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Ethnomedicinal, Pharmacological and Antimicrobial Aspects of *Moringa oleifera* Lam.: A review

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ABSTRACT

The inclusive information is provided in present review on traditional uses, antimicrobial activity and pharmacology of *Moringa oleifera* Lam. It is commonly known as 'drumstick tree'. *M. oleifera* is alternative tonic, astringent, emollient, aphrodisiac etc. Bark of this plant is considered as cooling. Seeds of this plant are considered as aphoradisiac. It has a depressant rather than a stimulant effect on the central nervous system. Many pharmacological investigations have been carried out based on its chemical constituents. Extensive literature survey revealed many pharmacological properties includes antibacterial, antifungal, anticancer, anticonvulsant, antidiabetic, antimutagenic, anticlastogenic, anti-fertility, antiulcer, antioxidant, antiviral and wound healing activities.

Keywords: *Moringa oleifera* Lam., folk medicine, antimicrobial potential, pharmacological uses.

1. INTRODUCTION

Moringa oleifera Lam. belongs to the family Moringaceae. It is popularly called 'miracle tree'. It is a native of sub Himalayan regionss of Northern India. It is widely cultivated in tropical and subtropical regions. *M. oleifera* flower is a rich source of bioactive phytochemicals. Various parts of *M. oleifera* crude extracts showed potential antibacterial, antifungal [1], antioxidant [2], anti-inflammatory [3-4], gastro-protective, neuro-pharmacological [5] analgesic, hyperchlesterolaemic [6] anaesthetic, wound healing, anti-tumour [7], anti-spasmodic [8] anti-depressant antiviral and anticancer properties.

1.1 Geographical distribution

It is distributed mainly in India, Ethiopia, Philippines and Sudan and is also being grown in West, East and South Africa, tropical Asia, Latin America, the Caribbean, Florida and the Pacific Islands [9].

1.2 Plant description

M. oleifera is a small or middle sized tree, about 10 m in height. *M. oleifera* is cultivated throughout India. It is found wild and cultivated throughout the plains, especially in hedges and in house yards, thrives best under the tropical insular climate, and is plentiful near the sandy beds of rivers and streams [10]. *M. oleifera* has drumstick-like fruits, small white flowers and small and teardrop shaped round leaves, which are cooked and eaten as vegetable [11]. *M. oleifera* grows very quickly and if cuttings are planted close together they will form fence that livestock cannot get through in just three months [12].

1.3 Classification

Kingdom – Plantae
Division – Tracheophyta
Class – Magnolipsida
Order – Brassicales
Family – Moringaceae
Genus – *Moringa*
Species – *oleifera*

2. TRADITIONAL USES

The leaves and young buds of *M. oleifera* are used as vegetable and can be rubbed on the temples for

for relieving headache while root and root bark are regarded as anti scorbutic and can be used externally as counterirritant [10]. The eye diseases are treated with the juice of the leaves with honey. *M. oleifera* is also known to possess high nutritional value and is used in a folklore medicine to treat various ailments related to pain and inflammation [13]. Dried seeds of *M. oleifera* are used in ophthalmic preparation, venereal affection anti-inflammatory and purgative and as tonic.

3. PHARMACOLOGICAL USES

The alcohol extract of the leaves of *M. oleifera* are reported to have analgesic activity [14] and the aqueous extract of *M. oleifera* roots also shown antifertility profile [15]. *M. oleifera* is reported to possess wide range of pharmacological activities that include antitumor, antipyretic, antispasmodic, diuretic, antiulcer, hypotensive, hypolipidemic, hepato-protective, antifungal and antibacterial activities [16].

3.1 Antibacterial activity

A considerable reduction in the growth of test bacteria was observed by distillate of *M. oleifera* suggesting antibacterial effect. Among bacteria tested, more inhibition was observed in case of *Escherichia coli* followed by *Staphylococcus aureus, Klebsiella pneumoniae, Pseudomonas aeruginosa* and *Bacillus subtilis* [17].

Rahman *et al.*, (2009) [18] reported that the powder from fresh leaf juice, and cold water extract of fresh leaf shown a potential antibacterial activity for *Shigella shinga, Pseudomonas aeruginosa, Sh. sonnei* and *Pseudomonas* sp. Maximum zones of inhibition were found in powder from fresh leaf juice against all the bacteria tested which was more than one and a half to twice as much effective as known antibiotic tetracycline (30µg/disc).

Vinoth *et al.*, (2012) [19] reported that the ethanolic extract was active against *S. typhi, S. aureus* while the aqueous extract exhibited an inhibitory effect on *Staphylococcus aureus* only. Abraham *et al.* (2014) [20] reported that extracts of *M. oleifera* had great antibacterial potential on the various isolates, acetone extract of *M. oleifera* had a greater antibacterial property than crude extract and higher the concentration of extract, the higher its antibacterial property.

Doughari *et al.*, (2007) [21] observed that ethanolic extracts of *M. oleifera* showed highest activity while the aqueous extracts showed the least activity. Singh *et al.*, (2014) [22] showed that the aqueous, ethanol and methanol extracts of the plant leaves shown an inhibitory effect on the growth of the bacteria. Both ethanol and methanol extract showed a significantly higher inhibitory effect at higher concentration of 120mg/ml. The powder from the leaves of *M. oleifera* has shown potential antibacterial activity against *S. aureus* and *E. coli* and *P. aeruginosa*.

Kalpana *et al.*, (2013) [23] reported the antibacterial activity of petroleum ether, chloroform, ethanol and aqueous extracts of *M. oleifera* leaf against *Escherichia coli, Staphylococcus aureus, Klebsiella pneumoniae,* and *Streptococcus pneumoniae*.

3.2 Antifungal activity

Inhibition of fungi was also observed as reduced colony diameter in plates poisoned with distillate as compared to control plates. More inhibition of *Aspergillus niger* was found followed by *A. oryzae, A. terreus* and *A. nidulans*. The antimicrobial activity and antifungal activities of steam distillate of *M. oleifera* might be possibly due to the essential oil fraction of the plant material present in the distillate fraction [17].

3.3 Antioxidant activity

The antioxidant property of *M. oleifera* may be due to the presence of phenolic compounds that was confirmed by phytochemical screening of the hydro-ethanolic extract. *M. oleifera* pods contain important bioactive compounds including glucosinolates, isothiocyanates, thiocarbamates, and flavonoids. These compounds quench ROS, chelate metal ions and regenerate membrane-bound antioxidants. The biochemical basis of the chemo-preventive potency of *M. oleifera* extract may be attributed to the synergistic action of the constituents of the extract and the induction of Phase- II enzymes (GSTs) and antioxidant enzymes, which might be implicated in the anti-carcinogenic activity [24-26].

The aqueous extract of *M. oleifera* reported strong scavenging effect on 2, 2-diphenyl-2-picryl hydrazyl (DPPH) free radical, superoxide, nitric oxide radical and inhibition of lipid per oxidation. The free radical scavenging effect of *M. oleifera* leaf extract was comparable with that of the reference antioxidants. The extracts of *M. oleifera* both mature and tender leaves have potent antioxidant activity against free radicals, prevent oxidative damage to major biomolecules and afford significant protection against oxidative damage [27].

3.4 Anti-gastric ulcer activity

Das *et al*., (2011) [28] reported the antiulcer activity of water extracts of *M. oleifera* in two animal models of ulcers. The water extract of leaves was tested for antiulcer activity at the dose level of 200 mg and 400 mg/kg p.o. in pyloric ligation and ibuprofen induced gastric ulcer models. The severity of gastric ulceration in both the models was assessed based on the means of ulcer index. Both the models produced moderate to severe ulcers in control group of animals; in that the maximum was by pylorus ligation method.

It was also found that the aqueous extract of *M. oleifera* leaf was shown to protect rats from developing gastric ulcer induced by indomethacin in a dose dependent manner. Tannins with its protein precipitating and vasoconstriction effect could be advantageous in preventing ulcer development [29]. Tannins being an astringent may have precipitated microproteins on the site of the ulcer thereby forming an impervious protective pellicle over the lining to prevent toxic substance and resist the attack of proteolytic enzyme [30]. Presence of flavonoids has also been reported to offer some protection in ulcer development by increasing capillary resistance, and improve microcirculation which renders the cells less injurious to precipitating factors [31].

The leaf extract of *M. oleifera* was found to protect the gastric mucosa against indomethacin effect in a dose dependent manner. The leaf extract thus has the potential of an antiulcerogenic agent, which suggest it is used in traditional medicine [32].

3.5 Analgesic activity

The analgesic activity of alcoholic extract of *M. oleifera* and its various fractions as petroleum ether, ethyl acetate, diethyl ether, n-butanol were carried out by using hotplate and tail immersion method.

Amongst alcoholic extract and its various fractions of seeds of *M. oleifera* alcoholic extract shown potent analgesic activity which is comparable to that of aspirin at the dose of 25 mg/kg of body weight [33].

3.6 Local Anaesthetic activity

The local anaesthetic activity of the methanol extract of *M. oleifera* was tested in frog and guinea pig models. Root bark of *M. oleifera* has produced significant local anaesthetic activity [33].

3.7 Anti-inflammatory

Ndiaye *et al.,* (2002) [34] reported the anti-inflammatory action of an aqueous root extract of *M. oleifera* in rats with weight between 120 and 160 gm. At a dose of 750 mg/kg the *M. oleifera* action significantly inhibited the development of oedema at 1, 3 and 5 hours (reduction by 53.5, 44.6 and 51.1% respectively). Increasing the dose of *M. oleifera* to 1000 mg/kg did not increase the inhibitory effect on oedema development at 1 and 3 hours, while this dose potentiated the oedema at 5 hours.

The anti-inflammatory activity of isolated compounds was investigated with the lipopolysaccharide (LPS)-induced murine macrophage RAW 264.7 cell line. It was found that 4-[(2'-O-acetyl-alpha-l-rhamnosyloxy)benzyl]isothiocyanate (1) possessed potent NO-inhibitory activity with an IC(50) value of 1.67 µM, followed by 2 (IC(50)=2.66 µM), 4 (IC(50)=2.71 µM), and 5 (IC(50)=14.4 µM), respectively [35].

3.8 Antinociceptive Activity

Sulaiman *et al.,* (2008) [18] evaluated the antinociceptive and anti-inflammatory effects of the aqueous extract of the leaves of *M. oleifera* in laboratory animals, using the writhing, hot-plate and formalin tests as the antinociceptive assays, and carrageenan-induced paw oedema test as the anti-inflammatory assay. The extract (10, 30 and 100 mg/kg) exhibited significant ($P < 0.05$) antinociceptive activity, which occurred in a dose-dependent manner, in all tests used. The extract also exhibited significant ($P < 0.05$) anti-inflammatory activity in a dose dependent manner.

3.9 Cardio-protective activity

Nandave *et al*., (2009) [36] reported cardio-protective activity of lyophilized hydro-alcoholic extract of *M. oleifera* in the isoproterenol (ISP)-induced model of myocardial infarction. Chronic treatment with *M. oleifera* demonstrated mitigating effects on isoproterenol -induced hemodynamic perturbations. Chronic *M. oleifera* treatment resulted in significant favourable modulation of the biochemical enzymes (superoxide dismutase, catalase, glutathione peroxidase, lactate dehydro- genase, and creatine kinase-MB) but failed to demonstrate any significant effect on reduced glutathione compared to the isoproterenol control group. *Moringa* treatment significantly prevented the rise in lipid peroxidation in myocardial tissue. Furthermore, *M. oleifera* also prevented the deleterious histopathological and ultrastructural perturbations caused by isoproterenol.

3.10 Wound healing activity

The aqueous extract of leaves of *M. oleifera* was investigated for its wound healing activity. The extract was studied at dose level of 300 mg/kg body weight using resutured incision, excision, and dead space wound models in rats. The pro-healing actions seem to be due to increased collagen deposition as well as better alignment and maturation [37].

3.11 Hypotensive activity

Bioassay directed fractionation of an ethanol extract of *M. oleifera* leaves showed hypotensive activity led to the isolation of two nitrile glycosides, niazirin and niazirinin, and three mustard oil glycosides, 4-[(4'-O-acetyl-alpha-L-rhamnosyloxy) benzyl] isothiocyanate, niaziminin A, and niaziminin B. Isothiocyanate 4 and the thiocarbamate glycosides niaziminin A and B showed hypotensive activity while nitrile glycosides 1 and 2 were found to be inactive [38]. Faizi *et al*., (1998) [39] also investigated the hypotensive activity of the ethanol and aqueous extracts of *M. oleifera* whole pods and their parts, namely, coat, pulp, and seed. The activity of the ethanol extract of both the pods and the seeds was equivalent at the dose of 30 mg/kg.

3.12 Spasmolytic activity

Spasmolytic activity exhibited by the constituents of *M. oleifera* provides a scientific basis for the traditional uses of the plants in gastrointestinal motility disorders [40].

3.13 Antihelmentic activity

Rastogi *et al.,* (2009) [41] reported that the *M. oleifera* showed potent antihelmentic activity and caused paralysis within 6-15 min while death is comparable with that of piperazine citrate as death of worms was observed at 64 minutes.

3.14 Hypolipidaemic and Antiathero- sclerotic activities

Chumark *et al*., (2008) [42] reported the hypolipidaemic and antiatherosclerotic activities of *M. oleifera* leaves extract. They found that in hypercholesterol-fed rabbits, at 12 weeks of treatment, the water extract of the plant significantly ($P<0.05$) lowered the cholesterol levels and reduced the atherosclerotic plaque formation to about 50% and 86%, respectively and these effects were at degrees comparable to those of simvastatin.

The methanol extract of *M. oleifera* (150, 300 and 600 mg/kg, p.o.) and simvastatin (4 mg/kg, p.o.) along with hyperlipidemic diet were administered to Albino Wistar rats for 30 days in order to observe hypolipidaemic effect. It was found that the serum cholesterol, triacylglyceride, VLDL, LDL, and atherogenic index were reduced by *M. oleifera* and simvastatin but HDL level was increased as compared to the corresponding high fed cholesterol diet group (control). *M. oleifera* was also found to increase the excretion of fecal cholesterol [43].

3.15 Anti-urolithiatic activity

The effect of oral administration of aqueous and alcoholic extract of *M. oleifera* root-wood on calcium oxalate urolithiasis has been studied in male Wistar albino rats. Ethylene glycol feeding resulted in hyperoxaluria as well as increased renal excretion of calcium and phosphate. Supplementation with aqueous and alcoholic extract of *M. oleifera* root-wood significantly reduced the elevated urinary oxalate, showing a regulatory action on endogenous oxalate synthesis. The

increased deposition of stone forming constituents in the kidneys of calculogenic rats was also significantly lowered by curative and preventive treatment using aqueous and alcoholic extracts [44].

3.16 Anticancer activity

Krishnamurthy *et al.*, (2015) [45] reported the bioassay guided fractionation to isolate the anticancer compounds from the leaves extract of *M. olefiera*. Although no anticancer compounds could be isolated from the leaves, they had successfully isolated and characterized a potential anticancer fraction. Jung (2014) [46] reported that the soluble cold distilled water (4°C conc., 300 µg/mL) from *M. olefiera* induced apoptosis, inhibited tumour cell growth and lowered the level of internal reactive oxygen species in human lung cancer cells as well as other several types of cancer cells, suggesting that the treatment of cancer cells with *M. oleifera* significantly reduced cancer cell proliferation and invasion. The *M. oleifera* extract showed greater cytotoxicity for tumour cells than for normal cells, strongly suggesting that it could potentially be an ideal anticancer therapeutic candidate specific to cancer cells.

3.17 Anti-anxiety activity

Bhat and Joy (2014) [47] reported the anxiolytic activity of ethanol extract of *M. oleifera* extract in Swiss Albino mice by. It showed that ethanol extracts of the leaves of *M. oleifera* (200 mg/kg) demonstrated significant ($P<0.001$) anxiolytic activity in EPM and LDA models of anxiety. It is concluded that ethanol extract of *M. oleifera* leaves may have produced its anxiolytic activity.

3.18 Anti-depressant activity

Adewale *et al.*, (2013) [48] reported that the ethanol extract of *M. oleifera* leaves possesses CNS (central nervous system) depressant and anticonvulsant activities possibly mediated through the enhancement of central inhibitory mechanism involving release γ-amino butyric acid.

3.19 Antiviral activity

Nworo *et al.*, (2013) [49] reported the extracts of *M. oleifera* showing inhibitory activity against early steps in the infectivity of HIV-1 lentiviral particles in a viral-vector-based screening which showed that IC_{50} concentration of extract inhibited viral infectivity by 50% and TC_{50} concentration of extract that is cytotoxic to 50% of the cells.

3.20 Antidiabetic activity

Manjari *et al.*, (2007) [50] reported that the extract from leaf has been shown to be effective in lowering blood sugar levels within 3hours ingestion, though less effectively than the standard hypoglycemic drug, glibenclamide.

3.21 Antipyretic activity

Hukkeri *et al.*, (2006) [51] reported the antipyretic activity of ethanolic, petroleum ether, solvent ether and ethyl acetate extracts of seeds was screened using yeast induced hyperpyrexia method. Paracetamol I.P (200mg/ kg) was used as standard for comparison. The ethanolic and ethyl acetate extracts of seeds showed significant antipyretic activity in rats.

3.22 Anti-asthmatic activity

Agarwal and Mehta (2008) [52] reported the efficacy and safety of seed kernels of *M. oleifera* in the treatment of bronchial asthma. The results showed an appreciable decrease in severity of symptoms of asthma and also simultaneous improvement in respiratory functions.

3.23 Anti-fertility activity

The aqueous extract of *M. oleifera* root and bark at a dose of 200mg/kg and 400mg/kg, respectively showed post-coital antifertility effect in rat and also induced foetal resorption at late pregnancy [53].

Shukla *et al.*, (1988) [8] reported the aqueous root extract of *M. oleifera* was investigated for its estrogenic, anti-estrogenic, progestational and antiprogestational activities. Doses up to 600 mg/kg of the extract orally failed to induce a decidual response in the traumatized uterus of ovariectomized rats.

4. PHYTOCHEMISTRY

The *M. oleifera* hydro-alcoholic leaf extracts (1000 mg/kg) and *M. oleifera* aqueous fruit extract (750 mg/kg) contain high amount of tannin, phenolic compounds and flavonoids. The poly phenolic constituents of this plant could be contributory to their ethnomedical utilizations [54].

Chollom *et al.*, (2010) [55] performed the phytochemical analysis and showed that methanol extract had higher phytochemical constituents compared to aqueous extract and ether extract. Methanol extract of leaves showed the presence of saponins, alkaloids, glycosides, tannins, carbohydrates, flavonoids, resins, proteins.

M. oleifera is rich in compounds containing the simple sugar, rhamnose, and it is rich in a fairly unique group of compounds called glucosinolates and isothiocyanates. For example, specific components of *M. oleifera* preparations that have been reported to have 4-(4'-*O*-acetyl-α-L-rhamnopyranosyloxy)benzyl isothiocy-anate**,** 4- benzyl isothiocy-anate**,** niazimicin, pterygospermin**,** benzyl isothiocyanate**,** and 4- benzyl glucosinolate. It is also rich in a number of vitamins and minerals as well as other more commonly recognized phytochemicals such as the carotenoids (including β-carotene or pro-vitamin A) [9]. *M. oleifera* leaves contain 2 nitrile glycosides, niazirin and niazirinin, and 3 mustard oil glycosides, 4[(4'OacetylalphaLrhamnosyloxy) benzyl] isothiocyanate, niaziminin A, and niaziminin B. In addition, betasitosterol, glycerol1 (9octadecanoate), 3O(6'-O-oleoyl-beta-D-glucopyranosyl) beta-sitosterol, and beta-sitosterol-3-O-beta-D-glucopyranoside have also been identified [56].

5. CONCLUSSION

M. oleifera is an important medicinal plant. It is one of the most widely cultivated species of the family moringaceae. Leaves, barks, roots, stems, buds, flowers have been used for different human ailments. Pharmacologically reported effects include antibacterial, antifungal, antiviral, anti-inflammatory and analgesic, antioxidant, hypotensive, antiulcer, anaesthetic cardioprotective, antiurolithiatic activity and wound healing activities. Present review summarized several pharmacological activities of *M. oleifera* which can be investigated further to isolate active compounds for novel herbal medicine.

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