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Plant with Multifarious applications: *Moringa oleifera*

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Abstract:

Moringa oleifera Lam., sometimes known as munga, is a widely grown plant in India. It refers to Moringaceae family. There are considerable levels of proteins, vitamin A, essential amino acids, minerals, antioxidants, isothiocyanates and flavonoids. Its extracts have a variety of pharmacological or nutraceutical properties, such as hypoglycemic, anti-inflammatory, antioxidant, anti-cancer, blood lipid-lowering abilities, hepatoprotective, and neuroprotective. Its phytochemicals, like flavonoids and isothiocyanates, have significant beneficial impacts which have bioactivities. In this study, we provide an overview of the bioactivities and pharmacological pathways of *M. oleifera* as they relate to the treatment and prevention of a number of chronic diseases, including inflammatory, cancer, neuro-dysfunctional and diabetes diseases.

Key words: Bioactivities, Cancer, Chronic diseases, Hepatoprotective , *Moringa oleifera*, Pharmacological effects.

1. INTRODUCTION

The well-known, widely-distributed, and multicultural *Moringa oleifera* Lam (syn. M. ptreygosperma Gaertn.) is one of the Moringaceae family's plants. (Nadkarni, 1976; Ramachandran *et al*., 1980). Due to the structure of its juvenile seed pods, other names for this tree include drumstick tree, horseradish tree (for the flavour of meals made with ground roots), and ben oil tree (for the oil produced from its seeds). Immature seed pods are consumed in some locations, despite the fact that the due to their great nutritional value, leaves are commonly utilized as a food staple (Thurber and Fahey, 2009; Mbikay, 2012; Razis *et al*., 2014). It thrives best in the tropical insular environment and is observed both naturally and artificially growing throughout the plains, notably in front yards or hedges. It frequently occurs close to the sand of rivers and streams' bottoms (The Wealth of India, 1962; Qaiser, 1973). It thrives during hot, dry, or rainy tropical climates, be able to tolerate poor soil conditions, and is not harmed by drought (Morton, 1991). Being the "natural nutrition of the tropics," it is a notable food item that has drawn a lot of attention. Many countries, including India, Pakistan, the Philippines, Hawaii, and many parts of Africa, consume the leaves, fruit, blossoms, and immature pods of this tree as a highly nutrient-dense food (D'souza and Kulkarni, 1993; Anwar and Bhanger, 2003; Anwar *et al*., 2005). Many commentaries claim that different plant preparations are employed for their anti-inflammatory, anti-hypertensive, diuretic, antibacterial, antioxidant, hypoglycemic, anti-hyperlipidemic, antitumor, febrifuge, antiulcer, cardioprotectant, and liver protective properties (Anwar *et al*., 2007; Mbikay, 2012; Razis *et al*., 2014; Sidney and Michael, 2015). It is identified as a member of the Order Brassicales, Family Moringaceae, Division Magnoliphyta, Class Magnoliopsida, Kingdom Plantae, and Genus *Moringa*, Specie *oleifera* (Fahey, 2005).

A little, quickly-growing evergreen or deciduous tree, the plant can grow as tall as 10 to 12 metres. It has scattering, fragile branches, tripinnate leaf, and pale grey bark (Foidl *et al*., 2001). The bipinnate or tripinnate leaves can reach a length of 45 cm. The hairy stalks bearing the fragrant, bisexual, yellowish-white blooms 10 - 25 cm long (hanging down or extending) axillary panicles. Various florals are around 0.7 - 1 cm in length and 2 cm broad. Tri-lobed capsules, or "pods," are what constitute fruits. When dry, they are triangular, pendulous and divided through three equal halves. They range in size from 1.8 cm wide and 30 to 120 cm long.

When the chemical components of *M. oleifera* stems, leaves, flowers, pods, and seeds were examined for the presence of bioactive substances, it was discovered that secondary metabolites with dietary, medicinal, and cosmetic benefits, such as phenolic acids, gallic acid, ellagic acid, chlorogenic acid, ferulic acid, glucosinolates, flavonoids, quercetin, vanillin, and kaempferol, predominated (Singh *et al*., 2009; Mbikay, 2012). As demonstrated in **Table 1,** many phytoconstituents of the plant have been identified and examined. Alkaloids, flavonoids, phenols, glycosides, tannins, saponins, and alkaloids from the leaves, as well as alkaloids, tannins, steroids, glycosides, flavonoids, terpenoids, and quercetin from the blooms, are the main phytochemicals obtained from the plant (Mensah *et al*., 2012; Alhakmani *et al*., 2013); vanillin, gallic corrosive, epicatechin, catechins, ferulic corrosive, caffeic corrosive, protocatecuic corrosive, cinnamic corrosive, glycosides, phytosterol, quercetin and phenols from seeds (Singh *et al*., 2013); aurantiamide acetic acid derivation, procyanidins, 3-dibenzylurea, quercetin glycoside, chlorogenic corrosive and rhamnoglucoside quercetin from roots; and triterpenoids, tannins, procyanidin, glycosides, sterols, alkaloids, octacosanoic corrosive and *β*-sitosterol from stem bark (Atawodi *et al*., 2010).

The extraordinary medical utilisation of *Moringa*, is slowly being supported by science and is a claim made by many tribes and communities based on personal experiences. It was discovered to have several necessary elements, such as omega 3 and 6 fatty acids, as well as amino acids, vitamins, antioxidants, minerals, *β*-carotene and other anti-inflammatory substances, through research (Fahey, 2005; Hsu *et al*., 2006; Kasolo *et al*., 2010). A plant's nutrient content is important for its medicinal, nutritional, and therapeutic effects (Kharusi *et al*., 2009). Moringa leaves are thought to be abundant in vitamin C, calcium, carbohydrate (between 9.17 % and 53.36 %), and

protein (between 18.6 % and 37.2 %). (Kawo *et al*., 2009; Bridgemohan and Mohamed, 2014). It is an exceptional resource of natural antioxidants. It has the ability to enhance the duration span of food items high in fat (Dillard and German, 2000; Siddhuraju and Becker, 2003). It is fed to children in various developing or undeveloped countries across the world (kasolo *et al*., 2010). It's leaves are being used for a variety of purposes, including pharmaceutical coated capsules (as powder), liquids (Ziga drinks), and tea (Al-Taweel and Al-Anbari, 2019). It is regarded as the miracle tree because of its nutritious benefits. The plant parts are traditionally utilised for a variety of purposes, even though leaves are the most frequently used part (Popoola and Obembe, 2013; Sivasankari *et al*., 2014). They are particularly useful in animal and human nourishment as well as conventional medication. Protein, calcium, beta-carotene, and antioxidant chemicals—all of which are frequently inadequate in the populations of developing and undeveloped nations—are abundant in leaves. The leaves are helpful in food preparations as dietary integrators. Traditional medicine uses these leaves to cure a range of ailments, namely diabetes, hypertension, genito-urinary problems, arthritis, swellings, wounds, typhoid fever, parasite infections, malaria, and swellings. Moreover, they are used to promote breastfeeding and boost immunity (to treat HIV/AIDS-related illnesses) (Popoola and Obembe, 2013; Sivasankari *et al*., 2014; Anwar *et al*., 2007; Abe and Ohtani, 2013; Yabesh *et al*., 2014; Kasolo *et al*., 2010). Raw plus dried leaves, as well as an aqueous infusion extract, can be consumed directly.

Similarly, using seeds is important for both traditional medicine and human nourishment. Boiling the bark in water and soaking them in alcohol yields infusions and drinks that has therapeutic potential in digestive problems (easing abdominal discomfort, ulcers, and digestion assistance), diabetes, anaemia, bad eyesight, hypertension and articular discomfort (Popoola and Obembe, 2013; Abe and Ohtani, 2013), toothache, haemorrhoids, uterine disorder, and toothache (Popoola and Obembe, 2013; Yabesh *et al*., 2014). The seeds of plant are commonly used to silt water pollutants (Popoola and Obembe, 2013).

To make drinks and infusions that are used as toothache treatments, anthelmintic and antiparalytic drugs, roots are employed (soaked in alcohol or water). (Popoola and Obembe, 2013; Sivasankari *et al*., 2014; Anwar *et al*., 2007), and sex enhancers.

Finally, flowers are utilised to create aphrodisiac chemicals as well as to cure swellings, spleen enlargement, muscle illnesses, tumours and hysteria (Anwar *et al*., 2007; Yabesh *et al*., 2014).

2. PHARMACOLOGICAL POTENTIAL

Plant has used for various nutritional and therapeutic purposes. Some pharmacological properties of *M. oleifera* is depicted in **Fig. 1**.

Table 1: Various components of *M. oleifera*

S.No	Plant Part	Chemical constituents	References
1	Seeds	β-sitosterol,4-(α-l-rhamnosyloxy-benzyl) isothiocyanate,Glycerol-1-(9-octadecanote), Kaempferol, Niazimicin, Niazinin, Quercetin	Guevara *et al*., 1999; Bennett *et al*., 2003; Atwodi *et al*., 2010; Siddhuraju and Becker, 2003; Faizi *et al*., 1992
2	Leaves	4-α-l-rhamnopyranosyloxy-benzylglucosinolate, 4-(α-l-rhamnosyloxy-benzyl) isothiocyanate, 4-*O*-glucopyranosyl-caffeoyl quinic acid, Kaempferol, Niazimicin,Niazinin,(α-l-rhamnosyloxy)benzyl) carbamate, Quercetin	Bennett *et al*., 2003; Atwodi *et al*., 2010; Siddhuraju and Becker, 2003; Faizi *et al*., 1992
3	Stem	4-α-l-rhamnopyranosyloxy-benzylglucosinolate, Kaempferol, Quercetin	Bennett *et al*., 2003; Atwodi *et al*., 2010; Siddhuraju and Becker , 2003
4	Roots	4-α-l-rhamnopyranosyloxy-benzylglucosinolate, 4-(α-l-rhamnosyloxy-benzyl) isothiocyanate, Kaempferol, Quercetin, Pterygospermin	Bennett *et al*., 2003; Atwodi *et al*., 2010; Siddhuraju and Becker, 2003; Rao *et al*., 1946; Das *et al*., 1954; Faizi *et al*., 1992
5	Flower	Pterygospermin	Rao *et al*., 1946; Das *et al*., 1954

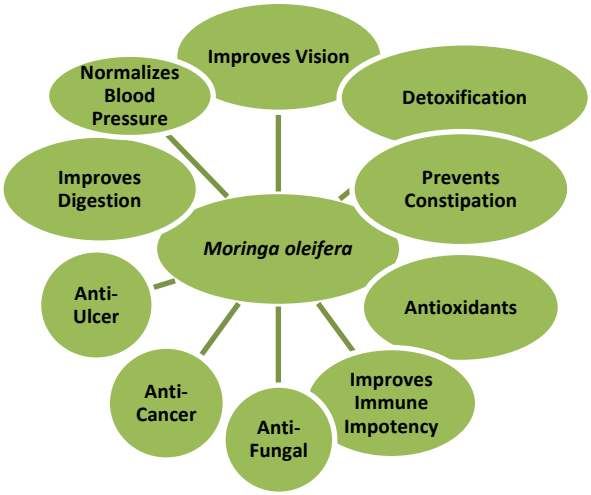

Fig. 1: Pharmacological properties of *Moringa oleifera*

Analgesic

In numerous animal models, almost every element of this "wonder tree" has been demonstrated to have analgesic effects. In both central and peripheral models (hot plate method and acetic acid-induced writhing method), extracts of leaves, seeds, and bark demonstrated considerable analgesic efficacy in a daily dosage process (Bhattacharya *et al*., 2014; Kumbhare and shivkumar, 2011; Nitin *et al*., 2008), and leaf extracts have analgesic strength comparable to indomethacin (Manaheji *et al*., 2011; Kanchan *et al*., 2012). A topical treatment was found to be effective against neuropathic pain caused by multiple sclerosis (Jurairat *et al*., 2012).

Anti-inflammatory

Leaf extract exhibits anti-inflammatory qualities when applied to paw edoema caused by carrageenan (Gurvinder *et al*., 2012; Sharma and Vaghela, 2011; Bhattacharya *et al*., 2014). In the same model, bark extracts had anti-inflammatory effects comparable to those of diclofenac. The root's anti-inflammatory qualities have also been discovered (Ndiaye *et al*., 2002; Ezeamuzie *et al*., 1996). Neutrophil modulation and the c-Jun N-terminal kinase alleyway could be responsible for the anti-inflammatory effects (McKenzie *et al*., 2014). Alkaloids, flavonoids, carotenoids, tannins, phenols, and alkaloids are active substances that contribute to the anti-inflammatory properties along with -sitosterol, 9-octadecenoic acid, vanillin, hydroxymellein, moringine, moringinine, -sitostenone, and moringine (Venkateshwara *et al*., 1999).

Antioxidant

The fruits and leaves of the plant contain antioxidant capabilities (Luqman *et al*., 2012). Extract of leaf increased glutathione levels and decreased malondialdehyde levels in dose-dependent way, the dose-dependent microsomal lipid peroxidation brought on by iron and FeSO4 was significantly reduced by root extract, while the fruit extract was helpful in removing free radicals (Sreelatha and Padma, 2009; Pasha *et al*., 2010; Kumar *et al*., 2012; Singh *et al*., 2009; Satish *et al*., 2014; Wangcharoen and Gomolmanee, 2011; Sinha *et al*., 2011). Pods may scavenge superoxyl, 2, 2-diphenyl-2-picryl hydrazyl (DPPH), and peroxyl radicals (Paliwal *et al*., 2011; Atawodi *et al*., 2010).

Its leaf concentrate has also demonstrated dose-dependent nephroprotective effectiveness in male BALB/c rats exposed to an acetaminophen-induced nephrotoxicity paradigm (Karthivashan *et al*., 2016; He *et al*., 2018; Aa *et al*., 2018). There have been numerous studies linking triterpenoids, avenasterol, vitamin A, and its precursor *β*-carotene, moringyne, monopalmitic, di-oleic triglycerides, campesterol, stigmasterol, and -sitosterol, to antioxidant qualities (Stavros and John, 2002).

Anti-diabetic

M. oleifera leaf (aqueous) extract contains anti-diabetic properties and consequently exhibits glycemic control (Ndong *et al*., 2007).

In streptozotocin (STZ)-induced diabetic albino rats, researchers looked at the antioxidant and anti-diabetic properties of methanol extracts of pods (Paikra *et al*., 2017). For 21 days, diabetic rats were given extract at different doses (150 or 300 mg/kg), and the anti-hyperglycemic properties were monitored in pancreatic and serum tissue biochemical markers. Following therapy with the extract, diabetes development was significantly inhibited. Both extract dosages significantly reduced serum glucose and nitric oxide levels in treated rats, while simultaneously increasing serum insulin and protein levels (Gupta *et al*., 2012).

In male rats, the anti-diabetic efficacy at 50 and 100 mg/kg of *Moringa* (seed) powder was assessed with STZ-induced diabetes. In comparison to the negative control group, the diabetic positive control group had higher amounts of IL-6, lipid peroxide, and lower levels of antioxidant enzyme in kidney tissue homogenate (Al-Malki and El Rabey, 2015).

Anticancer

Chemopreventive properties of the plant have been investigated, and it has been proven that it hinders the development of some human cancer cells (Karim *et al*., 2016). According to numerous studies, as oxidative DNA damage is linked to cancer and degenerative disorders, this plant's leaves can protect organisms and cells from it (Sidker *et al*., 2013). Acute lymphoblastic leukaemia, acute myeloid leukaemia, and hepatocellular carcinoma cells' viability was reduced by extract of the leaf (Khalafalla *et al*., 2010). Several bioactive chemicals found in it, including 4-(L-rhamnosyloxy) benzyl isothiocyanate, niazimicin, and -sitosterol-3-*O*-D-glucopyranoside, perhaps accountable for its malignant activities (Abdull *et al*., 2014). Pancreatic and breast cancer cells can be successfully treated using leaf extract (Sidker *et al*., 2013; Khalafalla *et al*., 2010).

It has been shown in pancreatic cells to suppress the creation of pancreatic tumor cells while also escalating effectiveness of chemotherapy by strengthening the action of drug (Berkovich *et al*., 2013). It has also been shown to have antiproliferative properties in cancer (breast) cells (Adebayo *et al*., 2017). In a recent research, breast MCF7, colorectal HCT116/Caco2, and HepG, cells were subjected to the effects of plant extractives, with roots and leaves and nanocomposites of these substances. All formulations were efficient in terms of cytotoxicity, as evaluated through cellular senescence (Abd-Rabou *et al*., 2017). *M. oleifera* leaves have also been demonstrated to successfully prevent cancer in rats with diethyl nitrosamine-caused hepatic carcinomas and reduce azoxymethane-induced colon carcinogenesis in mice in a number of research studies (Sadek et al., 2017; Budda *et al*., 2011).

Antimicrobial and Antifungal

Moringa roots work against bacteria and are high in antimicrobial compounds (Rao *et al*., 1996). These are said to include pterygospermin, a powerful antibacterial and fungicidal active ingredient in a drug (Ruckmani *et*

al., 1998). Its flowers' antibacterial and fungicidal properties have been attributed to a related chemical (Das *et al*., 1957). The root extract's 4-L-rhamnosyloxybenzyl isothiocyanate content has an antimicrobial effect (Eilert *et al*., 1981). The antibacterial and antifungal effects of the root bark's ethanol extract were attributed to deoxy-niazimicine aglycone (N-benzyl, S-ethyl thioformate), which was recovered from the chloroform fraction (Nikkon *et al*., 2003). *Staphylococcus aureus* is resistant to the antibacterial effects of the stem bark juice, and the antifungal properties of the bark extract (Bhatnagar *et al*., 1961; Mehta *et al*., 2003). Fresh leaf juice was found to prevent the growth of potentially harmful microorganisms (*Staphylococcus aureus* and *Pseudomonas aeruginosa*) (Caceres *et al*., 1991).

Anti-asthmatic

The postulated mechanism for this benefit included a direct bronchodilator action together with anti-inflammatory and antibacterial characteristics (Anita and Babita, 2008) and prevents acute oversensitive reaction (Goyal *et al*., 2009). An ethanol extract of seeds was tested against ovalbumin-induced airway inflammation in guinea pigs, and the results showed a considerable improvement in respiratory parameters and a drop in interleukins in broncho-alveolar lavage (Mahajan and Mehta, 2008).

Anti-tumor

Moringa extracts offer qualities that could help prevent cancer. Moreover, niazimicin, a substance that prevents the spread of cancer cells, is present in it (Amaglo *et al*., 2010). In this study, in sarcoma 180-bearing mice to examine the plant's floral trypsin inhibitor's anti-tumor properties (MoFTI). The treated animal tumors exhibited less minor vasculature and slighter main vessels than the control group. Food and water consumption, as well as organ and body weights do not alter much. Histological examination reveals, kidneys, spleen and the liver were not harmed. The results showed antitumor efficacy with no toxicity (Barhoi *et al*., 2021).

Anti-ulcer

Two experimental models were used to test the anti-ulcer efficacy of ethanol root's bark extract in albino Wistar rats: stomach ulcers brought on by ethanol and those brought on by pylorus ligation (Sonali *et al*., 2022). The extractive was administered (*p.o*.) in three different dosages for 15 days. Rats' antiulcer activity was assessed, and the results were statistically compared to the anti-ulcer properties of control rats given sodium chloride (saline). When contrasted with the control group, it lowered ulcer index (omeprazole). According to this study, it becomes a source for an antiulcer drug and develops advantageous antiulcer and anti-secretory properties (Choudhary *et al*., 2013).

Anti-fertility

An extract of plant's roots (aqueous) was tested in rats for its estrogenic, antiestrogenic, progestational, and antiprogestational characteristics. Oral therapy raised uterine weight in bilaterally ovariectomized rats, as did activation of the histologic framework of the uterus, indicating estrogen-like effect (Sonali *et al*., 2022). The uterine wet weight decreased along with the histologic suppression of the uterine structure when the extract was administered along with estradiol dipropionate (EDP), as opposed to when only EDP was administered. *Moringa's* anti-progestational activity was demonstrated in the deciduoma test, where the maximum dose prevented the development of deciduoma in 50 % of the rats (Shukla *et al*., 1998).

Cholesterol-lowering ability

By preventing cholesterol from building up in the veins and decreasing cholesterol production in the body, moringa lowers the risk of heart attacks and strokes (Sonali *et al*., 2022). The effectiveness of extract (methanol) of plant leaves and fruits to decrease cholesterol was investigated, and the extracts were evaluated in hypercholesterolemic animal models. After three and six weeks of treatment, the extract mixture dramatically lowered serum triglyceride levels in an animal fed a fat rich diet. The findings indicate that the plant combination may reduce levels of triglycerides and cholesterol by reducing cholesterol absorption and it may be created as a standard combination for consumers as dietary supplement (Gururaja *et al*., 2016).

CNS activity

Increased monoamine levels in the brain caused by *M. oleifera* leaf extract may be helpful for treating Alzheimer's disease (Paikra *et al*., 2017). *In vitro* tests were performed on penicillin-caused convulsions, norepinephrine, brain serotonin (5-HT), locomotor behaviour, dopamine levels, as well as the anticonvulsant effects of plant aqueous extract and ethanol extract of leaves (Talhaliani and Kar, 2000).

Fibrosis

Kidney damage is caused by kidney fibrosis, a dangerous connective tissue buildup on the kidney parenchyma. Kidney cirrhosis is primarily caused by epithelial to mesenchymal transition (EMT), and hypoxia and the TGF-1-SMAD network are known to be its main regulators (Sohn *et al*., 2015; Efstratiadis *et al*., 2009). Its extract prevents rat kidney fibroblast cells from producing PAI-1 and fibronectin, type I collagen when TGF is present (Park and Chang, 2012). Additionally, it reduced the TGF-induced stimulation of SMAD4 and ERK levels. These findings imply that it may inhibit fibrosis of the kidneys via a process related to its antifibrotic activity on rat nephro cell populations. Rats with cirrhosis of the liver brought on by CCl4 had it lessened by *M. oleifera* seed extract (Hamza, 2010).

Hepatoprotective

It appears that Moringa shields the liver from the effects of anti-tubercular drugs and may speed up the recovery time (Agarwal and Mehta, 2008). An ethanol leaf extract

was tested in rats for its ability to prevent liver damage brought on by antitubercular medications such isoniazid, rifampicin, and pyrazinamide. The extract had a significant shielding effect on blood levels of hepatic enzymes after oral dosing. This finding was supported by a liver segment histological study. Results of this study demonstrated *M. oleifera* extract therapy appeared to promote healing from liver damage brought on by antitubercular drugs (Pari and Kumar, 2002).

Reproductive effect

Testis weight, seminal vesicle weight, epididymis weight, and a greater assessment of epididymal maturation and luminal development were all considerably boosted by leaf extract, as well as the diameter of the seminiferous tubule (all doses) (Cajuday and Pocsidio, 2010).

In a cyclophosphamide-induced damage model, spermatogonial cells in the prepubescent stage in Swiss albino male mice were protected by an ethanol extract of a leaf; the likely fundamental mechanism may be an increase in c-Kit and Oct4 transcript expression unrelated to the p53-mediated pathway (Nayak *et al*., 2016).

Rats' 10-day abortive response to leaf extract following insemination has been described (Nath *et al*., 1992). The extract had a synergistic impact with estradiol and a suppressive outcome through progesterone (Shukla *et al*., 1989). Vitamin A, which is present in fresh *Moringa oleifera* leaves in amounts between 11,300 and 23,000 IU, is crucial for a number of anatomical processes, including cell differentiation, immunological development, reproduction, and embryonic growth and development (Leone *et al*., 2015; Vergara-Jimenez *et al.*, 2017).

CONCLUSION

This review's primary objectives were to study and characterise the pharmacologic and therapeutic benefits of *Moringa oleifera*; preliminary research showed that tree has a number of beneficial properties, including those for pain relief, inflammation reduction, cancer prevention, antioxidant activity, hepatoprotection, asthma relief, anti-ulcer activity, anti-tumor activity, cholesterol lowering, CNS activity, fibrosis treatment, and reproductive effects. Phytoconstituents found in the plant's flower, root, bark, stem, leaf, seeds, and pod may be responsible for these behaviours. It should be used to advance public health because it has enormous value and can serve as the foundation for pharmacological supplements. It may also be taken into account as an alternative therapy for the treatment of various disorders.

Conflict of Interest : No conflict of interest.

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