

Phyto-pharmacology of *Moringa oleifera* Lam.ó

An overview

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Abstract

Moringa oleifera Lam. is a small or medium-sized tree, about 10 m high, cultivated throughout India. It is a multipurpose tree, used as vegetable, spice, a source of cooking and cosmetic oil and as a medicinal plant. It is reported to contain alkaloids, flavonoids, anthocyanins, proanthocyanidins and cinnamates. It possesses anti-inflammatory, antioxidant, antimicrobial, antihyperlipidaemic, antifertility, anticancer, antihepatotoxic and antiulcer activities. Further, activity guided phytochemical and phytoanalytical studies may lead to development of novel agents to be used in various disorders. An overview of chemical constituents present in the plant and their pharmacological actions are given in the present paper.

Keywords: *Moringa oleifera*, Drumstick tree, Medicinal plant, Multipurpose tree, Chemical constituents, Pharmacological properties.

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Leaves

Introduction

From time immemorial, man depended on plants as medicine. From a historical perspective, it is evident that the fascination for plants is as old as mankind itself. The plant kingdom represents a rich storehouse of organic compounds, many of which have been used for medicinal purposes and could serve as lead for the development of novel agents having good efficacy in various pathological disorders in the coming years. Conventional anti-asthmatic compounds such as sodium cromolyn and sodium cromoglycate is one of the examples of the lead prepared from the analogs of the naturally occurring furanochromone khellin (visammin), found in *Ammi visnaga* Lam.¹ Exploration of the chemical constituents of the plants and pharmacological

screening will thus provide us the basis for developing new life saving drugs. *Moringa oleifera* Lam. (Family: Moringaceae) is a tree cultivated for different purposes such as medicine, vegetable, spice, for cooking and cosmetic oil. This article intends to provide an overview of the chemical constituents present in various parts of the drumstick tree and their pharmacological actions.

M. oleifera is a small or middle-sized tree, about 10m in height, cultivated throughout India. It is known as Drumstick in English, *Saragvo* in Gujarati, *Soanjna* in Hindi, *Sajna* in Bengali, *Nugge* in Kannada, *Sigru* in Malyalam, *Shevga* in Marathi, *Shobhanjana* in Sanskrit, *Munaga* in Telegu and *Murungai* in Tamil. It is used in abortion²⁻⁴, diabetes⁵ and as an

antipyretic⁶, anthelmintic⁷ and anti-herpes simplex virus type 1 (HSV-1)^(Ref. 8). All parts of the tree are considered to possess medicinal properties and used in the treatment of ascites, rheumatism, and venomous bites and as cardiac and circulatory stimulant. The root is laxative, expectorant, diuretic, and good for inflammations, throat, bronchitis, piles, cures stomatitis, urinary discharges and obstinate asthma⁹. The root bark is useful in heart complaints, eye diseases, all *tridosha* fevers, inflammation, dyspepsia, and enlargement of spleen. The root and bark are abortifacient¹⁰. The leaves are anthelmintic, aphrodisiac, cures hallucinations, dry tumours, hiccough and



Flowers

asthma. Dried powder of leaf extract (175g/kg body wt) produced cent percent abortifacient activity in rats⁴. The flowers cure inflammations and muscle diseases. The fruit cures biliousness, pain, leucoderma and tumour. The flowers, fruits and seeds cure *kapha* and *vata*. The seed cures eye diseases and head complaints. Oil is useful in leprosy ulcers and as external application for rheumatism⁹. The roots and seeds are prescribed for the treatment of snakebites and scorpion stings¹⁰.

Seed extracts have been proposed as an eco-friendly alternative, due to their traditional use for the clarification of drinking water. Recombinant or synthetic forms of a cationic seed polypeptide mediate efficient sedimentation of suspended mineral particles and bacteria. The polypeptide was also found to possess a bactericidal activity capable of disinfecting heavily contaminated water¹¹.

Phytochemical constituents

Roots of *M. oleifera* have high concentrations of both 4-(α -L-rhamnopyranosyloxy)-benzylglucosinolate and benzylglucosinolate¹². The stem contains: 4-hydroxymellein, vanillin,

β -sitosterone, octacosanic acid and β -sitosterol¹³ and bark, 4-(α -L-rhamnopyranosyloxy)-benzylglucosinolate¹².

The purified, whole-gum exudate from the drumstick plant contains: L-arabinose, D-galactose, D-glucuronic acid, L-rhamnose, D-mannose and D-xylose in the molar ratios of approx. 14.5 : 11.3 : 3.2 : 1.1 (Ref. 14). A leucoanthocyanin characterized as leucodelphinidin-3-O-B-D-galactopuranosyl (1->4)-O-B-D-glucopyranoside is also present in gum¹⁵.

Bioassay-guided analysis of an ethanolic extract of leaves showed the presence of two nitrile glycosides, niazirin and niazirin and three mustard oil glycosides, 4-[(4'-O-acetyl- α -L-rhamnosyloxy) benzyl] isothiocyanate, niaziminin A and B (Ref. 16, 17). The α -L-rhamnosides of 4-hydroxy-benzyl compounds with nitrile, carbamate and thiocarbamate groups occurring in leaf extracts and the α -L-rhamnoside of anisaldehyde derivatives were synthesized¹⁸. *M. oleifera* was analyzed for glucosinolates and phenolics (flavonoids, anthocyanins, proanthocyanidin and cinnamates). Leaves contain 4-(α -L-rhamnopyranosyloxy)-benzylglucosinolate and three monoacetyl isomers of this glucosinolate. The leaves contain 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 acid¹².

The aqueous extract of the mature flowers contains free natural sugars, D-mannose and D-glucose in the ratio of 1:5 and two unidentified



Pods

carbohydrate bearing materials along with proteins and ascorbic acid of the above materials with varying proportion. It also contains polysaccharide (PS) which on hydrolysis gives D-glucose, G-galactose and D-glucuronic acid in a molar ratio of 1:1.9:0.9 (Ref. 19).

The whole pods are reported to contain nitriles, an isothiocyanate and thicarbamates^{16, 17} and O-[2'-hydroxy-3'-(2''-heptenyloxy)]-propylundecanoate and O-ethyl-4-[(α -L-rhamnosyloxy)-benzyl] carbamate, methyl-*p*-hydroxybenzoate and β -sitosterol²⁰. The mucilage from the pods designated as drumstick polysaccharide, the investigation of which revealed the presence of galactose, dextrose, xylose and sodium, potassium, magnesium, calcium salts of glucuronic acid. Contrary to the definition of mucilages, the presence of dextrose was an exception²¹.

The mature seeds contain 332.5g crude protein, 412.0 g crude fat, 211.2 g carbohydrate and 44.3 g ash per kg dry

matter. The essential amino acid profile showed deficiency of lysine, threonine and valine. The content of methionine + cysteine (43.6 g/kg protein), however, was exceptionally high and close to that of human milk, chicken egg and cow's milk²². Seeds have high concentrations of both 4-(α -L-rhamnopyranosyloxy)-benzylglucosinolate and benzyl glucosinolate¹². Seeds of another species *M. peregrina* Fiori on treatment with myrosinase, produce 2-propyl, 2-butyl and 2-methylpropyl isothiocyanate in addition to 5, 5-dimethyl-oxazolidine-2-thione, all new to the family but known as natural derivatives from other sources²³. Drumstick seeds contain 38.16 % oil which contain Vitamin E (0.01 %) and beta carotene (0.014%), the precursor of Vitamin A²⁴. A glycoside having molecular formula $C_{15}H_{20}O_7$, provisionally named as moringyne, was isolated from an acidic extract of the seeds²⁵. Mono-palmitic and di-oleic triglyceride have been isolated from the benzene extract of semi-dried seeds²⁶. The hexane-extracted oil content of seeds ranged from 38.00 to 42.00%. Protein, fibre and ash contents were found to be 26.50-32.00, 5.80-9.29 and 5.60-7.50%, respectively.

Results of physical and chemical parameters of the extracted oil are as follows: iodine value, 68.00-71.80; refractive index (40°C), 1.4590-1.4625; density (24°C), 0.9036-0.9080 mg/ml; saponification value, 180.60-190.50; unsaponifiable matter, 0.70-1.10%; and colour (1 in. cell), 0.95-1.10 R + 20.00-35.30 Y. Tocopherols (alpha, gamma and delta) in the oil were up to 123.50-161.30, 84.07-104.00 and 41.00-56.00 mg/kg, respectively. The oil was found to

contain high levels of oleic acid (up to 78.59%) followed by palmitic (7.00%), stearic (7.50%), behenic (5.99%) and arachidic acid (4.21%)²⁷. From the raw seeds by hot water extraction, 4(α -L-rhamnosyloxy) benzyl isothiocyanate and 4(α -L-rhamnosyloxy) phenylacetone nitrile were isolated²⁸; 4(α -L-rhamnosyloxy) benzyl glucosinolate and its thermal degradation product 4(α -L-rhamnosyloxy) phenylacetone nitrile were also reported²⁹. Starting from L-rhamnose, the first synthesis of the major glucosinolate isolated from drumstick seeds was completed in seven steps³⁰.

Pharmacological studies

Anti-inflammatory

The crude ethanolic extract of dried seeds was tested for anti-inflammatory activity using carrageenan-induced inflammation in the hind paw of mice by various workers and found to inhibit 85% of inflammation at a dose of 3mg/kg body weight, while the mature green seeds inhibited edema by 77% at the same dose^{31,32}. Hot water infusions of flowers, leaves, roots, seeds and bark also showed anti-inflammatory activity against carrageenan-induced hind paw edema. The seed infusion showed anti-inflammatory and diuretic activity at 1000 mg/kg³³.

A crude methanol extract of the root was also screened for anti-

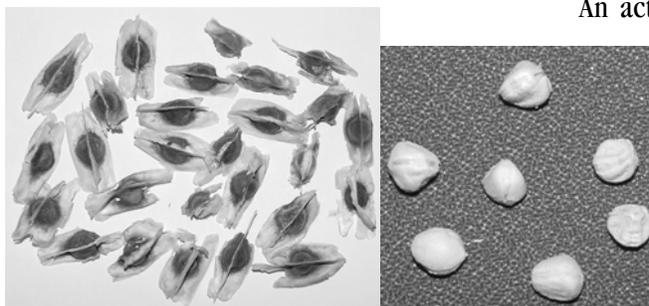
inflammatory effect using the rat paw edema and the rat 6-days air pouch inflammatory models. Following oral administration, the extract inhibited carrageenan-induced rat paw edema in a dose-dependent manner, with IC_{50} of 660 mg/kg. In the 6-day air pouch acute inflammation model induced with carrageenan, the extract was much more potent, with IC_{50} values of 302.0 mg/kg and 315.5 mg/kg, for the inhibition of cellular accumulation and fluid exudation, respectively. It contains anti-inflammatory principle(s) that may be useful in the treatment of both the acute and chronic inflammatory conditions^{21, 34}.

Antioxidant

The oil from the dried seeds showed higher antioxidant activity than butylated hydroxyl toluene and alpha-tocopherol³⁵. Aqueous, methanol (80%) and ethanol (70%) extracts of freeze-dried leaves showed radical scavenging and antioxidant activities. All the extracts were capable of scavenging peroxy and superoxy radicals. The major bioactive compounds of phenolics were found to be flavonoid groups such as quercetin and kaempferol³⁶. The drumstick leaves are found to be a potential source of natural antioxidants³⁶.

Antimicrobial

An active antimicrobial agent, 4(α -L-rhamnosyloxy) benzyl isothiocyanate was identified from the seeds. Defatted and shell free seeds contain about 8-10% of 4(α -L-rhamnosyloxy) benzyl isothiocyanate, but this



Unhusked seeds

Husked seeds

amount is produced when ascorbic acid is added during water extraction. The compound acts on several bacteria and fungi. The minimal bactericidal concentration *in vitro* is 40mmol/l for *Mycobacterium phlei* and 56mmol/l for *Bacillus subtilis*³⁷.

The antimicrobial activity of leaves, root, bark and seeds were also investigated against bacteria, yeast, dermatophytes and helminths pathogenic to man. The fresh leaf juice and aqueous extract of seeds inhibited the growth of *Pseudomonas aeruginosa* and *Staphylococcus aureus*³⁸. The seed extract exhibited significant antibacterial activity against pyoderma (skin infection) causing bacterium, *S. aureus* in experimental mice³⁹.

Cardiovascular

The aqueous extract of stem bark induced a positive inotropic effect at low concentration and negative inotropic effect at high concentration on isolated perfused frog heart and it also produced a dose dependent hypotensive effect on dog blood pressure⁴⁰. Five compounds niazinin A and B, niazimicin, niaziminin A and B isolated from the ethanolic extract of the leaves produced hypotensive and bradycardiac effect in anaesthetized rat at a dose of 1-10 mg/kg i.v. (Ref. 41).

Ethanolic and aqueous extracts of whole pods and their parts, namely, coat, pulp and seed also showed hypotensive activity. The activity of the ethanolic extract of both the pods and the seeds was equivalent at the dose of 30 mg/kg²⁰.

The alkaloids obtained by fractionation of the water extract of the leaves converted into their salt form, were

tested for their activity on the isolated frog heart. The total alkaloidal salts were found to produce a negative inotropic effect on the isolated perfused frog heart. This activity was further characterized by testing it on the isolated guinea pig ileum⁴².

Antihyperlipidaemic

The leaves possess hypocholesterolemic activity; administration of the crude leaf extract along with high-fat diet decreased the high-fat diet-induced increase in serum, liver and kidney cholesterol levels by 14.35% (115-103.2mg/100ml of serum), 6.40% (9.4-8.8mg/g wet wt) and 11.09% (1.09-0.97mg/g wet wt), respectively⁴³.

In another study by Mehta *et al*, fruits of *M. oleifera* were reported to possess hypolipidaemic effect. They were found to lower the serum cholesterol, phospholipid, triglyceride, VLDL, LDL, cholesterol to phospholipid ratio and atherogenic index in hypercholesterolaemic rabbits, but were found to increase the HDL ratio (HDL/HDL-total cholesterol) as compared to the corresponding control groups⁴⁴.

CNS depressant

The methanolic extract of the root exhibited significant CNS depressant activity in mice. The extract potentiated significantly the sleeping time induced by pentobarbitone sodium, diazepam and meprobamate, showed analgesic properties and also potentiated analgesia induced by Morphine and Pethidine. Pretreatment with methanolic extract caused significant protection against strychnine- and leptazol-induced convulsions⁴⁵.

Effect of chronic treatment of standardized aqueous extract of root (100, 200, 300, 350, 400, 450 mg/kg; p.o.) on penicillin induced convulsion, locomotor behaviour, brain serotonin (5-HT), dopamine (DA) and norepinephrine (NE) level was studied in Holtzman strain adult albino rats. The extract showed central inhibitory effect and improvement in the disturbed balance between 5-HT, DA and NE⁴⁶.

Antifertility

Bark of drumstick tree was screened for its antifertility effect on early pregnancy in albino rats⁴⁷. The aqueous extract of root and bark at a dose of 200 mg/kg and 400 mg/kg, respectively showed post-coital antifertility effect in rat and also induced foetal resorption at late pregnancy⁴⁷. The aqueous or ethanolic (90%) extract of root showed abortifacient and teratogenic effect in rat⁴⁸. The aqueous extract of roots possesses antioestrogenic and antiprogesterone activity⁴⁹. The aqueous extract of root was found to induce biochemical alteration in female genital tract of ovariectomised rat⁵⁰ and exhibited biphasic effect on periodicity of oestrous cycle in adult intact rat⁵¹. The aqueous extract of roots induced anti-implantation activity in rats⁵².

Anticancer

Paste of drumstick leaves has been screened for its influence on the carcinogen detoxifying glutathione-S-transferase (GST) in Swiss mice. It increased GST activity by more than 78% in the stomach, liver and oesophagus and show protective activity against carcinogenesis. The crude ethanolic extract of seeds exhibited anti-tumour

activity against Epstein-Barr virus-early antigen (EBV-EA) ³².

A number of biosynthetically and chemically related compounds were isolated from the roasted seeds. Structure-activity correlation studies showed that 4(α -L-rhamnosyloxy) phenylacetonitrile, 4-hydroxyphenylacetonitrile, and 4-hydroxyphenylacetamide exhibited mutagenic activity²⁹.

Antihepatotoxic

Aqueous and alcoholic extracts of root and flower of this plant were screened for antihepatotoxic activity in paracetamol treated albino rats. Liver function was assessed based on liver to body weight ratio, serum levels of transaminase (SGPT, SGOT), alkaline phosphatase (SLAP) and bilirubin. All extracts were found to have antihepatotoxic activity. The LD₅₀ value of ethanolic (90%) extracts of roots and flowers were calculated to be 1.23 and 1.47g/kg i.p. in mice, respectively. The corresponding values for aqueous extract were 1.78 and 1.92mg/kg, respectively⁵³.

Hepatoprotective effect of an ethanolic extract of leaves on liver damage induced by antitubercular drugs such as isoniazid, rifampicin and pyrazinamide in rats has been evaluated. The extract was found to enhance the recovery from hepatic damage induced by antitubercular drugs^{54,55}.

Antiulcer

The methanolic extract of drumstick leaves inhibited gastric lesion formation induced by aspirin, serotonin or indomethacin in rats⁵⁵. The methanolic extract of flower buds showed antiulcerogenic activity against aspirin

induced gastric ulcer at a dosage of 4g/kg body weight⁵⁶.

Miscellaneous activities

Hot water infusions of flowers, leaves, roots, seeds and stalks of bark of drumstick tree possess antispasmodic activity³³. The seeds infusion showed a significant inhibition of acetylcholine-induced contraction of rat ileum with an ED₅₀ of 65.6mg/ml bath concentration and diuretic activity at 1g/kg³³.

Availability of carotene (vitamin A) from vegetables was studied in rats by the liver storage bioassay method. Carotene of *M. oleifera* was 49.1% active in producing vitamin A. When rats were supplemented with pure carotene, the Hb level increased⁵⁷. The bioavailability of thiamin and riboflavin from leaves was higher⁵⁸.

One of the studies carried out at Saudi Arabia showed that *M. oleifera* increased the blood glucose by 15% in alloxanized mice⁵⁹. While in another study, ethanolic extract showed significant blood glucose lowering effect within 2 weeks in alloxan induced diabetic albino rats⁶⁰. The blood glucose levels and the corresponding insulin levels in response to drumstick leaves in southern India were compared to the levels achieved in response to 75g of glucose in non-insulin dependent diabetes mellitus patients. The blood glucose response was 56% compared to 75g of glucose. It was concluded that the reduced blood glucose response to drumstick leaves is not due to insulin secretion⁶¹.

The role of aqueous leaf extract in the regulation of thyroid hormone status was studied in adult Swiss rats. Other than the thyroid hormone

concentrations, hepatic lipid peroxidation and the activities of antioxidant enzymes, superoxide dismutase and catalase were evaluated. Reduction in the serum T₃ concentration (approx. 30%) and an increase in the T₄ concentration were observed suggesting the inhibiting nature of leaf extract in the peripheral conversion of T₄ to T₃. It is suggested that the lower concentration of this plant extract may be used for the regulation of hyperthyroidism⁶².

Conclusion

M. oleifera, popularly known as 'The miracle tree', mainly contains alkaloids, flavonoids, anthocyanins, proanthocyanidins and cinnamates. The alkaloid-moringine is reported to resemble ephedrine in its action. Seed extracts have been proposed as an environment-friendly alternative, due to their traditional use for the clarification of drinking water. The pharmacological studies reported in the present review confirm the therapeutic value of drumstick tree. Thus, activity guided phytochemical and phytoanalytical studies may lead to development of novel agents for various disorders.

The available literature regarding the chemical constituents and pharmacological properties appear to be very impressive. However, there are several areas unexplored. Very less information is available regarding the chemical constituents of roots of this plant. The standardization of the extracts, identification and isolation of active principles and pharmacological studies of isolated principles may be considered for detailed studies. Further, synthesis of the active principle can lead to development of promising pharmacological actions.

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