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Moringa: A Narrative Review of its therapeutic properties

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Abstract: ***Moringa is a plant with many boons. Each and every part of this plant has a nutraceutical role. Moringa has a rich phytochemical profile, including isothiocyanates (MIC-1), flavonoids (myricetin, quercetin, kaempferol), phenolic acids (gallic acid, caffeic acid and chlorogenic acid). These phytochemicals show pharmacological properties such as; antioxidant, anticancer, antiobesity, antiarthritic, anti diabetic, antiulcer, antimicrobial activities. This paper provides an overview of the merits of Moringa as a promising nutraceutical for multifactorial diseases. These properties position it as a promising natural adjunct for managing diverse conditions, though further clinical validation is essential.***
Keywords: Anticancer, Flavonoids, MIC-1, Moringa, Phenolic acids, ROS

I. INTRODUCTION

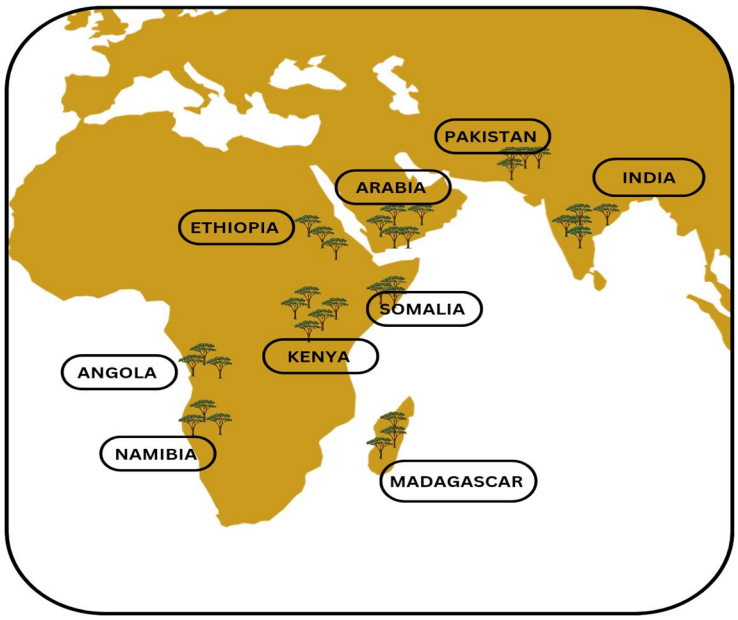
Moringa - "The Tree of life"

Moringa oleifera Lam. (Lamarck, Jean Baptiste Antoine Pierre de Monnet de, 1785) is a fast-growing and water-efficient plant. It is an annual softwood tree. For that reason, it is also called "Tree of life". It is mainly found in tropical Asia but also became naturalized and widely cultivated in many countries (Adeleye et al., 2021; Paliwal et al., 2011). It is widely known as सहजन (Sahjan) and मुनगा (Munga) in most parts of India. Moringa oleifera is a wholesome tree. All parts of the Moringa plant are edible, including the leaves, flowers, immature pods, and roots (Paliwal et al., 2011). Due to abovementioned properties, The World Health Organization (WHO) has recommended Moringa oleifera leaves for the treatment of malnutrition (El Bilali et al., 2024).

II. BOTANICAL OVERVIEW

Moringa (Moringa oleifera) is very well known as a wonder tree. The Moringaceae family consists of 13 species, but the most famous is Moringa oleifera, which is native in India and grows in the southern Himalayan valleys and in tropical and subtropical regions (Shamlan et al., 2021).

Geographical distribution of native *Moringa* species



1. *Moringa oleifera* ***India***
2. *Moringa arborea* ***Kenya***
3. *Moringa borziana* ***Somalia and Kenya***
4. *Moringa concanensis* ***India and Pakistan***
5. *Moringa drouhardi* ***Madagascar***
6. *Moringa hildebrandtii* ***Madagascar***
7. *Moringa longituba* ***Ethiopia, Somalia and Kenya***
8. *Moringa ovalifolia* ***Namibia and Angola***
9. *Moringa peregrina* ***Arabia***
10. *Moringa pygmaea* ***Somalia***
11. *Moringa rivae* ***Kenya and Ethiopia***
12. *Moringa ruspoliana* ***Ethiopia and Somalia***
13. *Moringa Stenoptala* ***Kenya and Ethiopia***

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A. Historical mentions in Indian text

Moringa is used as a medicine from ages ago Charaka Samhita (1000 BC–4th century AD) prescribes its powder and decoction for ailments including worms, headaches, edema, and asthma.

B. Nutritional Composition

Moringa leaves have a wholesome value, being high in lipids, fiber, proteins, vitamins, and minerals (Afuang et al., 2003, Gowda et al., 2020). Various studies indicate that *Moringa oleifera* has exceptional nutrient composition, specifically its leaves have remarkable properties. Its leaves contain high crude protein levels and essential amino acids. The mineral profile of M. oleifera leaves further enhances their nutritional value, providing approximately 17 times more calcium than milk, 15 times more potassium than bananas, 25 times more iron than spinach, and significant concentrations of magnesium, phosphorus and zinc (Islam et al., 2021). Moringa leaves have bioactive agents namely phenolic acid and flavonoids. It enhances the different pharmacological actions such as, antibacterial, antioxidant, antifungal, anti-inflammatory, antidiabetic, and anticancer effects (Islam et al., 2021).

The bioactive compound profile in Moringa oleifera's leaves

Bioactive compound	In leaves	Function	Reference
Vitamins	Vitamin A Vitamin B Vitamin C Vitamin E (alpha-tocopherol)	Immune-stimulating functions	Peñalver et al. (2022) Paliwal et al. (2011) Anwar et al. (2007) Makkar et al. (2007) Makkar & Becker (1997)
Minerals	Potassium Iron Calcium	Nutritive importance, Healing properties, Prominent growth-stimulating effects	Ahmadifar et al. (2021)
Phytochemicals	Carotenoids Flavonoids Phenolics Alkaloids Terpenoids	Immune-stimulating functions, Preventing lipid peroxidation, Scavenging free radicals, Prominent growth-stimulating effects	Ahmadifar et al. (2021) Anwar et al. (2007) Makkar et al. (2007) Vergara-Jimenez et al. (2017)
Antioxidants	Catalase Oxidase Polyphenol oxidase	Immune-stimulating functions	Meireles et al. (2020) Anwar et al. (2007) Makkar et al. (2007)
Flavonol glycosides	Kaempferol Quercetin Alkaloids (moringinine)	Controlling glucose homeostasis	Mbikay (2012)

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III. THERAPEUTIC VIRTUES OF MORINGA LEAF

A. Anticancer

Cancer is a disease which is characterized as an uncontrolled division of abnormal cells in any part of the body metastasis via blood stream. It is one of the leading diseases with lack of advancement of treatment.

Moringa has a specific phytochemical called 4-(α-L-Rhamnosyloxy)benzyl isothiocyanate. It is also known as Moringa isothiocyanate (MIC-1). This phytochemical causes reactive oxygen species (ROS) formation and stimulates cysteine. This causes caspase 3 activation and anti apoptotic factors inhibition, resulting in apoptosis of cancer cells. This ROS specifically targets only cancerous cells (Wu et al., 2021).

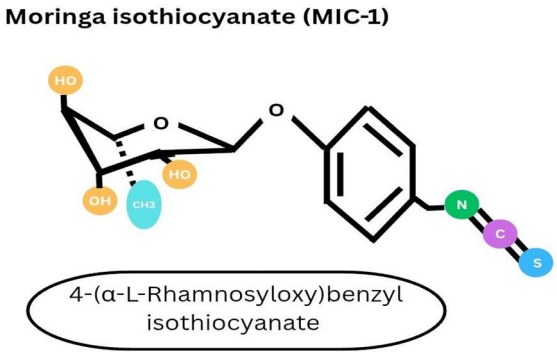

Diagram **1**

B. Anti-diabetic

Diabetes is an incurable, metabolic dysfunction wherein sugar levels in blood increase tremendously. This long-term disease provokes cardiovascular system impairment, renal failure, damage to eyes and nervous system . Type 2 diabetes is prevalent, in which the body does not produce sufficient insulin or when the body resists insulin actions. The process includes elevated glucose travel throughout the body and enters mitochondria of pancreatic β cells. As a result, an immense amount of ROS is released and these cells do not have plentiful antioxidants. This causes apoptosis of β cells, eventually decreasing insulin secretion and activating hyperglycemia. Literature indicated that flavonoids and phenolic acids (Diagram 2) present in Moringa acts as an antioxidant and work against ROS, improving diabetic condition (Mthiyane et al., 2022).

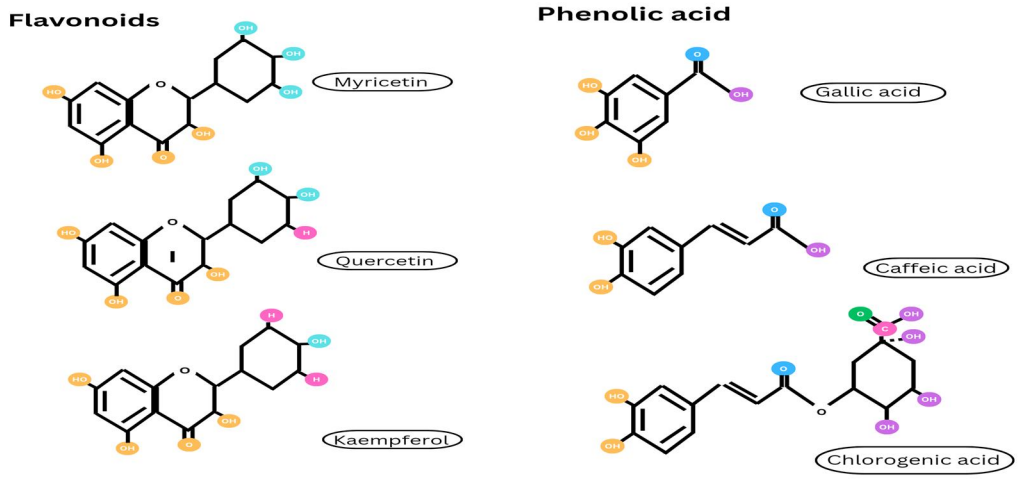

Diagram 2

C. Antiarthritic

Inflammation of joints (places where two bones meet) is Arthritis. With age some joints naturally wear down. The symptoms start with mild pain, redness, heat, and swelling in the joints, leading to acute pain and reduced mobility. These symptoms are caused by pro-inflammatory cytokines; TNF-α (Tumor Necrosis Factor-alpha) and IL-1 (Interleukin-1). Where TNF-α begins the inflammation and swelling of joints, while IL-1 degrades cartilage and bones. In an investigation on arthritic rats, it is seen that flavonoids and antioxidants present in Moringa peregrina reduce the level of TNF-α and IL-1. It also increases the bone mineral density by providing necessary minerals (Shamlan et al., 2021).

D. Antiulcer

Stomach is responsible for breaking down food and helps in digestion. It is done by stomach acid and a group of digestive enzymes. Normally the stomach itself is protected from this highly eroding process by a strong mucous lining. However, if the lining got damaged causing open wounds known as ulcers. Some signs include persistent stomach pain and burning sensation. One research done on rats where acidified ethanol induced secretion of mucosa resulting in ulcer conditions. As Moringa oleifera infusion is given to infected rats, following events occur -

(i) Increase in antioxidant enzyme activity (SOD,CAT,GPx)
(ii) Decrease in gastric juice secretion
(iii) Decrease in MDA level.

This leads to entire protection of the mucus lining of the stomach (Dalhoumi et al., 2022).

E. Antiobesity

Obesity is a chronic disease characterized by unnatural or excessive fat deposition in the body. A body mass index (BMI) over 30 is considered obese. Obesity creates metabolic, biophysical, and psychosocial issues throughout life. Moringa has low carbohydrate and fat content. Additionally it adjusts serum lipid profile. Therefore, it has low calorific value, making it an excellent diet food for the obese (Kashyap et al., 2022).

F. Hypercholesterolemia

Cholesterol is a waxy substance which is produced by the liver. It primarily helps in cell membrane formation and hormone synthesis. However when a person consumes high amounts of saturated/trans fats, in addition to lack of exercise, obesity, and smoking Hypercholesterolemia could occur. An excessive amount (greater than 190 mg/dL in blood) of low-density lipoprotein or "bad" cholesterol causes Hypercholesterolemia. This contributes to plaque buildup in arteries. Ultimately, causing cardiovascular events like heart attacks or strokes. Moringa has an antinutrient known as “Saponin”. It inhibits cholesterol adsorption by binding to bile acids. Along with increased fecal excretion of cholesterol, resulting in low plasma cholesterol level (Gopalakrishnan et al., 2016).

G. Against Neurodegenerative diseases

Neurodegenerative diseases are chronic diseases where nerve cells in the brain or peripheral nervous system progressively lose function and ultimately die. This includes mainly two diseases: Alzheimer's disease (AD) and Parkinson's disease (PD). AD is triggered by extracellular amyloid-beta plaques and intracellular tau tangles forming in the brain, causing memory loss and weakening of cognition. Whereas PD is characterized by alpha-synuclein-containing Lewy bodies, resulting in movement issues such as; tremors, rigidity and bradykinesia (Azlan et al., 2023).

- Gallic Acid helps in neutralizing ROS.
- Caffeic acid enhances the defense system in the brain by decreasing Malondialdehyde level and increasing Glutathione levels. It regulates oxidative stress and neuroinflammation.
- In AD, Chlorogenic acid blocks the enzymatic activity of Acetylcholinesterase (AChE) and Butyrylcholinesterase (BChE), which contributes in amyloid plaque formation, hence protecting neurons.
- Myricetin prevents the loss of dopaminergic neurons and improves altered motor behaviour.
- Quercetin helps in reducing oxidative stress and inhibits caspase-3 expression in the hippocampus during an experiment performed on rats as a model.

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H. Antimicrobial activity

Moringa has antibacterial activity against bacteria such as ; *Bacillus subtilis, Staphylococcus aureus, Vibrio cholerae, Pseudomonas aeruginosa, E coli* (El-Sherbiny et al., 2024). The phytochemicals present in Moringa disintegrate the cell wall of these bacteria and decrease cytoplasmic density. Moringa is also effective against fungi namely; *Trichophyton rubrum, Trichophyton mentagrophytes, Epidermophyton floccosum, Saccharomyces cerevisiae, Candida tropicalis*, making it antifungal in nature (Patil et al., 2022).

IV. CONCLUSION

Thus, Moringa acts as a multi-therapeutic agent as deduced from multiple clinical studies on rat subjects. Bioactive isothiocyanates, flavonoids and antioxidants act on cancer (by apoptosis), arthritis (cytokine regulation), obesity (lipid metabolism), microbial infection (cellwall disruption), diabetes (insulin sensitization), hypercholesterolemia (lipid lowering effect), oxidative stress (ROS scavenging) and neurodegeneration (neuroprotection). It can be used as an alternative to pharmaceuticals, and it is a sustainable and accessible nutraceutical source for consumers. Standardization and bioavailability of extracts, profile of antinutrients and human clinical trials will be required in the future. Strategies such as nanoencapsulation of compounds and their use in synergistic combination with allopathic drugs can improve therapeutic efficacy. By combining Moringa-based functional foods with personalized medicine and climate-resilient agriculture, health benefits could be increased while bridging customary medical knowledge and modern preventive medicine.

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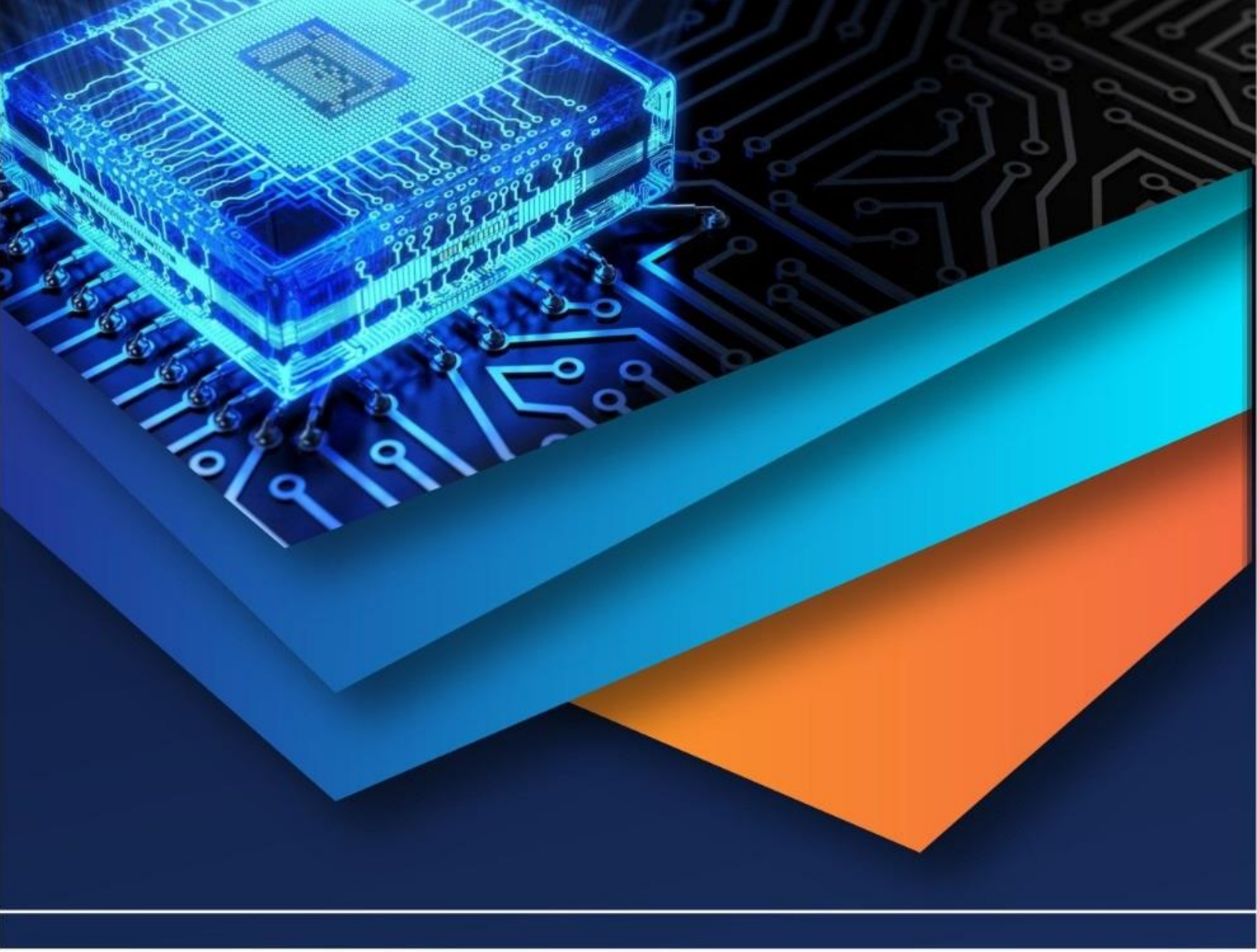

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