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# *Moringa Oleifera* Lam. (Sahijan) - A Plant with a Plethora of Diverse Therapeutic Benefits: An Updated Retrospection

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## Abstract

*Moringa oleifera* Lam. syn *M. pterygosperma* Gaertn (Family-Moringaceae) is exemplified as a panacea for various ailments in traditional medicine. Scientific studies over a few decades have reconfirmed to the folklore claims, establishing its potential as an analgesic, anti-inflammatory, diuretic, antihypertensive, antioxidant and antitumor agent. Various other pharmacological attributes such as antiarthritic, antispasmodic, antiurolithic, hepatoprotective, anaphylactic, antihyperglycemic etc have also been conferred to it. The present review is an updated compilation of some important phytochemical, pharmacological and preliminary studies on *M. oleifera* and the principles isolated from it. The above investigations are motivational enough and demand further studies to explore its therapeutic and other possible benefits.

**Keywords:** Phytochemical profile; Pharmacological attributes; *Moringa oleifera*; Toxicity studies

## Introduction

*Moringa oleifera*, Lam syn. *M. pterygosperma*, Gaertn ( Family – Moringaceae), is a small or medium-sized tree, attractive enough to be a focal point in the tropics and sub-tropics owing to its creamy – white, sweetly scented flowers and light –green, tripinnately compound foliage [1-3]. It is a native to India, occurring wild in the sub-Himalayan regions of Northern India and cultivated throughout the country. It is commonly known as Sajina, sajna (Bengali); Horseradish tree, drumstick tree(English); Sahinjan, mungna(Hindi); Murinna, muringa, tishnagandha (Malyalam); Sevaga, segata (Marathi); Sohanjana (Punjabi); Sobhanjana, sigru, murungi, dvishiguru (Sanskrit) and Sehjan(Urdu) in varied Indian languages and regions [4,5]. It also thrives well in Pakistan, Bangladesh, Sri Lanka, tropical Africa, Arabia, Philippines, Cambodia and Central, North and South America [6-10].

Described as "one of the most amazing trees God has created", almost every part of drumstick viz. bark,root, fruit, flowers, leaves, seed and gum is a rich repository of proteins, vitamins and minerals including potassium, calcium, phosphorus, iron, folic acid as well as β carotene. Leaves can be eaten fresh, cooked or stored as dry powder for many months without refrigeration, without loss of nutritional value. Almost all the parts of this plant have been used for various ailments in the indigenous medicine of South Asia [11,12]. The named varieties of moringa include Jaffna or Yazhpanam, grown in various parts of South India, (producing 60-90 cm long pods), Chavakacheri murungai, (producing pods 90-120 cm long), Chemmurungai (with red tipped fruits), Kadumurungai, Palmurungai, Puna murungai (with thick pulp and bitter taste), Kodikkal Murungai etc. [13,14]. The Horticultural College & Research Institute of Tamil Nadu Agricultural University has released two improved annual moringa varieties (PKM-1, PKM-2) within a span of 10 years, for commercial cultivation [15,16]. The folklore claims and ancient literature report moringa to be an abortifacient, antidote, antirheumatic, bactericide, diuretic, ecbolic, emetic, expectorant, purgative, rubefacient, stimulant, tonic, vermifuge and vesicant [17-20].

M. oleifera is incorporated in various marketed formulations, such as Rumalaya and Septilin (The Himalaya Drug Company, Bangalore India), Orthoherb (Walter Bushnell Ltd. Mumbai, India ), Kupid Ford (Pharma Products Pvt Ltd, Thayavur, India ) and Livospin ( Herbals APS Pvt. Ltd., Patna, India ), which are available for a variety of ailments [21]. Ayurvedic preparations include Ratnagiri Rasa, Sarasvata Ghrta, Sudarsana churna, Sarsapadi Pralepa, Visatimduka Taila etc [4,5].

Leaves of moringa are applied as poultice to sores and in treatment of anemia and menstrual irregularities. Young leaf paste with curd, is used internally for stomachache while externally for sprains. Leaf juice or bark paste is used as a drink for constipation and piles [22,23].

The root juice is applied externally as rubefacient or counter irritant, in hiccups, lumbago, enlarged spleen or liver. Bark, leaves and roots are acrid and pungent, taken to promote digestion. A reddish gum exuded from the bark possess anti diarrhoeal, emmenagogue, antiscorbic and abortifacient properties. According to Materia Medica, a compound spirit made from equal parts of roots of Moringa and orange peel acts as carminative and stimulant in nervous debility, paralytic afflictions, epilepsy and hysteria [24-26]. Not only this, moringa is glorified as a 'traditional mother care plant', for the leaves are highly nutritious for pregnant women [27].

Until now, only a very few attempts have been made to compile the myriad of potential uses of this "miracle tree". In view of a number of recent findings of ethnopharmacological importance, an updated appraisal was much needed. So, the present review is an attempt to bridge the lacunae in the existing literature and offer immense scope for researchers engaged in validation of traditional claims & development of effective novel herbal formulations of *M. oleifera*.

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## Pharmacological Attributes

### Antipyretic

A dose-dependent reduction in normal body temperature and yeast-provoked pyrexia was observed after administration of ethanol extract of seeds to albino rats [66].

### Antiasthmatic

The ethanolic seed extract of *M. oleifera* has potential to prevent immune mediated inflammatory responses in toluene diisocyanate – induced asthma in wistar rats. Levels of TNF-alpha, IL-4 and IL-6 were found to reduce significantly in the serum and bronchalveolar fluid [67]. The n-butanol extract of the seeds of the plant possess inhibitory effect on airway inflammation [68].

Finely powdered dried seed kernels find great utility in patients of bronchial asthma [69].

### Anti-inflammatory, antiarthritic and analgesic

Extract of roots of *M. oleifera* reduces the carrageenin- induced paw oedema to similar extent as the potential anti inflammatory drug indomethacin [70]. Aurantiamide acetate and 1,3 dibenzyl urea isolated from roots showed significant anti-inflammatory /antiarthritic and analgesic activity mediated via inhibition of TNF-alpha, IL-2 and other cytokines [21]. The serum level of rheumatoid factor (RF) was also reported to decrease [71]. The alcoholic extract of seeds was found to be a potent analgesic when study was carried out in wistar male albino rats using hot plate and tail immersion method [72]. It was found that methanolic extract of the root not only produced analgesia in mice but also potentiated the analgesic action morphine and pethidine [73].

### Hypocholesterolemic

A dose of 1 mg/g of crude leaf extract was co-administered with high fat diet to male Wister rats for a period of 30 days .The high-fat diet- induced increase in cholesterol was reduced in serum (14.35 %), liver (6.40 %) and kidney (11.09 %), compared to the high fat exclusive group, when their levels were determined by the method of Zlatis [74,75].

*M. oleifera* treated hypercholesterolaemic rabbits also showed a decrease in lipid profile of liver, heart and aorta with an increase in excretion of faecal cholesterol [76]. The incidence of formation of atherosclerotic plaque reduced to about 86% after 12 weeks of treatment [77].

### Wound healing

The aqueous extract of *M. oleifera* leaves and ethyl acetate extract of dried leaves was found to posses significant wound healing potential. For study, 10 % extract were applied on excision, incision and dead space (granuloma) wound models in rats, in the form of ointment [78,79].

| Phytochemical present | Isolated from | References |
|---|---|---|
| Aurantiamide acetate (a rare dipeptide) and 1,3 dibenzyl urea | Root | 21 |
| Vanillin, β-sitosterol, β-sitostenone, 4-hydroxymellein and octacosanoic acid | Stem | 28, 29 |
| Alkaloids- moringine, moringinine | Stem bark | 30 |
| L-arabinose, D-galactose, D-glucuronic acid, L-rhamnose, D-mannose and D-xylose | Gum | 31 |
| Nitrile glycosides- niazirin and niazirinin, three mustard oil glycosides, 4-[(4'-O-acetyl-α-L-rhamnosyloxy)benzyl]isothiocyanate, niaziminin A and niaziminin B.<br>Growth promoters, Phenolic acids-gallic,chlorogenic,ellagic and ferulic acid.<br>Flavonoids- kaempferol, quercetin and rutin;<br>Ascorbic acid, carotenoids (mainly lutein and β-carotene) | Leaves | 29, 32-41 |
| Glycosides- thiocarbamate and isothiocyanate<br>Two new compounds, O-[2'-hydroxy-3'-(2"-heptenyloxy)]-propyl undecanoate and O-ethyl-4-[(α-L-rhamnosyloxy)-benzyl] carbamate.<br>Methyl p-hydroxybenzoate and β-sitosterol have also been isolated.<br>A water-soluble polysaccharide was isolated from the aqueous extract of pods of *Moringa oleifera*. The polysaccharide contains d-galactose, 6-*O*-Me-d-galactose, d-galacturonic acid, l-arabinose and l-rhamnose.<br>Plant hormones- auxins and cytokinins | Pods | 42-45 |
| Glycosides-carbamate,thiocarbamate, and isothiocyanate<br>Ascorbic acid, oestrogenic substances, β-sitosterol, iron, calcium, phosphorus, copper, Vitamin A, B, C, α-tocopherol,riboflavin,nicotinic acid, folic acid, pyridoxine, β-carotene, proteins, essential amino acids – methionine, cystine, tryptophan and lysine<br>Novel bioactive nitrile glycosides-<br>Niaziridin and niazirin | Leaves and pods | 29,35,46-54 |
| Amino acids,sucrose,d-glucose, traces of alkaloids, wax<br>Flavonoids -quercetin, kaempferol, isoquercitrin,rhamnetin, kaempferitrin<br>Minerals- potassium, calcium | Flowers | 29, 55-57 |
| α and gamma tocopherols | Leaves, flowers and fresh beans | 58 |
| O- ethyl -4- (α-L-rhamnosyloxy)benzyl carbamate, 4(α-L-rhamnosyloxy)benzyl isothiocyanate, 4(α-L-rhamnosyloxy)benzylglucosinolate, niazimicin, 3 –O-(6'-O-oleoyl-beta-D-glucopyranosyl)-β-sitosterol, β-sitosterol-3-O-β-D-glucopyranoside, niazirin, β-sitosterol, glycerol-1-(9-octadecanoate), isothiocyanates,thiocarbamates and flavonoids<br>Presence of a hemagglutin is also reported | Seeds | 16, 59-62 |
| Campesterol(up to 15.13 %),stigmasterol(up to 17.27%), β-sitosterol (up to 50.07 %),delta5-avenasterol,delta7-avenasterol, clerosterol,24- methylenecholesterol, delta7-campestanol, stigmastanol, 28- isoavenasterol, unsaturated fatty acids - (especially oleic acid upto 75.39 %)<br>Saturated fatty acids- behenic (up to 6.73%) and palmitic (upto 6.04 %)<br>monoterpenoid compounds (81.8%) dominate the oil of *Moringa oleifera* with an abundance of α-phellandrene (25.2%) and p-cymene (24.9%) | Seed oil | 34,50,63-65 |

A wide range of phytoconstituents have been isolated from *M. oleifera*, as mentioned in Table 1.

**Table 1:** Various phytochemicals isolated from *Moringa oleifera* Lam.

### Antithyroid

Tahilyani and Kar studied the role of *M. oleifera* leaf extract in the regulation of thyroid hormone status in adult Swiss rats and found that it plays an inhibitory role in the peripheral conversion of tetraiodothyronine (T4) to triiodothyronine (T3) .Lower concentrations of this extract can be used to check hyperthyroidism [80].

### Antimicrobial

Fresh leaf juice and aqueous extract from the seeds was found to inhibit the growth of *P. aeruginosa*, *S. aureus* and *B. subtilis*. A compound 4 (α-L-rhamnosyloxy) benzylisothiocyanate, isolated from the seeds and roots is reported to act on several bacteria and fungi [81,82]. Rao and Kurup performed a series of experiments to establish pterygospermin, a phytochemical isolated from moringa, as a potent antimicrobial agent [83-86]. Various compounds isolated from the leaves, seed, flowers, root, stem etc showed antimicrobial character [87,88]. *In vitro* anti fungal activity was observed against dermatophytes such as *Trichophyton rubrum*, *Trichophyton mentagrophytes*, *Epidermophyton floccosum*, and *Microsporum canis* including certain Aspergillus and Penicillium species [89-91]. Recent findings have unveiled cyanobactericidal potential in the seeds [92].

### Anaphylactic

Ethanolic extract of seeds *M. oleifera* was reported to possess profound anti- anaphylactic potential [93].

### Hepatoprotective

Various studies reported the ethanolic extract of *M. oleifera* seeds and leaves to possess hepatoprotective reaction [94-97]. The root and flower extracts also showed antihepatotoxic activity [56].

Remarkable protective effect has been observed against CCl4 – induced liver fibrosis in rats [98].

### Radioprotective

Radioprotective effect was observed in the methanolic leaf extract pretreated, irradiated Swiss albino mice [99].

### Antiulcer

Methanolic flower bud extract showed a decrease in ulcer index in aspirin-induced gastric ulcers in rats [100]. The leaf extracts also produced a significant reduction of stress-induced gastric ulcers and cysteamine-induced duodenal ulcers [101-103]. The possible mechanism behind the ulcer protective effect may be an increase in EC cell count and 5- HT levels [104].

### Antispasmodic

The roots as well as ethanol extract of the leaves showed antispasmodic action, possibly through calcium channel blockade. Spasmolytic activity exhibited by the constituents of the plant provides a scientific basis for the traditional uses of the plant in gastrointestinal motility disorders [105,106].

### Antihyperglycemic

The aqueous extract exhibited hypoglycemic and anti diabetic effect in normal and streptozotocin-induced sub, mild and severely diabetic rats [107]. Studies have also approved that *M. oleifera* has an ameliorating effect for glucose intolerance which might be mediated by quercetin-3-glucoside and fiber contents in the leaf powder [108].

### Antitumor

Epstein-Barr virus-early antigen (EBV-EA) activation in Raji cells was found to be inhibited by various bioactive compounds isolated from the ethanolic extract of *M. oleifera* [59]. Niazimicin, niaziminin and beta-sitosterol-3-o-beta-D-glucopyranoside showed antitumor action. Studies have explored possible chemo-preventive & antiproliferative potential of *M. oleifera* against chemical carcinogenesis, along with its role in epithelial ovarian cancer [109-113].

### Antiplasmodial

*In vitro* studies depicted antiprotozoal effect of *M. oleifera* (114). The soluble lectin from the seed extract showed larvicidal activity by delaying larval development and promoting mortality in *Aedes aegypti*, possibly on account of its hemagglutinating activity [115,116].

### Antifertility and abortifacient

*M. oleifera* root is shown to have unique antiprogestational activities. It is reported to induce alterations in the normal uterine histoarchitecture (metaplastic changes in cervical epithelia and cornification of vaginal epithelium) which might be the reason for anti-implantational characteristics [117-122].

### Antioxidant and antiperoxidative

Exploration of *M oleifera* as a potential source of antioxidants has yielded affirmative results [77]. The phenolic content present in the leaves imparts free-radical scavenging property while the ethanolic fraction showed considerable metal chelation properties with potential to protect against DNA nicking [33,123-125]. Pari and Kumar suggested that the protective effect may be attributed to decrease in liver lipid peroxides and enhanced antioxidants level [126]. The seed powder showed reduction in tissue arsenic concentration, thus providing protection from oxidative stress [127].

### Diuretic and antiurolithiatic

According to a traditional claim, powdered gum of *M. oleifera* mixed with curd taken daily for a week cures painful and burning urination [128].

The leaves, flowers, gum, roots and the aqueous infusion of seeds exhibited diuretic activity [105,129,130]. Administration of 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 was also significantly lowered in the kidneys of calculogenic rats [131].

### Antihypertensive & cardio protective

Moringa leaf juice exerts a stabilizing effect on blood pressure [132]. A variety of glycosides viz. Nitrile, mustard oil glycosides, thiocarbamate and isothiocyanate, isolated through bioassay – directed fractionation of ethanolic extract of leaves and pods showed blood pressure lowering effect [29,46-48]. Presence of methyl p-hydroxybenzoate and beta sitosterol confer hypotensive potency to the pods [42]. Lyophilized hydroalcoholic extract of *M. oleifera* showed myocardial preservative effect in isoproterenol (ISP)-induced model of myocardial infarction [133]. Recent investigations have explored platelet aggregation inhibitory potential in the leaf extract [134].

### CNS activities of Moringa oleifera Lam.

Chronic oral treatment of ethanolic extract of *M. oleifera* leaves

can alter the brain monoamines ( norepinephrine, dopamine and serotonin) in distinct areas of brain in rat model of Alzheimer's disease caused by intracerebroverticle (ICV) infusion of colchicine and hence can provide protection against monoaminergic deficits associated with Alzheimer. The electrical activity was also altered [135]. Pretreatment with aqueous extract inhibited penicillin - induced seizure and markedly reduced locomotor activity. Chronic treatment significantly increased the 5-hydroxytryptamine and decreased the dopamine level in cerebral cortex, midbrain, caudate nucleus and cerebellum. Norepinephrine level was significantly decreased in cerebral cortex. The aqueous extracts induce the potentiation of sleeping time induced by pentobarbitone, meprobamate and diazepam. Protection against strychnine- and leptazol-induced convulsions was observed on pretreatment with methanolic root extract including a dose - dependent CNS depressant effect [73,136,137].

### Non- pharmacological uses

Moringa oleifera possesses a multitude of non – pharmacological uses as well. The defatted seed meal is an excellent additive in sheep diet as it is reported to improve rumen fermentation [138]. Milk production in cows was found to increase on administration of Moringa as a protein supplement with low quality diets [139].

Biodiesel derived from M oleifera oil by alkali-catalyzed trans-esterification with methanol is reported to be an acceptable substitute for petrodiesel. Its cetane number was found to be [67], the highest reported for a biodiesel fuel with much better oxidative stability [140,141].

The seeds serve as one of the best natural coagulants for water treatment and a cheap and feasible alternate to the synthetic ones. The seed extract is an effective natural clarification agent for highly turbid and untreated pathogenic surface water [142-148].

Ben oil, a non drying oil obtained from the seeds is employed in the manufacture of perfumes, hairdressings etc and as a lubricant for fine machinery. As it is resistant to rancidity, it is extensively used in the 'enfleurage' process whereby delicate fragrances are extracted from flower petals [65]. The chemical properties of protein fraction of *M. oleifera* permit their use in a wide variety of skin care, hair care and cosmetic formulations such as purisoft, puricare etc. [149,150].

Shelled moringa seeds possess potential to eliminate toxic metals such as cadmium from water resources. The sorption was found to occur due to amino acid-Cd interactions, as revealed by Fourier transform infrared spectrometry [151]. The bark too has an excellent bio-sorbent property for removal of heavy metal ions from waste water or effluents [152]. Similar investigations have revealed the removal of zinc ions and sodium lauryl sulphate (up to 80 %) from aqueous solutions [153,154].

### Toxicity studies

*In vitro* data showed a significant CYP3A4 inhibitory effect which might lead to a potential risk of interaction, on concomitant administration of *M. oleifera* leaf extract with antiretroviral drugs to HIV/AIDS patients [155].

4(alpha-L-rhamnosyloxy) phenylacetonitrile, 4-hydroxyphenyl-acetontrile, and 4-hydroxyphenyl-acetamide exhibited mutagenic activity, when subjected to micronucleus test [156]. The root bark extract causes severe skin inflammations and skin dermatitis and may cause violent uterine contractions that can be fatal [157,158].

The interior flesh of the plant can also be dangerous if consumed too frequently or in large amounts. Even though the toxic root bark is removed, the flesh has been found to contain the alkaloid spirochin, which can cause nerve paralysis [6,159].

## Conclusion

The essence of the entire retrospection depicts that *M. oleifera* possesses diverse utility inviting further investigations in future. The multiple array of pharmacological activities need to be studied more exhaustively to establish exact molecular- mechanism responsible for the activity of individual components. Since the available data is somewhat illusive, standardization of the plant extract and structure elucidation of the phytochemicals reported is essential to develop coherence between its Phytochemistry and pharmacology. Bioavailability studies should be performed to optimize the active dose. In addition, clinical trials should be made to unfold its adverse effects or toxicity, to establish safe use of *M. oleifera* in human beings. Moreover, there is a great need to formulate the best alternative herbal preparation of *M. oleifera* that can either be used individually or as an adjuvant therapy to complement the synthetic drugs used presently.

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