An Overview on Phytochemistry and Pharmacological Explorations of *Moringa oleifera*

Surbhi Kesharwani*, Pushpa Prasad, Amit Roy, Ram Kumar Sahu

Columbia Institute of Pharmacy, Tekari, Raipur-493111 (C.G.), India

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*Corresponding Author:

E-mail:

surbhikesharwani666@gmail.com

Tel.: +919691643654

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Abstract

Medicinal plants have been one of the prominent sources of remedies since the inception of human civilization. In rural area herbal medicines are considered to be best healthcare products due to its easily availability. Globally, demand of herbal based medicines, health products, pharmaceuticals, food supplements, cosmetics, etc. has been intensified in alarming rate. *Moringa oleifera* belongs to family Moringaceae, native of the Indian subcontinent, where its diverse parts have been employed throughout history as food and medicine. The *M. oleifera* is extensively used for treating cancer, hyperlipidemic, diabetic, ulcer, analgesic, fertility, convulsant, liver disorder, wound, etc. Dietary consumption of its part is therein promoted as a strategy of personal health preservation and self-medication in various diseases. The phytoconstituents present in this plant are niazirin, niazirinin, flavonoids, anthocyanins, proanthocyanidin, kaempferol-3-O-(6"- malonyl-glucoside), 4-hydroxymellein, β -sitosterone, octacosanic acid, β -sitosterol, etc. These various phytoconstituents contribute for different pharmacological activities. The present review is therefore, an effort to give a detailed overview of the published writings on phytochemistry and pharmacological activities of *M. oleifera*; this information will be beneficial in developing new formulations, which are more effective and have more therapeutic values.

1 Introduction

Since ancient times medicinal plants are utilized for the ailment of human disease. The resurgence of interest in natural drugs pioneered at last a decade, mostly because of the wide-spread persuasion that natural medicine is safer than the synthetic product. Nowadays, there is manifold increase in medicinal plant based industries due to the increase in the interest of use of medicinal plant throughout the world which is growing at a rate of 7 to 15% annually¹. In India diverse system of medicinal practices are employed namely Ayurveda, Siddha, Unani, Amchi and local health traditions. These systems utilize a large number of medicinal plants for treatment of human and animal diseases^{2,3}. Among different medicinal plants *Moringa oleifera* are used in Indian traditional medicine and in folklore for many diseases. The interesting things of this plant are each part of *M. oleifera* is used as medicines.

M. oleifera belongs to family Moringaceae. It is known for high nutritional and medicinal value. It physically resembles as a stick therefore a closely name given as drum stick⁴. It is widely used as a

nutritive herb and possesses valuable pharmacological activities. It possess various pharmacognostical features, phytochemistry, nutritive and pharmacological activities like antimicrobial, anticancer, antihyperlipidemic, antidiabetic, antiulcer, analgesic, antifertility, anticonvulsant, hepatoprotective etc⁵. The leaves, roots, barks, flowers, pods and seeds of *M. oleifera* are used for the treatment of various diseases⁶.

M. oleifera are widely promoted in areas of chronic malnutrition as nutritional supplements for weaning infants and nursing mothers. Pods and leaves are suited for local markets where South and Southeast Asian foods are sold. In various scientific data it is documented that this plant content high nutritive value. Now it is required to aware the people of its nutrition value along with medicinal properties so that they can easily consume it⁷.

This review accomplishes to contribute an overview of the phytoconstituents present in various parts of the *M. oleifera* and their pharmacological actions.

2 Geographical sources

M. oleifera is a quick growing tree of 10 m tall, widely cultivated all over the plains of India and naturalized in tropical area. It is also cultivated in north-eastern Pakistan, north-eastern Bangladesh, Sri Lanka, West Asia, the Arabian Peninsula, East and West Africa, throughout the West Indies and southern Florida, in Central and South America from Mexico to Peru, as well as in Brazil and Paraguay. It is cultivated in hedges and homeyard. It grows in all types of soil and grows best in conditions provided in North India and South India⁸. Leaves are up to 60 cm long. The flowers are 1.5-2 cm long. Fertile filaments covered with long fire hair pods 15 to 30 cm long pendulous^{9,10}.

3 Taxonomical classifications

Kingdom	-	Plantae
Subkingdom	-	Tracheobionta
Super division	-	Spermatophyta
Division	-	Magnoliophyta
Class	-	Magnoliosida
Subclass	-	Dilleniidae
Order	-	Capparales
Family	-	Moringaceae
Genus	-	<i>Moringa</i> Adans
Species	-	<i>Moringa oleifera</i> Lam
Synonyms	-	<i>Moringa pterygosperma</i>

4 Vernacular names¹¹

Sanskrit	-	Shigru
Hindi	-	Soanjna
Bengali	-	Sajna
Tamil	-	Murungai
English	-	Drum stick tree, Horseradish tree

5 Traditional uses

Each part of *M. oleifera* has unique medicinal properties; hence traditionally it is used for the treatment of various diseases. Some of them are listed below⁵:

- a) **Leaves:** It possess different properties such as Antibacterial, Infection, Urinary tract infection, Epstein –bar virus, Herpes simplex virus, Fever, Hepatic, Anti-tumor,

Headache, Antioxidant, Lactation, Antiseptic, Scurvy, and tonic.

- b) **Flowers:** Throat infection, Common cold, Anthelmintic, Antitumor, Rheumatism, Diuretic, Tonic.
- c) **Roots:** Cardiotonic, Dental caries, Common cold, Diuretic, Antispasmodic, Epilepsy, Gout, Headache, Abortifacient, Carminative.
- d) **Bark:** Dental caries, Toothache, Common cold, Antitumor, Snakebite, Scorpion bite, Abortifacient, Birth control and Scurvy.
- e) **Pods:** Anthelmintic, Skin cancer, Anti-hypertensive, Diabetes, Joint pain.
- f) **Gum:** Rheumatism, Astringent.
- g) **Seeds:** Anthelmintic, Warts, Anti-tumor, Ulcer, Rheumatism, Arthritis, Antispasmodic
- h) **Exudates:** Dental caries, Syphilis, Typhoid, Headache, Abortifacient.

6 Pharmacological activity

The *M. oleifera* contain wide range of phytoconstituents and due to these important pharmacological activities have been reported¹²⁻³⁶. The scientifically proved pharmacological activities of this plant are listed in Table 1.

7 Phytochemistry

Phytochemical investigations of *M. oleifera* have revealed that many components of this plant are highly bioactive. The summarize phytoconstituents³⁷⁻⁴² of *M. oleifera* are illustrated in table 2, and some important chemical structure are presented in figure 2.

8 Conclusion

It is concluded that *M. oleifera* play vital role in the ailment of various diseases. The different parts of this plant are reported to possess anticancer, antihyperlipidemic, antidiabetic, antiulcer, analgesic, antifertility, anticonvulsant, hepatoprotective, etc. Moreover *M. oleifera* have been used for decades to combat malnutrition. In *M. oleifera* the phytoconstituents such as sterols, flavonoids, β -sitosterol, glycosides, anthocyanins, proanthocyanidin etc present in adequate amount; and this make the plant medicinally important and/or nutritionally valuable. The present review showed that it is useful in a number of diseases. These investigations will be helpful to researchers for further utilization of the *M. oleifera* in inventing novel formulations, which are more effective and have more therapeutic values. Moreover, not much work has done on isolation and purification of bioactive component presents in this plant. Hence this review also support the researchers belong to phytochemistry, to isolate and purify novel pharmacologically active and industrially important compounds.

Table 1 Pharmacological activities of *M. oleifera*

Pharmacological activity	Plant parts	Extracts	Outcomes	References
Nephrotoxicity activity (Gentamicin-induced)	Leaves	Aqueous-ethanolic	Aqueous-ethanolic extract of <i>M. oleifera</i> leaves attenuates renal injury in rabbits treated with gentamicin, possibly by inhibiting lipid peroxidation	Ouedraogo et al. 2013
Antiproliferative effect (Cancerous human alveolar epithelial cells)	Leaves	Aqueous	Extracts exerts antiproliferative effects in A549 lung cells by increasing oxidative stress, DNA fragmentation and inducing apoptosis.	Tiloke et al. 2013
Antidiabetic activity (T)	Leaves	Leaves formulated into tablets	<i>M. oleifera</i> leaves formulated into tablets possess good physicochemical and antidiabetic properties in addition to being a supplement.	Momoh et al. 2013
Antiulcer potential	Root-bark	Ethanol	Extract significantly reduced the free acidity, total acidity, and ulcer index and increased the pH of gastric content compared with the control group. This suggests that MO possesses valuable antiulcer, antisecretory, and cytoprotective activity.	Choudhary et al. 2013
Retinoprotective effects			Extract treated retinae showed intact retinal vasculature. Further, results of the transmission electron microscopy study showed thickened capillary BM in the diabetic retina as compared to normal retinae. However, treatment with extract prevented thickening of capillary basement membrane.	Gupta et al. 2013
Antidiabetic activity	Pod	Methanol	Extract significant reduced serum glucose and nitric oxide, with concomitant increases in serum insulin and protein levels. Furthermore, extract treatment increased antioxidant levels in pancreatic tissue, with concomitant decreases in levels of thiobarbituric acid-reactive substances. <i>M. oleifera</i> exerts protective effects against STZ-induced diabetes.	Gupta et al. 2012
Hepatoprotective activity (Acetaminophen-induced hepatotoxicity)	Leaves	Hydroalcoholic	Extracts significantly recovered necrosis of liver cells, by antioxidant mechanism.	Fakurazi et al. 2012
Antioxidant property	Leaves	Ethanol	Strong antioxidant activity	Moyo et al. 2012
Antistress activity	Leaf and Fruit	Ethanol extracts	Both leaves and fruit exhibited antistress activity by reducing the free radical generated by stress.	Luqman et al. 2012
Protease activity	Leaves and	Aqueous	Both the extracts exerted their procoagulant activity	Satish et al. 2012

	root		by selectively hydrolyzing A α and B β subunits of fibrinogen to form fibrin clot, thereby exhibiting fibrinogenolytic activity.	
Antinociceptive and anti-inflammatory effects	Seed	Isolate chitin-binding protein from seeds	Study describes that the chitin-binding protein from <i>M. oleifera</i> seeds, exhibits anti-inflammatory and antinociceptive properties and scientifically supports the use of this multipurpose tree in folk medicine.	Pereira et al. 2011
Anti-oxidative stress (Radiation-induced oxidative stress)	Leaves	Ethanol	Pretreatment with extract protected against γ -radiation-induced liver damage. The protection may be attributed to the free radical scavenging activity of extract, through which it can ameliorate radiation-induced oxidative stress	Sinha et al. 2011
Antiarthritis activity (Freund's adjuvant-induced arthritis in rats)	Leaves and root	Methanolic	Methanolic extracts of the root or leaf of <i>M. oleifera</i> are effective in the reduction of pain induced by complete Freund's adjuvant in rats. A comparison of single and combination therapies of root and leaf extracts also showed a synergistic effect on pain reduction.	Manaheji et al. 2011
Renoprotective effects	Pods	Hydroethanolic	Enhanced the levels of antioxidants and enhanced the levels of biochemical assays in DMBA-induced carcinogenesis were by reducing the formation of free radicals	Sharma et al. 2010
Anti-inflammatory activity of phenolic glycosides	Fruits	Four polyphenolic compound	Polyphenolic compounds were responsible for the reported NO-inhibitory	Cheenpracha et al. 2010
Cardioprotective activity (Isoproterenol-induced myocardial damage in rats)	Leaves	Hydroalcoholic extract	Extract possesses significant cardioprotective effect, which may be attributed to its antioxidant, antiperoxidative, and myocardial preservative properties.	Nandave et al. 2009
Hyperglycemic activity	Leaves	Aqueous	Extract indicates significant reduction in urine sugar and urine protein levels	Jaiswal et al. 2009
Protective Effect of Antiarthritis activity	Seeds	Ethanolic	Extract exhibited, percentage reduction in body weight was less, paw edema volume and arthritic index score was decreased significantly as compared to diseased control animals. This confirmed plant possesses promising antiarthritic property	Mahajan et al. 2007
Wound healing activity (resutured incision; excision and dead space wound models in rat)	Leaves	Aqueous	Significant increase in wound closure rate, skin-breaking strength, granuloma breaking strength, hydroxyproline content, granuloma dry weight and decrease in scar area was observed.	Rathi et al. 2006

Inhibit arsenic-induced toxicity	Seed	Seed powder	Extract has significant role in protecting animals from arsenic-induced oxidative stress and in the depletion of arsenic concentration.	Gupta et al. 2005
Radioprotective effect	Leaves	50 methanolic	Result demonstrated that pretreatment with the methanolic leaf extract of <i>M. oleifera</i> confers significant radiation protection to the bone marrow chromosomes in mice and this may lead to the higher 30 day survival after lethal whole body irradiation	Rao et al. 2001
Antitumor promoter	Seed	Ethanol	Results indicates that it was potent chemo-preventive agent in chemical carcinogenesis	Guevara et al. 2001
Regulation of thyroid hormone	Leaves	Aqueous	After administration of the extract, serum triiodothyronine concentration and hepatic LPO decreased with a concomitant increase in the serum thyroxine concentration, in female rats, while in males no significant changes were observed, suggesting that <i>Moringa oleifera</i> leaf extract is more effective in females than in the males.	Tahiliani et al. 2000
Screening for antispasmodic, antiinflammatory and diuretic activity	Flowers, leaves, roots, seeds and stalks	Water infusions	The seed infusion showed a significant inhibition of acetylcholine-induced contraction with an ED50 of 65.6 mg/ml bath concentration, inhibition of carrageenan-induced edema at 1000 mg/kg and diuretic activity at 1000 mg/kg. Some activity was also demonstrated in the roots. All doses expressed here are as equivalents of dried starting plant material.	Caceres et al. 1992
Abortifacient activity	Seed	Ethanol	Extract exhibited significant abortifacient activity	Sethi et al. 1988

Table 2 Phytoconstituents present in *M. oleifera*

Plant Parts	Phytoconstituents	Reference
Leaves	Two nitrile glycosides, niazirin and niazirin and three mustard oil glycosides, 4-[(4'-O-acetyl- α -L-rhamnosyloxy) benzyl] isothiocyanate, niaziminin A and B, α -L-rhamnosides of 4-hydroxy-benzyl compounds with nitrile, carbamate and thiocarbamate groups, flavonoids, anthocyanins, proanthocyanidin and cinnamates, quercetin-3-O-glucoside and quercetin-3-O-(6"-malonyl-glucoside), and lower amounts of kaempferol-3-O-glucoside and kaempferol-3-O-(6"- malonyl-glucoside). They also contained 3-caffeoylquinic and 5-caffeoylquinic acid	Bennett et al. 2003; Faizi et al. 1994; Faizi et al. 1995
Bark	4-(α -L-rhamnopyranosyloxy) -benzylglucosinolate	Bennett et al. 2003
Stem	4-hydroxymellein, vanillin, β -sitosterone, octacosanic acid and β -sitosterol	Saluja et al. 1978
Roots	4-(α -L-rhamnopyranosyloxy)-benzylglucosinolate and benzylglucosinolate	Bennett et al. 2003
Flowers	Sugars, D-mannose and D-glucose , G-galactose and D-glucuronic acid	Pramanik et al. 1998

Pods	Nitriles, an isothiocyanate and Thicarbamates and O-[2'-hydroxy-3'-(2"-heptenyloxy)]-propylundecanoate and O-ethyl-4-[(α -l-rhamnosyloxy)-benzyl] carbamate, methyl- <i>p</i> -hydroxybenzoate and β -sitosterol	Bennett et al. 2003; Faizi et al. 1998; Faizi et al. 1995; Faizi et al. 1994

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4-hydroxy mullein

4-hydroxymellein

R=H → β -sitosterol

Niazirin

Niazirin

Benzylglucosinolate

Quercetin

Anthocyanins

Proanthocyanidin

Methyl-phydroxybenzoate

Figure 1 Chemical structure of some important phytoconstituents present in *M. oleifera*