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Review Article

Moringa oleifera (L.) (*Moringaceae*): A Phytochemical and Pharmacological Review

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Abstract

Moringa oleifera, sometimes referred to as a "miracle tree" or "tree of life," has demonstrated its diversity and potential as a useful resource in numerous ways., is a member of the Moringaceae family. It is a popular crop in India and is regarded as a healthy herb. These plants have excellent medical qualities in all of their parts. The plant commonly called "horseradish plant" or "drumstick plant" contains biological activities that include anticancer, antidiabetic, antihypertensive, treating malnutrition, and being useful as a focus booster and as a wound healing venture. As a result, the objective of the current review is to provide thorough information on the traditional applications, phytochemical compounds, and pharmacological activities of the medicinal plant M. oleifera from reliable sources. The knowledge offered in this study will be helpful in future research projects aimed at creating innovative therapeutic medicines.

Key words: *Moringa oleifera;* pharmacological activities; phytochemical compounds.

INTRODUCTION

Since ancient times, medicinal plants have been used to treat human illnesses. Since the last ten years, there has been a renaissance in interest in natural medicines, largely due to the widespread belief that natural medicine is safer than synthetic medicine. Due to the global interest in using medicinal plants, which is expanding at a pace of 7 to 15% yearly, there has been a tremendous expansion in the number of industries based on medicinal plants.(Kumar, S. *et al*., 2013)

Ayurveda, Siddha, Unani, and regional medical customs are among the many medical systems used in India. For the treatment of human and animal ailments, these systems make extensive use of medicinal herbs. (Handral, H. K. *et al*., 2012).

Moringa arborea, indigenous to Kenya; Moringa pygmaea, indigenous to Somalia; Moringa borziana, indigenous to Somalia and Kenya; Moringa rivae, indigenous to Kenya and Ethiopia; Moringa longituba, indigenous to Kenya, Ethiopia, and Somalia; Moringa stenopetala, indigenous to Kenya and Ethiopia; Moringa ruspoliana, indigenous to Kenya and Ethiopia (Paliwal, R. *et al*., 2011)

M. oleifera, sometimes referred to as a "miracle tree" or "tree of life," has demonstrated its diversity and potential as a useful resource in numerous ways. Its significant positive benefits on health, nutrition, water cleanliness, and the environment have led many to call it a "tree of life" or "tree of miracles." Around the world, it is used for a wide range of medical purposes. For the treatment of conjunctivitis and to remove intestinal worms from the body, traditional folk medicines recommend making an infusion of the leaves. M. oleifera's fresh leaves are recommended for treating anemia and improving milk supply, which is good for expectant and nursing women. (Fuglie, L. J, 1999)

Various pharmacological effects, including antibacterial, hypotensive, and anti-inflammatory properties, of moringa oleifera preparations have also been noted in scientific literature. (C.S.I.R, 1962)

Natural antioxidants such flavonoids, quercetin, -sitosterol, and zeatin are recognized to potentially be present in the leaves. There have been reports of antispasmodic properties in the roots and leaves of Moringa oleifera. (Aney, J. S. *et al*., 2009)

M. oleifera is widely prized for its therapeutic capabilities in addition to its powerful abilities to filter water and its nutritional advantages. Different sections of this widely revered tree have been credited with a multitude of medicinal qualities. Phytochemicals and secondary metabolites are known to be abundant in the many

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parts of M. oleifera, including the roots, leaves, flowers, fruits, and seeds. It is said to include proanthocyanidins, anthraquinones, alkaloids, flavonoids, carotenoids, tannins, and flavonoids. (Goyal, B. R. *et al*., 2007)

As nutritional supplements for nursing women and weaning infants, M. oleifera are frequently recommended in areas with chronic malnutrition. The local marketplaces where South and Southeast Asian delicacies are marketed are a good fit for pods and leaves. This plant has a great nutritional value, which is supported by numerous scientific studies. Now it is necessary to inform the populace of both its nutritional value and therapeutic properties so that they may quickly eat it. (Radovich, T. *et al*., 2009)

The leaves of the moringa tree are rich in vital amino acids, vitamin C, and vitamin A. Furthermore, because the species are drought-resistant, they are valuable during the dry season when other vegetables are scarce. (Seifu, E, 2014)

It contains significant amounts of vital proteins, minerals, vitamins, and polyphenols. It contains a variety of phytochemicals, such as flavonoids, anthocyanins, isothiocyanates, anthracene, alkaloids, essential oils, tannic acid, saponins, steroids, terpenoids, and cardiac glycosides. Additionally, it has pharmacological benefits (such as hepatoprotective, antihypertensive, cholesterol-lowering, anti-urolithiasis, antifertility, antidiabetic, and antioxidant activity), as well as nutraceutical and antibacterial properties. (Fahey, J. W, 2017)

Taxonomical Classification

The plant M. oleifera belongs to the Kingdom: Plantae; Sub kingdom: Tracheobionta;

Super division: Spermatophyta; Division: Magnoliophyta; Class: Magnoliopsida; Subclass: Dilleniidae; Order: Capparales; Family: Moringaceae; Genus: Moringa; Species: oleifera (Paikra, B. K, 2017)

Plant Description

M. oleifera is a short, slender, deciduous, perennial tree that grows to about 10 m tall, slender with drooping branches; branches and stem are brittle, with corky bark.

Leaves are feathery, pale green, compound, tripinnate, (30–60 cm long), with many small leaflets, 1.3–2 cm long, 0.6–0.3 cm wide, lateral ones slightly elliptic, terminal ones obviate, and slightly larger (Figure 1). Flowers are fragrant, white, or creamy-white, 2.5 cm indiameter, and borne in sprays. The stamens are yellow, and the pods are pendulous, brown, triangular, splitting length wise into three parts when dry, and containing about 20 seedsembedded in the pith. The pod has nine ribs on both ends and the seeds are dark brown with three papery wings.

MATERIALS AND METHODS

The study has collaborated from the relevant other studies in international scientific journals published in PubMed, Google Scholar, Science Direct, Elsevier, Springer, and Scopus and compiled as a review for further details.

Traditional Uses

The herb has historically been employed as an antispasmodic, stimulant, expectorant, and diuretic. The flavour of the fresh root is harsh and vesicant (horseradish-like). It is utilized internally as a stimulant, diuretic, and antilithic. Gum is mucilaginous and tasteless. Acrid and stimulating, seeds. Bark is emmenogogue, even an abortifacient, as well as antibacterial and antifungal. Flowers are excellent to improve bile flow since they are cholagogues, stimulants, tonics, diuretics, and tonics. The herb also functions as an antibacterial and heart circulatory tonic. (Paikra, B. K, 2017)

Pods are anthelmintic and antipyretic, and fried pods are used to treat diabetes. Root juice is used as an antiepileptic and heart tonic. used as a diuretic in calculus condition, for neurological debility, asthma, enlarged liver and spleen, and for deep-seated inflammation. For sore throats and hoarseness, decoction is gargled. Fruit and roots are anti-paralytic. High cough is treated with leaf juice (which can be emetic in strong quantities), while influenza and catarrhal ailments are treated with fried leaves. Root bark has antiviral, anti-inflammatory, and analgesic properties. Flowers and stem bark have hypoglycaemic effects. (Nadkarni, K. M, 2009)

As a diuretic, antispasmodic, and anti-inflammatory, seed infusion is also used in the treatment of venereal illnesses. The Ayurvedic Pharmacopoeia of India listed these medicinal uses with others, including the use of dried root bark in goitre, glycosuria, and lipid diseases (together with dried seeds) and leaf, seed, root, and stem bark in internal abscess, piles. (Khare, C. P, 2007)

Phytochemistry

The leaves of the Moringa oleifera plant are rich in polyphenols, simple sugar, tannins, vitamins, rhamnose, carotenoids, phytates, phenolic acids, flavonoids, alkaloids, isothiocyanates, saponins,

oxalates, and glucosinolate triterpenoids.In addition to flavonoids, anthocyanins, proanthocyanidin, and cinnamates, (Augustin, J.M. *et al*., 2011) Leaves of MO also contains two nitrile glycosides, niazirin and niazirinin, three mustard oil glycosides, 4-[(4'-O-acetyl--Lrhamnosyloxy) benzyl] isothiocyanate, niaziminin A and They additionally included 3- and 5-caffeoylquinic acids.(Bennett, R. N. *et al*., 2003)

Benzylglucosinolate 4-(Lrhamnopyranosyloxy) is present in the bark of the moringa plant. (Bennett, R.N. *et al*., 2003) Octacosanic acid, vanillin, 4-hydroxymellein, and -sitosterol are all present in stem. (Saluja, M.P. *et al*., 1978) Roots containing benzylglucosinolate and 4-(-Lrhamnopyranosyloxy)-benzylglucosinolate. D-mannose, D-glucose, G-galactose, and D-glucuronic acid are all present in 18 flowers. Nitriles, an isothiocyanate, Thicarbamates, and O-[2'-hydroxy-3'-(2″-heptenyloxy)] are all present in 19 Pods.- O-ethyl-4-[(-l-rhamnosyloxy)-benzyl] carbamate, propylundecanoate, methylphydroxybenzoate, and beta-sitosterol. (Faizi, S. *et al*., 1994)

The discovery of three mustard oil glycosides, 4-[(4'-O-acetylalpha-L-rhamnosyloxy)benzyl]isothiocyanate, niaziminin A, and niazimin B, and two nitrile glycosides, niazirin and niazirinin, from the ethanolic extracts of Moringaoleifera leaves. A novel chemical is niazirinin. While 4-[(4'-O-acetyl-alpha-L-rhamnosyloxy)benzyl]isothiocyanate hasn't been found before from this source, niaziminins A and B have been combined with this extract in the past. In order to determine the structure, spectroscopic techniques were used, including the right 2D nmr tests and chemical processes. It is the first time that the isolation of nitriles, an isothiocyanate, and thiocarbamates from the same plant species 21 has been documented. Moringyne, 4-(-L-rhamnosyloxy)benzylisothiocyanate, and a number of amino acids are also present in the seeds. Additionally, benzyl isothiocyanate is present in the roots.

Additionally, the plant has antibacterial components including spirochin and pterygospermin that work against both gram-negative and gram-positive bacteria. (Anonymous, 2005)

Aldotriouronic acid, also known as O-(D-glucopyranosyluronic acid) (1-6)-D-galactopyranosyl (1-6)-Dgalactose, is a component of the gum and is produced by the acid hydrolysis of gum. Aspartic acid, glutamic acid, glycine, threonine, alanine, valine, leucine, isoleucine, histidine, lysine, phenylalanine, tryptophan, cysteine, and methionine can all be found in the leaves. (Rastogi, R. P. *et al*., 2006)

In addition to kaempferol-3-rutinoside, the stem also contains 4-hydroxy mellein, vanillin, octacosonoic acid, and sitosterol and sitosterone. (Rastogi, R. P. *et al*., 2004)

Pharmacological Activities-

Antibacterial and Antifungal Efficacy

The essential oil portion of the plant material that is present in the distillate fraction may be the cause of the stem distillate of Moringaoleifera's antibacterial and antifungal properties. The distillate of M. oleifera showed an antibacterial action by significantly reducing the growth of the test bacteria. Among the examined microorganisms, E. coli showed the most inhibition, followed by S. aureus, K. pneumoniae, P. aeruginosa, and B. subtilis. Reduced colony diameter on distillate-poisoned plates compared to control plates was another indication of fungus being inhibited. (Arora, D. S. *et al.*, 2014)

Anti-Oxidant Effect

By screening the hydro-ethanolic extract for phytochemicals, it was discovered that Moringa has the antioxidant activity of phenolic compounds. Bioactive substances such flavonoids, isothiocyanates, glucosinolates, and thiocarbamates are present in moringaoleifera pods. These substances replenish membrane-bound antioxidants, quench ROS, and chelate metal ions. The principal chemicals identified in the plant's drumsticks and the vitamins A and C found in M. oleifera provide an explanation for their mechanism of action in the induction of antioxidant

Neuroprotective Potential

An area of research into M. oleifera'sneuroprotective properties is just beginning. In mice with colinotoxin-induced dementia, it has been demonstrated that M. oleifera leaf aqueous and hydroalcoholic extract potentiates cognitive function in addition to acting as a neuroprotec-

tive. In response to the administration of leaf extract, there were lower levels of brain lipid peroxidation and higher levels of catalase and superoxide dismutase. Additionally, another study has shown that an ethanolic extract of M. oleifera leaves exhibits neuroprotective characteristics when it is incubated with a primary culture of hippocampus neurons. (Brilhante, R. N. *et al*)

Anti-Convulsant

The maximum electroshock seizure test and the pentylenetetrazole-induced convulsion test were subjected to experiments on Swiss albino mice to determine the effects of M. oleifera leaf ethanol extract. In both tests, M. oleifera reduced mortality relative to the control group, which had deaths. According to the study, the extract may block NMDA receptors, calcium channels, sodium channels, or channels, or it may have GABA agonist activity. (Joy, A. E. *et al*., 2013)

Antiviral

A hydroalcoholic extract of the plant's leaves decreased the ccDNA level of HBV in HepG2 cells, and a buffer extract of M. oleifera fruits showed anti-HBV efficacy. (Waiyaput, W. *et al*., 2012) A survey indicated that M. oleifera was being used as an addition to antiretroviral therapy for HIV infection, but no additional research has been done on the effectiveness of the plant as an antiviral agent. (Monera, G. T. *et al*., 2010)

Antifertility

According to Mekonnen, (2002), an ethanolic extract of moringa leaves decreased fertility by 73.3%. On the uteri of guinea pigs and mice, the extract displayed oxytocic action. Additionally, the extract enhanced the mice's uteri's smooth muscle, which could cause it to contract and prevent implantation.

Furthermore, 400 mg/kg of the extract from M. stem bark reduced implantation by 46% (Ravichandiran, V. *et al*., 2007).

Anti-Inflammatory Activity

Use of carrageenan-induced hind paw edema in rats to test the anti-inflammatory effects of hot water infusions of Moringa oleifera flowers, leaves, roots, seeds, and stalks or bark (Cáceres, A. *et al*., 1992).

A mouse model of carrageenin-induced paw edema was used to test the anti-inflammatory properties of a methanol extract of Moringa oleifera root bark.(Medhi, B. *et al*., 1996)

Using indomethacin (10 mg/kg) as the reference medication and carrageenin as the oedema inducer, an aqueous extract of the root of Moringa oleifera was tested for its anti-inflammatory effects in rats. The treatment with Moringa oleifera at a dosage of 750 mg/kg considerably prevented the onset of oedema at 1, 3, and 5 hours (reductions of 53.5, 44.6, and 51.1%, respectively (Ndiaye, M. *et al*., 2002).

The ethanolic extract of Moringa oleifera seed has anti-inflammatory properties. Toluene diisocyanate (TDI as antigen)-induced asthma in Wistar rats was tested pharmacologically to see how the extract affected immune-mediated inflammatory responses (Mahajan, S. G. *et al*., 2007).

Anti-Diabetic Activity

Glucose tolerance in Goto-Kakizaki and Wistar rats was improved by the anti-diabetic effects of leaves of Moringa oleifera. Wistar rats' blood glucose levels were considerably lowered with moringa. The area under the curve for changes in blood glucose was much greater in Goto-Kakizaki rats. Comparing Goto-Kakizaki rats to Wistar rats, MO's effect was stronger. (Ndong, M. *et al*., 2007)

Moringa oleifera leaf aqueous extract's antidiabetic effects on body weight, urine sugar, urine protein, hemoglobin, and glycemic control (Jaiswal, D. *et al*., 2009).

Wound Healing Effect

Ethyl acetate and a 300 mg/kg dosage of a water extract of M. oleifera leaves had a substantial impact on wound healing following incision or excision, according to research (Mishra, G. *et al*., 2011).

According to research, dried pulp extracts from leaves, seeds, and other plant materials can effectively improve wound closure, reduce granuloma rupture strength, and lessen skin rupture strength in scar tissue in preclinical tests (Muhammad, A. A. *et al*., 2016).

In diabetic rats, leaf extracts improved the down

regulation of inflammatory markers and increased the amount of vascular endothelial growth factor in the wounded tissue, demonstrating encouraging outcomes. Materials (Bhattacharya, A. *et al*., 2018)

Various inflammatory indicators have been down regulated by substances in aqueous extract, which has had a significant impact on diabetic foot ulcers (Muhammad, A. A. *et al*., 2016).

Immunomodulatory Activity

Active plant components such isothiocyanate and glycoside cyanide are present in the plant's methanolic extract, and they have immune-stimulatory action and can thus help to improve immunity. According to a recent review study, a variety of bioactive substances have been utilized to treat a number of immune-related conditions, including cancer, hypertension, and diabetes, and this has improved host immunity (Mehwish, H. M. *et al*., 2020).

Cardiovascular Activity

Examined how giving M. oleifera seed powder to spontaneously hypertensive rats (SHR) by mouth affected their hearts. For eight weeks, SHR was given either regular food or food with the powder (750 mg/day). Then, hemodynamic parameter measurements were made in vivo. According to the findings, M. oleifera treatments did not change the blood pressure in SHR but instead decreased nocturnal heart rate and enhanced cardiac diastolic function. After therapy, there was also a decrease in the thickness of the front wall of the left ventricle (LV), the interseptal thickness during diastole, and the relative wall thickness. In the left ventricle of the SHR treated with M. oleifera, they also discovered a considerable decrease in fibrosis. They linked higher expression of the PPAR- and - receptors and higher plasmatic prostacyclin levels to the aforementioned antihypertrophic and antifibrotic action. In SHR, the extracts also increased cardiac output and ejection volume. The authors hypothesized that the positive effects of M. oleifera seed powder on cardiac function in rats may be due to their effects on signaling pathways involved in pressure overload-induced LV hypertrophy, specifically, calcium handling mechanisms, and they specifically mentioned the calmodulin-activated serine-threonine protein phosphatase calcineurin pathway as a potential target of the compound. This may be because calcineurin activity was found to gradually rise with aging in the heart of SHR, while calcineurin inhibition slows the growth of hypertrophy. Their findings supported the practical use of the plant to treat cardiac problems brought on by high blood pressure. (Randriamboavonjy, J. I. *et al*., 2016)

Antiasthmatic Activity

About 90% of cases in most global surveys of chronic respiratory diseases are asthma, which affects a significant part of people globally. For hundreds of years, asthma has been treated using complementary and alternative medicine. The Ayurvedic system of medicine has received more attention in this area, and various medications derived from local plant sources have been suggested for the treatment of bronchial asthma and have also been mainly successful in treating the condition. For the treatment of asthma, moringa oleifera has proven very helpful. guinea pigs' airways were inflamed by ovalbumin, thus it was investigated how well n-butanol extracts of M. oleifera seeds (MONB) worked against this.

Their findings suggested that MONB treatments had protective effects against acetocholine-induced bronchoconstriction and airway inflammation by increasing respiration rate, tidal volume, and total and differential cell counts in blood and bronchoalveolar lavage fluid. They came to the conclusion that MONB's antiasthmatic 44 Activities were caused by the modification of Th1/Th2 cytokine imbalances.

Investigated the effectiveness of M. oleifera seed kernels in treating bronchial asthma through a clinical investigation. For three weeks, 20 patients with mild to severe asthma received a dosage of 3 kg of the dried seed kernels. The outcomes demonstrated that therapy with M. oleifera extracts significantly reduced the intensity of asthma symptoms while concurrently improving lung function metrics.

Most patients had much higher hemoglobin (Hb) levels than expected and lower erythrocyte sedimentation rates (ESR). Additionally, asthmatic patients showed a considerable improvement in

their forced vital capacity, forced expiratory volume, and peak expiratory flow rates. No patient displayed any adverse side effects with M. oleifera. As a result, M. oleifera seeds were thought to be helpful for treating individuals with bronchial asthma. (Agrawal, B. *et al*., 2008)

CONCLUSION

Various research has been conducted to evaluate the traditionaluses of Moringa species and all of the research supported thetraditional claims. However, there are still an abundance oftraditional uses that have not been evaluated, especially in speciesother than M oleifera andM. stenopetala.Hence, further researchis needed to exploit the many uses of Moringa species.

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