serum immunoglobulin levels, indicating a positive effect on the humoral immune response.
- Enhances cell-mediated immunity: It promotes the proliferation of T and B lymphocytes and enhances the activity of immune cells like macrophages.
- Modulates cytokine production: Moringa can promote anti-inflammatory cytokines (like IL-10) and inhibit pro-inflammatory cytokines (like TNF-α and IL-6).
- Supports immune function during stress or suppression: Pre-treatment with Moringa extract has been shown to inhibit the suppressive effects of chemotherapy drugs (like cyclophosphamide) on immune cells.
- Combats inflammation: It has antioxidant and anti-inflammatory properties that can help reduce chronic inflammation and oxidative stress.
- Regulates immune responses to infections: Studies suggest moringa can help regulate immune responses during certain parasitic and viral infections, potentially by reducing pathogen load and modulating cytokine release.
- Contributes to gut-associated immunity: Its polysaccharides can modulate gut microbiota, which in turn benefits the immune system that is closely associated with the gut.

CONCLUSION

Moringa oleifera has rightfully earned the title "Miracle Tree" due to its extraordinary nutritional richness, broad pharmacological activities, and diverse applications in medicine, public health, agriculture, and environmental sustainability. While preclinical data strongly supports its therapeutic benefits—especially as an antioxidant, anti-inflammatory, cardiometabolic, antidiabetic, analgesic, anticancer and antimicrobial agent—clinical evidence remains preliminary. Well-designed, large-scale studies are essential to fully validate its therapeutic potential and establish standardized guidelines. Moringa stands as a promising natural resource with significant potential to impact nutrition, global health, and future drug development.

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