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***Moringa oleifera*: A Nutritional tree with immense medicinal value-Ethonobotanical and Pharmacological review**

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Article History:	Abstract
<p>Received on: 29-11-2019 Accepted on: 30-01-2020 Published on : 31-01-2020</p>	<p><i>Moringa oleifera</i> Lam commonly called horse-radish is a pan-tropical species which is abundantly found in now become naturalized Asia Minor, Africa, the Indian subcontinent (Bangladesh, India & Pakistan). It has been used due to its excellent nutritional value in all its parts, It also offers various medical benefits. Traditionally it is used for treating various ailments. <i>M. oleifera</i> possess several phytoconstituents which are of interest because of their medicinal value. Extensive scientific investigations have been carried over in past decades to give evidence to claimed traditional and folklore uses. Many Pharmacological works have undertaken to screen its various parts for digestive disorders, heart complaints, antioxidant, fevers, inflammation, antihypertensive, analgesic, diuretic anti-inflammatory, and anti-tumor activities. Additionally, all parts of <i>M. oleifera</i> claimed some beneficial use which gave great value to the plant. This review provides latest compilation of the published scientific evidence on Pharmacological activities of Extracts and nanoparticles.</p> <p>Keywords: <i>Moringa oleifera</i>, Chemical constituents, Ethonopharmacology, Nanoparticles</p>
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Introduction

Moringa oleifera is one among the highly nutritious cultivated tree all over world because of its medicinal value. It belongs to the family *Moringaceae* and genus *Moringa* has 14 species, which includes shrubs as well as trees. The accepted botanical name of the species is *Moringa oleifera* Lam. It has many names depend on the region including Ben oil tree, Horseradish tree and Drumstick tree [1]. *M. oleifera* nated in Indian, Asia Minor, Africa, Bangladesh, Pakistan and widely distributed many countries like Philippines, Caribbean Islands, Cambodia, South America Central America, North America. Its height may range from 5 - 12 m and the fruits

are approximately 50 cm long. After maturation, the fruit becomes brown in color and has 10 to 50 seeds inside the pod [2]. Traditionally, it has been used as diuretic, stimulant, antispasmodic and expectorant. Fresh root is vesicant and acrid. Internally has been used as anti lithic, diuretic and stimulant. Gum is mucilaginous and bland in nature. Seeds are stimulant and acrid. Bark is anti bacterial, abortifacient, antifungal and even menagogue. Flowers are used to rise the bile flow and as chologogue, diuretic, stimulant. The plant can also be used as cardio tonic and as antiseptic [3]. Pods are antipyretic and anthelmintic; fried pods are used in diabetes. Juice prepared from pod is used as cardiac tonic and to treat epilepsy. Used for asthma,

to treat inflamed liver as well as spleen, nervous debility and as diuretic to treat calculus infection. Pods decoction gargled to overcome sore throat. Root and fruit are antiparalytic.

Juice prepared from leaves employed to reduce hiccup can also be used as emetic (in high doses); cooked leaves are given to treat catarrhal affections and influenza. Bark obtained from Roots is used as analgesic, anti-inflammatory and antiviral. flowers are employed in hypoglycemic conditions. Seed infusion is antispasmodic, anti-inflammatory and diuretic, may also give to treat various venereal diseases. The *Ayurvedic Pharmacopoeia of India* specified the use of the dried root bark in lipid disorders, goitre and glycosuria, and leaf, root bark, seed and stem bark in internal abscess, and piles [4].

This review provides latest compilation of the published scientific evidence on Ethnobotanical aspects and Pharmacological activities of Extracts and nanoparticles.

Botanical Description

Scientific Classification [5]

Kingdom : Plantae
Subkingdom : Tracheobionta
Super division : Spermatophyta
Division : Magnoliophyta
Class : Eudicots
Subclass : Rosidsae
Order : Brassicales
Family : Moringaceae
Genus : Moringa
Species : oleifera

Morphology

Moringa oleifera is a small and fast – growing tree may be evergreen and deciduous, typically grows up to 10 -12 m height. It has fragile branches which spreads like feather with tripinnate leaves, possess whitish gray bark.

Leaves: The leaflets appear to be hairy, green but almost hairless on the top surface, and are usually tripinnate and can grow up to 45 cm long. These are compound leaves with leaflets 1-2 cm long. The tree limbs are furry and green.

Flowers: The fragrant, bisexual, yellowish white flowers are hairy stalks with axillary panicles 10 - 25 cm long, spreading or drooping. Individual flowers are approximately 0.7 to 1 cm long and 2 cm broad and five unequal yellowish – white, thinly veined, spatulate petals, five stamens with five smaller sterile stamens and pistil composed of a 1-celled ovary and slender style.

Fruits: Fruits are of 3-lobed capsules which are referred as pods when dry 30-120 cm long, 1.8 cm wide fruit production occurs primarily in march and april, it is pendulous, brown triangular, and breaks into three sections lengthwise. During their growth period, fruits produce about 26 seeds. Immature pods are green in colour, and on adulthood they turn into brown.

Seeds: Seeds are rounded and diameter is 1cm. It has brownish semi-permeable seed hull with 3 seed hulls of papery wings which are brown - black in color, however if kernels are of low viability, they may be white. About 14 days, fertile seed germinates, each tree can grow between 15,000 to 25,000 seeds per year. The weight mean is 0.3 gm/seed [6].

Chemical Constituents:

leaves, Highly used part is rich in saponins ,vitamins, tannins, carotenoids, tannins polyphenols, phenolic acids, glucosinolates, flavonoids and alkaloids [7].The *Moringa* family is rich in phytochemicals such as isothiocyanates ,zeatin, glucosinolates quercetin, rhamnose, β -sitosterol, rhamnetin ,caffeoylquinic acid, Isoquercitrin , kaempferol and kaempferitrin. Leaves Fruits and seed aqueous extracts analysed by HPLC and MS showed the presence of vanillin , gallic acid, quercetin, chlorogenic acid, kaempferol, ellagic acid and ferulic acid [8].*M. oleifera* shows the presence of Polyphenols but Butanol fraction of the leaves and aqueous fraction of fruits shows more quantity of Polyphenols [9].The leaves were also informed to contain o-coumaric acid, niazirin, niazirin, 4-[(4'-O-acetyl-L-rhamnosyloxy) benzyl] isothiocyanate, epicatechin , niaziminin A, 5- caffeoylquinic acid, 3-caffeoylquinic as well as carotenoids [10].*M. oleifera* seed oil found to consists of campesterol, stigmaterol, stigmastanol, clerosterol, β -sitosterol, and minor quantities of 24-methylenecholesterol and 28- isoavenasterol [11]. Isolation of water soluble Polysaccharides from aqueous extracts of Pods shown to have L-rhamnose, D-galactose, L-arabinose, 6-O-Me-D-galactose and D-galacturonic acid [12].The flowers of *M. oleifera* found to be rich in calcium and potassium as well as antioxidants like α - and γ -tocopherol [13,14].It also consists nine amino acids,kaempferol,quercetin ,wax, sucrose, traces of alkaloids, D-glucose and They have also been stated to contain flavonoid pigments such as rhamnetin, alkaloids,kaempferitrin, kaempferol and isoquercitrin [15]. A precipitate protein fractions from the flowers part consists a combination of serine, aspartic, cysteine and Ca²⁺-dependent proteases which possess caseinolytic and milk clotting property [16]. Phytochemical inquiries displayed that water, ether and ethanolic extracts of the leaves comprise catechol gallic tannins, triterpenoids, saponins, flavonoids, anthraquinones, alkaloids,steroids and reducing sugars,tannins which may contribute the pharmacological effect of the plant/tree [17].Various investigations identified several Plant chemicals like palmitic acid ethyl ester,hexadecanoic acid, 2, 6-dimethyl-1, 7-octadiene-3-ol, 2-hexanone, ethyl palmitate and 3-cyclohexylidene-4-ethyl-E2-dodecenyacetate in leaves [18]. The gum of *M. oleifera* contains aldouronic acid (got from the acid hydrolysis of gum) and is characterized as O-(β -D-glucopyranosyluronic acid) (1 \rightarrow 6)- β -D-galactopyranosyl (1 \rightarrow 6)-D-galactose [19].Glucosinolates are also found in the bark of *M. oleifera* with only 4-(alpha-

l-rhamnopyranosyloxy)-benzylglucosinolate being detected in the bark tissue. The roots of *M. oleifera* contain high concentrations of both 4-(alpha-l-rhamnopyranosyloxy)- benzylglucosinolate and benzyl glucosinolate [20]. Sashidhara et al. isolated and characterized compounds; aurantiamide acetate 4 and 1, 3-dibenzyl urea 5 from the roots of *M. oleifera*, which was done for the first time from this species [21]. Protective phytochemicals like reducing sugars, gallic tannins, anthraquinones, catechol tannins, steroids, saponins and triterpenoids and alkaloids were found in ether, ethanol and aqueous extracts of the roots [22].

Toxicological Profile

The Lethal dose 50 of *M. Oleifera* is estimated to be 1585 mg/kg. The extract did not elicit any significant difference ($P \geq 0.05$) in haematological as well as biochemical parameters and sperm quality and show no considerable differences in weight gain in control and treated animals even though a dose-dependent reduction in food consumption of the animals treated with 250 to 1500 mg/kg extract is exhibited [23].

Pharmacological Profile:

Table 01: Reported Pharmacological activities of Different Parts of *Moringa oleifera*

Sl No.	Part	Extract	Activity	Model	Significant findings	Reference
01	leaves, flowers, seeds, pods and stem)	Ethanol	acetaminophen (APAP)- induced toxic liver injury- invitro and invivo	FRAP, DPPH. and Acetaminophen induced male sprague dwaley rats	Elevation in oxidative biomarkers concentration like MDA and 4-HNE protein adduct. Decreased in GSH, CAT, SOD in hepatotoxic rats.	24.
02	Root and leaves	methanol	Analgesic	Complete Freund's adjuvant induced arthritis	Reduced thermal hyperalgesia as well as allodynia (mechanical)	25
03	Leaves	Ethanol	Antidiarrhoeal	Castor oil induced	Produces significant Antidiarrhoeal effect	26
04	leaves	Hexane Ethanol (kaempferol-3-glucoside present in the polar extract and fatty acids like chlorogenic acid, among others, in the non-polar extract)	Analgesic and anti-inflammatory	The formalin test. Carrageenan-induced paw edema. Induction of experimental arthritis with subcutaneous injection of collagen.	Produces significant Antidiarrhoeal effect Analgesic and anti-inflammatory	27
05	Leaves powder	-	Metabolic syndrome	Oral glucose tolerance test (OGTT)	Produces significant effect on metabolic syndrome	28
06	Seeds	Hydroalcoholic	Anti-inflammatory	Acetic acid induced Colitis model	Produces significant Anti-inflammatory effect	29
07	Leaves	Methanolic and Ethylacetate	Antifungal	Disc diffusion method	extract of ethyl acetate is more active against <i>M. gypsum</i> , <i>R. stolonifer</i> shown to be highly sensitive to methanolic extract.	30

08	Flowers	Ethanol	in- vitro anti-inflammatory activity in- vitro anti-inflammatory activity	DPPH Scavenging	Produces significant activity	31
09	Pod husks	hexane, butanol, chloroform, petroleum ether, acetone, methanol, ethyl acetate and water	Antimicrobial against Enterococcus faecalis, MRSAa Staphylococcus aureus, Staphylococcus epidermidis, Escherichia coli, Klebsiella pneumoniae, Klebsiella pneumonia, Pseudomonas aeruginosa, Salmonella typhimurium, Salmonella typhimurium, Shigella flexneri, Candida albicans, Candida tropicalis	Agar diffusion assay	All tested microorganisms showed sensitive to acetonic extract.	32.
10	Leaves	Ethanol	Neuropharmacology	Novelty induced behavior (NIB) hole-board test (Exploratory activity) Y-maze (learning and memory) elevated plus maze model (Antianxiety)	Produces significant Neuropharmacological activity	33
11	Seed	Aqueous and ethanol	Antihelminthic against H. contortus	egg hatch assay and larval motility test	Produces significant Antihelminthic against H. contortus	34
12	Root bark	Ethanol	Antiulcer	ethanol-induced and pylorus ligation-induced gastric ulceration	Produces significant antihelminthic against Antiulcer activity	35
13.	Whole plant	Aqueous	cardiotoxicprotective	Aluminium phosphide-induced	Produces significant cardiac toxicprotective activity	36
14	Leaves	Ethanol ethyl acetate fraction	Wound healing	Wound Scratch Assay	Shows good migratory and proliferative property on normal skin fibroblasts	37
15	dried leaves, bark, and seeds	Ethanol	Anticancer MDA-MB-231 and HCT-8 cancer cell lines, Breast and Colorectal Cancer Cell Lines	Motility assay In vitro Clonogenic survival assay Cell viability assay: Apoptosis assay Cell cycle assay	Produces significant Anticancer activity	38
16	Aerial Parts	Ethanol	Anti-obesity	obese female rat	down-regulated the expression of mRNA	39

					leptin and resistin, Up- expression in obese rats relative to untreated obese control regulated adiponectin gene counterparts. reduction in body weight improvement of the atherogenic index and coronary artery index, glucose level and insulin resistance value without adverse effects on liver or kidney functions, versus the untreated obese control ones.	
17	Roots	Methanol	Antidiarrhoeal	Castor oil-induced diarrhoea	Reduction in the frequency, severity of diarrhoea and accumulation of intestinal fluid, Decreased volume of intestinal content as well as intestinal transit	40
18	Leaves	Aqueous	nicotine-induced neurobehavioral disturbances	open field apparatus	Improvement in the antioxidant level of neuronal cells, Maintains the integrity of the cerebellar neuronal cells.	41
19.	Leaves	N,a-L-rhamnopyranosyl vincosamide (an indole alkaloid isolate)	Cardioprotective activity	isoproterenol (ISO)-induced cardiac toxicity	Decrease in necrosis of myocardial cells	42
20	Leaves	Ethanol	Chemiluminescence and Chemotactic Activity of Phagocytes	Luminol-based chemiluminescence assay Chemotaxis assay modified 48- well Boyden chamber	Inhibitory activity on the oxidative burst of polymorphonuclear leukocytes	43
21	Leaves	Aqueous	Antidiabetic	streptozotocin-induced Diabetes mellitus	significantly ameliorated the altered FPG, reduced glutathione and malondialdehyde. Histopathological damage of islet cells is reversed.	44

Table 02: Reported activities of Different nanoparticle preparations of *Moringa oleifera*

Sl No.	Part	Fomulation	Activity	Model	Refere nce
01	Leaves	Silver nanoparticles	Antimicrobial against S. aureus, E. coli, B. cereus, C. albicans, C. tropicalis, C. krusei	Agar well diffusion assay	45
02	Leaves	Nickel oxide nanoparticles	Cytotoxicity HT- 29 (Colon Carcinoma) cell lines antibacterial activity against Gram negative bacterial strains like Escherichia Hermannii, Escherichia Coli and Gram-positive bacterial strains like Streptococcus Pnemoniae, Staphylococcus Aureus	MTT (Micro culture Tetrazolium) assay Disc diffusion (Recative oxygen species has led to the destruction of the cell protein, DNA and cell membrane resulting in cell death, leads to the formation of electron-hole pairs, thereby resulting in the production of hydrogen peroxide, which enters cell membrane and kills bacteria.)	
03	Leaf and Seeds	Iron nanoparticles	Antibacterial Gram negative Escherichia coli (E.coli)	Modified paper disc method	46
04	Leaves	Titanium dioxide	Wound healing	Excision induced wound	47
05	Stembark	Silver nanoparticles	Anticancer-human cervical carcinoma HeLa	Annexin V/PI double staining assay	48

Conclusion

Moringa oleifera one of the important trees with both excellent nutritional and medicinal values. As it can be grown easily with no expenses it can provide great alternative for nutrition and can also provides primary solution for various health conditions. Even though *M. Oleifera* has been extensively researched and used for its various medicinal purpose, additional studies are warranted to examine its beneficial as well as other potential advantages, as well as to overcome many of the remaining difficulties with regard to the scientific review of its medicinal uses. As it has immense nutritional and medicinal profile, There is a need of clinical trials on order to efficiently establish toxicity profile of on human beings which enable its safe use. The therapeutic potential of this tree has to be explored based on isolated studies and experiments to make it more beneficial and commercial utility.

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Conflict of Interest

None

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