IJPSR (2022), Volume 13, Issue 5 (Review Article)

INTERNATIONAL JOURNAL OF PHARMACEUTICAL SCIENCES AND RESEARCH

Received on 18 July 2021; received in revised form, 17 October 2021 accepted, 26 March 2022; published 01 May 2022

MIRACLE TREE: *MORINGA OLEIFERA*

Vidhan Jaiswal, Gurinder Singh * and Jaswinder Kaur

G. H. G. Khalsa College of Pharmacy, Gurusar Sadhar, Ludhiana - 141104, Punjab, India.

Keywords:

Moringa oleifera, Phytoconstituents, Traditional use, Pharmacological activities

Correspondence to Author:
Gurinder Singh

Assistant Professor,
G. H. G. Khalsa College of Pharmacy, Gurusar Sadhar, Ludhiana - 141104, Punjab, India.

E-mail: gurindersidhu705@gmail.com

ABSTRACT: *Moringa oleifera* is an angiosperm plant that belongs to the family Moringaceae. It is also known as the Drumstick tree or Horseradish tree. Alkaloids, protein, quinine, saponins, flavonoids, tannin, steroids, glycosides, fixed oil and lipids are among the active phytoconstituents present. It is distributed throughout the world's tropical and subtropical regions. Several studies show that various parts of the plant, such as seeds, flowers, bark, fruits, pods, gum and leaves, have antitumor, anti-inflammatory, wound healing, cholesterol-lowering, antioxidant, antidiabetic, antibacterial and antifungal, antimicrobial, antiulcer, antifibrotic, antifertility, antiurolithiatic, anticonvulsant, analgesic, local anesthetic, antiasthmatic and are used in the indigenous system of medicine to treat various diseases. This review aims to provide complete data, including morphology, cultivation and propagation**,** distribution, phytochemistry, traditional uses & Pharmacological activities.

1. INTRODUCTION:

Moringa oleifera is commonly known as 'drumstick tree' or 'horseradish tree' belonging to the family of Moringaceae [1]. It belongs to the genus *Moringa* having 13 different species. The most widely grown of them is *Moringa oleifera*, which is native to tropical and subtropical regions of the world [2]. The tree reaches a height of 5-10 m and can be found wild and cultivated across the plains, especially in hedges and house yards. It grows best in an insular tropical environment and is widespread near river and stream sandy beds [3]. Alkaloids, protein, quinine, saponins, flavonoids, tannin, steroids, glycosides, fixed oil and fat and other active phytoconstituents have been found in this plant through phytochemical studies [4].

QUICK RESPONSE CODE

DOI: 10.13040/IJPSR.0975-8232.13(5).1924-34

This article can be accessed online on www.ijpsr.com

DOI link: http://dx.doi.org/10.13040/IJPSR.0975-8232.13(5).1924-34

It is a good source of vitamins A, B, and C, riboflavin, pyridoxine, Folic acid, beta-carotene, ascorbic acid, nicotinic acid, and alpha-tocopherol, as well as a significant source of essential amino acids due to its high mineral content for iron and calcium [5]. *Moringa* has been used as a traditional medicine around the world for anemia, skin infections, blackheads, anxiety, bronchitis, catarrh, chest congestion, asthma, blood impurities, cholera, glandular, swelling, headaches, conjunctivitis, cough, diarrhea, eye and ear infections, fever, abnormal blood pressure, hysteria, pain in joints, pimples, psoriasis, respiratory disorders, scurvy, semen deficiency, sore throat, sprain, tuberculosis, for intestinal worms, lactation, diabetes and pregnancy [6].

Various parts of this plant such as leaves, roots, seed, bark, fruit, flowers, and immature pods have antitumor, antipyretic, antiepileptic, anti-inflammatory, antiulcer, antispasmodic, diuretic, antihypertensive, cholesterol-lowering, antioxidant, antidiabetic, hepatoprotective, antibacterial, cardiac and antifungal activities and are used for the

treatment of various ailments in the indigenous system of medicine [7, 8].

2. Taxonomy:

TABLE 1: TAXONOMY [9]

S. no.	Taxonomy	
1	Kingdom	Plantae
2	Subkingdom	Tracheobionta
3	Super division	Spermatophyta
4	Division	Magnoliophyta
5	Class	Magnoliopsida
6	Subclass	Dilleniidae
7	Order	Capparales
8	Family	Moringaceae
9	Genus	Moringa
10	Species	Oleifera

3. Species: *Moringa oleifera* is the most famous of the thirteen species in the variety Moringa of the family Moringaceae. These are *Moringa oleifera, M. concanensis, M. drouhardii, M. arborea, M. borziana M. hildebrandtii, M. longituba, M. pygmaea, M. rivae, M. ruspoliana, M. ovalifolia, M. peregrine and M. stenopetala*n [10].

4. Vernacular Name:

TABLE 2: VERNACULAR NAME [11, 12]

S. no.	Vernacular Name	
1	Latin	*Moringa oleifera*
2	English	Drumstick tree, Horseradish tree
3	Sanskrit	Subhanjana,
4	Hindi	Sahjan
5	Assamese	Sojina
6	Bengali	Sojnedanta
7	Gujarati	Saragvo
8	Nepali	Sajiwan or swejan
9	Punjabi	Surajana, sohajana
10	Marathi	Shvega
11	Tamil	Murungaimaram
12	Telugu	Munagachettu
13	Malayalam	Muringaya, murinna
14	Indonesian	Kelor
15	Guyana	Sijan
16	Thai	"ma rum"
17	Sinhalese	Murunga
18	Kannada	Nuggekayee
19	Konkani	MushingaSaang
20	Hausa	Zogale
21	Oriya	Sajana or Sujuna

5. Morphology:

Bark: Smooth, dark grey slashes thin, yellowish bark. The tree's twigs and shoots are short and thickly-haired. The crown is made up of a single stem that is large, open, and umbrella-shaped. The tree has a strong root system and softwood [13].

Height: *Moringa oleifera* is a fast-growing, deciduous-to-evergreen shrub or small tree with a maximum height of 7 to 12 m and a diameter of 20-60 cm at height.

Stem: The stem is normally straight that reaches a height of 1.5 - 2.0m before it begins branching, and it can reach up to 3.0m.

Leaves: The leaves are alternate, twice or thrice pinnate leaves crowded at the end of the branches, long petiole with 8-10 pair of pinnate leaves each bearing two pairs of opposite, elliptic or obovate, rounded or emarginate, entire, dull green on both sides, at first shortly grey, pubescent, glabrous [14].

Flowers: It has a pleasant fragrance and flowers that are 2.5 cm wide and delivered in axillary, hanging panicles 10–25 cm long. They have a cream or white coloration with yellow spots at the root.

Straight lanceolate sepals with slender-spatulate petals are the state of reflexed sepals. They include the stamens and staminodes, which are five stamens and five staminodes [15].

Branch: The branches develop in a disarranged way, and the covering is formed in an umbrella shape.

Fruits: The fruits are three-lobed pods 20-60 cm long and hang from the branches. When they're dry, they split into three parts. Between 12 and 35 seeds are contained in each pod [16].

Seeds: The seeds have three whitish papery wings and are dispersed by wind and water [17].

FIG. 1: LEAVES OF *MORINGA OLEIFERA*

FIG. 2: SEEDS OF *MORINGA OLEIFERA*

FIG. 3: *MORINGA OLEIFERA* TREE

FIG. 4 AND 5: PODS (FRUITS) OF *MORINGA OLEIFERA*

6. Cultivation: It grows in hot, semi-arid, and humid climates, as well as sandy or loamy soils with good drainage. The seed must be fresh to germinate successfully. Germination requires warm conditions. Because the seed is nutty and considered a good meal by mice and wood lizards, it would be kept out of reach of these small scavengers.

In the spring and summer, 10-60cm long stem cuttings can also be struck. Trees are often planted in tropical, subtropical, and warm-climate environments. After a bunch of years in a cold climate, trees adapt, but they may still go dormant in the winter [18].

7. Harvesting: During high-density cultivation, moringa trees can be harvested when they reach a height of 1.5 to 2 meters.

Cutting the leaf stems with a sharp knife or snapping leaf stems from branches 20 cm to 45 cm above the ground are the best methods for harvesting the leaves. This method encourages the growth of new shoots. It can take up to 35 to 40 days to harvest. However, when collecting fodder, the tree should be harvested every 75 days. The leaves should not be heaped together since they would deteriorate quickly.

Harvesting should be done early in the morning to avoid excessive water loss. Fresh leaves should be sold the same day as they are harvested because they lose moisture quickly. Moringa may be collected to a height of 50 cm above ground level, enabling mechanical harvesting easier [19].

8. Distribution: *Moringa oleifera* is native to India, Pakistan, Bangladesh, Nepal, Asia Minor, Africa, and Arabia in the western and sub-Himalayan regions.

However, it is also found in the Philippines, Cambodia, Central America, North and South America, and the Caribbean Islands. It is grown extensively in all tropical and subtropical parts of the world for various purposes [15, 19, 20, 21].

9. Phytochemical Constituents:

TABLE 3: PHYTOCONSTITUENTS AND PURE COMPOUNDS ISOLATED FROM THE VARIOUS PARTS OF *MORINGA OLEIFERA* ARE DISCUSSED AS FOLLOWS

S. no.	Part of Plant	Phytochemical Constituents
1	Bark	Moringine and moringinine, phytosterols like β-sitosterol and β–sitostenone, glucosinolates like 4-(alpha-l-rhamnopyranosyloxy)-benzylglucosinolate [22, 23, 24]
2	Stem	Vanillin, β-sitostenone, 4-hydroxymellin, β-sitosterol, and octacosanoic acid [22]
3	Leaves	Glucosinolates like 4-(alpha-L-rhamnopyranosyloxy)- benzylglucosinolate and three monoacetyl isomers of this glucosinolate, nitrile glycosides niaziridin and niazirin, isothiocyanate like 4-[(4'-O-acetyl-a-L-rhamnosyloxy) benzyl], acetylated glycosides bearing groups like thiocarbamate, carbamate or nitrile, thiocarbamate glycosides niaziminin A and B, phenols like quercetin-3-O-glucoside and quercetin-3-O-(6"-malonyl-glucoside), kaempferol-3-O-glucoside, kaempferol-3-O-(6"-malonylglucoside), 3-caffeoylquinic acid and 5-caffeoylquinic acid, rhamnetin, apigenin and myricetin [3, 24]
4	Flowers	Flowers contain nine amino acids, as well as D-glucose, sucrose, wax, a few alkaloids, kaempferol, and quercetin, ascorbic acid, protein, D-mannose; calcium and potassium are present in the fiery remains. Alkaloids, rhamnetin, kaempferol, isoquercitrin and kaempferitrin are examples of flavonoid pigments that they contribute [22, 25, 30]
5	Roots	Moringine, moringinine, spirachin, 1,3-dibenzyl urea, α-phellandrene, p-cymene, Deoxy-niazimicine, 4-(alpha-L-rhamnopyranosyloxy) benzylglucosinolate [4, 26]
6	Whole-gum exudate	L-arabinose, L -galactose, L -glucuronic acid and L-rhamnose, L-mannose and L -xylose, while a homogeneous, degraded-gum polysaccharide consisting of L-galactose, β-glucuronic acid and L-mannose has been obtained on mild hydrolysis of the whole gum with acid [27]
7	Pods	Isothiocyanate, nitrites, thiocarbamates, O-(1heptenyloxy) propyl undecanoate, O-ethyl-4-(alpha-L-rhamnosyloxy) benzyl carbamate, methyl- p-hydroxybenzoate and β-sitosterol [4]
8	Seeds	Mature seeds contain 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, Moringyne, mono-palmitic and di-oleic triglyceride, Crude protein, Crude fat, carbohydrate, methionine, cysteine, Hemagglutin, and seed oils contain Vitamin A, beta carotene, a precursor of Vitamin A, Campesterol, stigmasterol, β-sitosterol, delta5-avenasterol,delta7-avenasterol, Clerosterol,24- methylenecholesterol, delta7-campestanol, stigmastanol, 28- isoavenasterol, unsaturated fatty acids, Saturated fatty acids- behenic acid and palmitic acid, Monoterpenoidcompounds contains α-phellandrene, p-cymene [26, 28, 29]
9	Fruits	Cytokinins, O-ethyl-4-(α-L-rhamnosyloxy) benzyl carbamate [30]

10. Traditional Uses: The Moringa tree has a wide range of medicinal applications, including both prevention and therapy. In several countries, the bark, sap, roots, leaves, seeds, oil and flowers are used in traditional medicine. A folk remedy for stomach complaints, catarrh, cancer, gastric ulcers, skin diseases, lowering blood sugar, increasing bone density, nervous conditions, diabetes, fatigue, increased lactation, hay fever, impotence, edema, cramps, haemorrhoids, headaches, sore gums; to strengthen the eyes and brain, liver, gallbladder, digestive, respiratory, and immune systems and as a blood cleanser and blood builder [8].

Leaves: The leaves were traditionally used as a treatment on the stomach to expel intestinal worms. Conjunctivitis is treated with a leaf infusion used as an eyewash.

The natural prevention of tuberculosis, bronchitis, and asthma is highly effective when made with drumstick leaves soup. The decoction of drumstick leaves is consumed as a soup; lime juice, pepper, and salt can be added to improve the flavor at the patient's choice [31]. Thyroid hormone can be reduced by using leaves [32]. To boost breast milk production, Philippine women use Moringa leaves combined with shellfish and chicken soup [33]. The leaves are mashed and used to scrub utensils and clean dividers. Its blossoms are known to be cholagogues, stimulants, diuretics, and tonics, all of which serve to increase the flow of bile [34].

Agriculturists add leaves to animal feed to keep up sound domesticated animals [35]. Leaves have been used as antibacterial infection, urinary tract infection, HIV-AIDS, fever, hepatic, antitumor,

antihypertensive, diarrhea, dysentery, ulcer, headache, antioxidant, protein and iron deficiency, vitamin (a mineral deficiency, lactation enhancer, catarrh and scurvy [36]

Bark: As a medicinal, the powdered form of the bark improves the quality of sperm and treats problems like premature ejaculation in men. To cure the problem of premature ejaculation, a decoction of bark powder and water sweetened with honey should be eaten [31]. Bark has been used for dental caries/toothache, common cold, sore/ulcer, antitumor, snakebite, scorpion bite, digestive, epilepsy, hysteria, headache, birth control, and scurvy [36]. Antifungal, abortifacient, antibacterial, and emmenagogue properties are all found in the bark. Bark can be used for tanning and also produces a coarse fiber [37].

Pods: The pods are used to treat diabetes and are anthelmintic, antipyretic, and anthelmintic. Amino acids such as arginine and histidine can also be found in moringa pods. The delicate pods are boiled or pickled before being used in a culinary arrangement [34].

Roots: Roots have been used for dental caries/toothache, common cold, fever, asthma, diarrhea, flatulence, epilepsy, hysteria headache, gout, low back/kidney pain, scurvy [36]. The root juice is used as a heart tonic, antiepileptic, anxiety, asthma, and an enlarged liver and spleen. Almost every element of the plant serves as a source of nourishment [30].

Seeds: In Malaya, the seed is reported to be eaten like a peanut. Salad greens, vegetable curries, pickles, and flavorings are all made with foliage. The oil extracted from the seed is odorless and transparent, making it suitable for the manufacture of perfumes and hair treatments [30]. Seeds have been used for numerous ailments in warts, antitumor, ulcer, rheumatism, arthritis, mineral/vitamin deficiency [36].

Flowers: Flowers have been used for throat infections, common cold, antitumor, rheumatism, tonic abortion, hysteria [36]. High medicinal value as a stimulant, aphrodisiac, abortifacient, and cholagogue; used to treat inflammations, muscle diseases, hysteria, tumors, and spleen enlargement; lower serum cholesterol, phospholipid, triglyceride, VLDL, LDL cholesterol to phospholipid ratio, and atherogenic index in hypercholesterolaemic rabbits; decrease lipid profile of liver, heart and increased the excretion of fecal cholesterol [38].

Gum: Gum is astringent and rubefacient and has been used to treat tooth cavities. Gum, mixed with sesame oil, is used to relieve headaches, fevers, digestive ailments, dysentery, asthma, and is sometimes used as an abortifacient and to cure syphilis and rheumatism [38].

11. Industrial Uses: The seed oil is used in the arts and lubricating watches and other delicate machinery. It is also utilized for the production of perfumes and hairdressing products. After oil extraction, the pressed cake can be used as a fertilizer. The drumstick tree's wood is used in the paper and textile industries, the bark is used in tanning, and the seeds are used in water purification [39].

12. Pharmacological Activities:

12.1 Anti-Inflammatory Activity: In an LPS-induced in vitro inflammatory model, the ethyl acetate fraction of *Moringa oleifera* extract exhibits significant anti-inflammatory therapeutic effects. Its anti-inflammatory activities were mediated by inhibiting the production of numerous inflammatory proteins in the signaling cascade and suppressing NF-kB activation and translocation into the nucleus. To investigate the cellular and molecular basis for Moringa oleifera ethyl acetate fraction's anti-inflammatory activity and explore *Moringa oleifera* therapeutic potential as a nutritious functional food for the treatment of inflammation-related diseases and disorders [40].

12.2 Wound Healing Activity: The wound healing activity of an aqueous extract of *Moringa oleifera* leaves was studied. The extract of *Moringa oleifera* was studied in rats using resutured incision, excision, and dead space wound models at 300 mg/kg body weight doses. Increased collagen deposition and better alignment and maturation seem to be involved in wound healing. It can be determined that *Moringa oleifera* aqueous extract has significant wound healing properties [41].

12.3 Antioxidant Activity: Using specific *in-vitro* standard procedures, evaluate the phytochemical profile and antioxidant activities of *Moringa*

oleifera pods against free radicals. Free radical scavenging activity of the hydro-ethanolic extract of *Moringa oleifera* pods was evaluated by 1,1-diphenyl-2-picrylhydrazil (DPPH), Ferric reducing antioxidant power assay (FRAP) assay, reducing power assay, Ferric thiocyanate (FTC), Thiobarbituric acid (TBA) and non-specific assay. The assay's results are compared to a natural antioxidant, Quercitin, as well as rutin, butylated hydroxyl toluene (BHT), butylated hydroxyanisole (BHA). In the present study, the extract had a high level of significance ($p<0.001$) when compared to the standards. The extract of *Moringa oleifera* pods is a good source of antioxidant properties, and it also showed significant free radical scavenging activity, reducing power activity and total antioxidant activity [42].

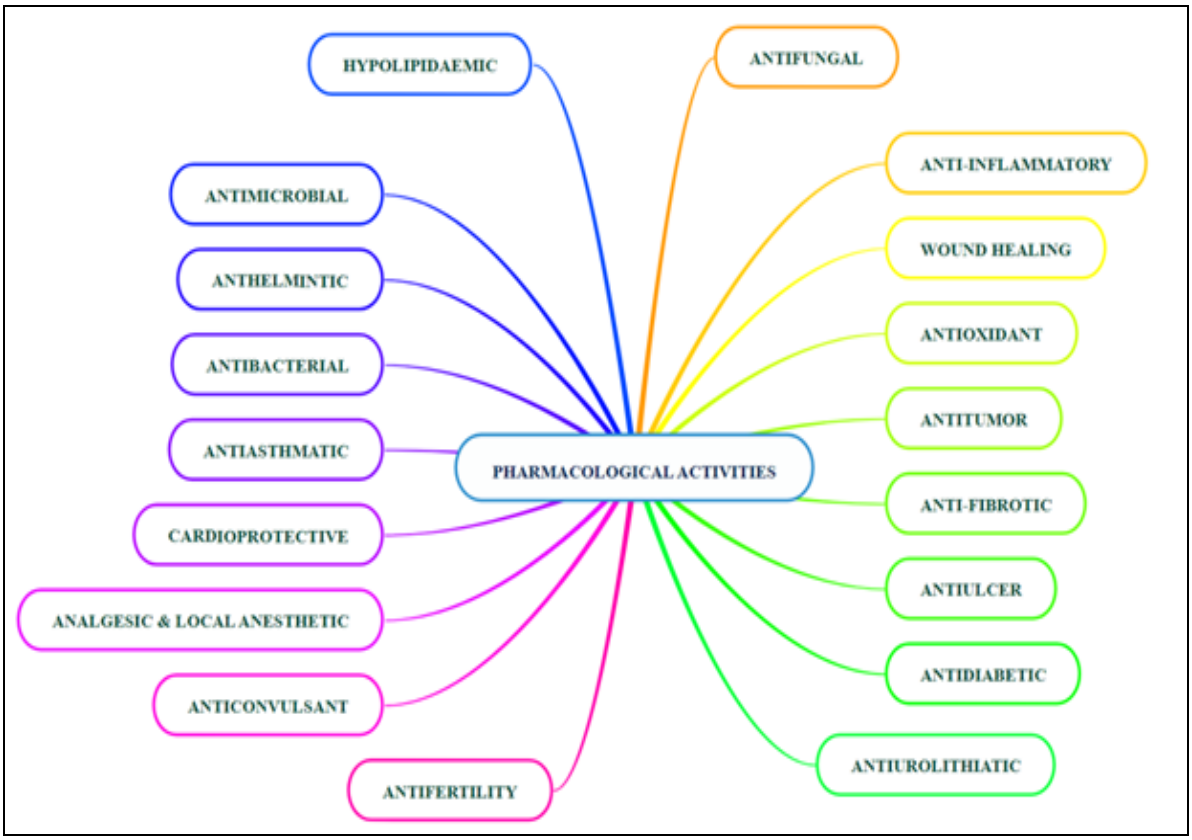

FIG. 6: PHARMACOLOGICAL ACTIVITIES OF *MORINGA OLEIFERA*

12.4 Antitumor Activity: *Moringa oleifera* leaf and ethanolic seed extracts have significant antitumor activity. Thiocarbamate and isothiocyanate-related substances have been found as tumor promoter inhibitors. The presence of three recognized thiocarbamate and isothiocyanate-related chemicals, which act as inhibitors of tumor promoter teleocidin B-4-induced Epstein-Barr virus, was responsible for the *in-vivo* antitumor potential [4].

12.5 Anti-fibrotic Activity: *Moringa oleifera* Lam (Moringa) seed extract's effect on liver fibrosis. The oral dose of 20% carbon tetrachloride (CCl4) twice weekly for eight weeks was used to induce liver fibrosis. *Moringa oleifera* Lam seed extract (1 g/kg) was also given orally on a daily. According to biochemical and histological studies, Moringa reduced liver damage and symptoms of liver fibrosis. The administration of Moringa seed extract decreased the CCl4-induced elevation of serum aminotransferase activities and globulin level. Moringa administration also reduced elevations in hepatic hydroxyproline concentration and myeloperoxidase activity.

According to immunohistochemistry research, Moringa also reduced the number of smooth muscle α-actin positive cells and the build-up of collagens I and III in the liver. Moringa seed extract substantially reduces antioxidant power and a significant inhibitory effect on the 1,1-diphenyl-2-picrylhydrazyl free radical. After treatment with Moringa, superoxide dismutase activity was

restored, as was the concentration of both malondialdehyde and protein carbonyl, both of which are oxidative stress markers. This research showed that Moringa seed extract could protect rats from CCl4-induced liver injury and fibrosis through an antioxidant mechanism, an anti-inflammatory action, and attenuating hepatic stellate cell activation [43].

12.6 Antiulcer Activity: The antiulcer activity of an ethanolic root-bark extract of *Moringa oleifera* (MO) in albino Wistar rats was examined utilizing two experimental models: ethanol-induced and pylorus ligation-induced gastric ulceration. For 15 days, the extract was administered orally at three different doses (150, 350, and 500 mg/kg). The antiulcer effects in rats treated with different doses of the extract and omeprazole (30 mg/kg, p.o.) were measured and statistically compared to the antiulcer effects in saline-treated control rats (NaCl, 0.9 %). Compared to the control group, MO at doses of 350 and 500 mg/kg significantly reduced the ulcer index ($p < 0.01$). In the pylorus-ligated ulcer model, the %age protections against gastric ulcers were 82.58 %, 85.13 %, and 86.15 %, respectively, at MO doses of 150, 350, and 500 mg/kg, and 55.75 %, 59.33 %, and 78.51 %, respectively, in the ethanol-induced ulcer model. Compared to the control group, the MO significantly reduced free acidity, total acidity, and ulcer index ($p<0.01$) and elevated the pH of gastric content. This research reveals that MO has antiulcer, antisecretory, and cytoprotective properties. As a result, an ethanolic *Moringa oleifera* root-bark extract can be used as a source for an antiulcer medication [44].

12.7 Antidiabetic Activity: Streptozotocin (STZ) induced diabetic male rats; the antidiabetic activity of two low doses of Moringa seed powder (50 and 100mg/kg body weight, in the diet) was evaluated. Forty rats were divided into four groups. When compared to the negative control group (G1), the diabetic positive control (STZ treated) showed higher levels of lipid peroxide, IL-6, and antioxidant enzyme in the serum and kidney tissue homogenate. Diabetes increased immunoglobulins (IgA, IgG), fasting blood sugar, and glycosylated hemoglobin (HbA1c) in the Positive control group rats (G2). Albumin was also reduced; however, liver enzymes and α-amylase were unaffected. Furthermore, renal functions and potassium and sodium levels in the Positive control group (G2) were elevated, indicating diabetic nephropathy. Glycosuria and elevated potassium, sodium, creatinine, uric acid, and albumin levels were detected in the urine. Compared to the negative control group, the kidney and pancreatic tissues showed pathological changes. When diabetic rats were administered 50 mg (G3) and 100 mg (G4) Moringa seeds powder/kg body, the levels of all these parameters ameliorated, approaching negative control values, and the normal histology of the kidney and pancreas was restored, compared to the diabetic positive control group [45].

12.8 Antifertility Activity: In female Wistar rats with artificially induced decidualization, the effects of ethanol extract at doses of 100, 250, and 500 mg/kg on fertility, implantation, decidualization, and local cytokine signalling during decidualization were studied. Compared to the control group, *Moringa oleifera* at dose levels of 250 and 500 mg/kg resulted in defective implantation, with smaller and dull-colored implants, which could be due to defective decidualization.

Furthermore, artificial decidualization studies revealed dose-dependent reductions in weight gain, oestradiol levels, and progesterone levels, which led to reduced expression of various local cytokines, include cyclooxygenase-2, leukaemia inhibitory factor, vascular endothelial growth factor, and interleukin 11, as demonstrated by immunohistochemistry and reverse transcription polymerase chain reaction studies. *Moringa oleifera* ethanol extract at doses of 250 and 500 mg/kg inhibited implantation in female rats, indicating that it has an antifertility effect and should be investigated further for potential contraceptive action [46].

12.9 Antiurolithiatic Activity: The antiurolithiatic activity of an aqueous extract of *Moringa oleifera* bark administered orally was evaluated in albino rats of Wistar strains. The stones were produced in this research by inserting a zinc disc foreign body into the bladder, supplemented with 1% ethylene glycol in the drinking water. The weight reduction of the stones was used to evaluate whether the bark of this plant had a preventive or curative antiurolithiatic effect. For the prophylactic and

curative groups, two doses of the extract were administered. When compared to the control group, oral administration of *Moringa oleifera* bark extract resulted in a significant reduction in the weight of bladder stones in both groups [47].

12.10 CNS Activity: The effect of *Moringa oleifera* aqueous leaf extracts on healthy mice motor and behavioral activities. For 14 days, male mice were divided into three groups: a control group (administered 0.9% NaCl orally) and three groups treated with the extract at doses of 100, 200, and 400 mg/kg/day. Motor and behavioral activity were evaluated by quantifying motor activity, exploration (hole-board), neuromuscular coordination (rota-rod treadmill), pain (hot plate, cold-water tail-flick, and acetic acid-induced abdominal constriction), and depression (forced swimming test, FST). *Moringa oleifera* extracts demonstrated a significant and dose-dependent antinociceptive effect ($p<0.05$). In the FST, the extract (400 mg/kg) reduced exploration activity and neuromuscular coordination and decreased mobility time, indicating an antidepressant-like effect. Motor activity was not significantly affected by any of the doses used. The research shows that the plant aqueous extract may have a dose-dependent depressant activity of the central nervous system (CNS) [48].

12.11 Anticonvulsant Activity: At different dose levels (200 mg/kg and 400 mg/kg i.p.), the anticonvulsant activity of methanolic extract of *Moringa oleifera* leaves against pentylenetetrazole (PTZ) and maximum electroshock (MES) caused convulsions was determined. Diazepam and phenytoin (5 mg/kg i.p. and 25 mg/kg i.p., respectively) were used as a reference standard. It significantly ($P<0.0001$) delayed the onset of clonic seizures in PTZ-induced convulsions and significantly ($P<0.0001$) reduced the duration of hind limb extension in the MES test at both doses. Alkaloids, flavonoids, tannins, and saponins were shown to be major constituents in the phytochemical analysis of the plant. According to the studies, a methanolic extract of *Moringa oleifera* leaves may help in the treatment of grand mal and petit mal epilepsy [49].

12.12 Analgesic Activity and Local Anesthetic Activity: Using the Hotplate and Tail immersion methods, the analgesic activity of *Moringa oleifera* alcoholic extract and its various fractions, such as Petroleum ether, Ethyl acetate, Diethyl ether, and n-butanol, was evaluated. The alcoholic extract and its different fractions of *Moringa oleifera* seeds showed significant analgesic activity that was comparable to that of aspirin at a dose of 25 mg/kg body weight. The study revealed that the seeds of *Moringa oleifera* Lam. have significant analgesic activity and are comparable to a standard drug (aspirin), showing that *Moringa oleifera* Seeds can be used as a regular analgesic [50]. The methanol extract of *Moringa oleifera* was studied for local anesthetic activity in frog and guinea pig models, and it was revealed that the plant (root bark) produced significant local anesthetic activity in both animals [51].

12.13 Cardioprotective Activity: To study the cardioprotective effects of a lyophilized hydroalcoholicextract of *Moringa oleifera* in a myocardial infarction model induced by isoproterenol (ISP). Compared to the ISP control group, chronic Moringa oleifera administration resulted in significant favorable modulation of biochemical enzymes (superoxide dismutase, catalase, glutathione peroxidase, lactate dehydrogenase) creatine kinase-MB), but no significant effect on reduced glutathione. Treatment with moringa significantly reduced lipid peroxidation in cardiac tissue. *Moringa oleifera* also protected against the deleterious histopathological and ultrastructural perturbations caused by ISP. According to the result of this research, *Moringa oleifera* extract has a significant cardioprotective effect, which can be related to its antioxidant, antiperoxidative and myocardial preservation properties [52].

12.14 Antiasthmatic Activity: Moringa plant alkaloid closely resembles ephedrine in action and can be used to treat asthma. Morning, an alkaloid, relaxes the bronchioles. During a study to assess the efficacy and safety of seed kernels for the management of asthmatic patients, the seed kernels of MO also showed potential for the treatment of bronchial asthma. The study found a significant reduction in the intensity of asthma symptoms as well as improvements in respiratory function [53].

12.15 Antibacterial and Antifungal Activity: The distillate of *M. oleifera* inhibited the growth of test microorganisms significantly, showing an antibacterial effect. *E. coli* showed the most inhibition among the microorganisms studied, followed by *S. aureus, K. pneumoniae, P. aeruginosa and B. subtilis*. Fungi inhibition was also observed as a reduction in colony diameter in distillate-poisoned plates compared to control plates. A. *niger* showed the most inhibition, followed by *A. oryzae, A. terreus* and *A. nidulans*. The antibacterial and antifungal activities of *M. oleifera* steam distillate could be attributed to the essential oil portion of the plant material present in the distillate fraction [54].

12.16 Anthelmintic Activity: In an *in-vitro* study, fresh eggs, embryonated eggs, L1 and L2 larvae of Haemonchuscontortus were evaluated against macerated and infused aqueous extract as well as ethanolic extract of *Moringa oleifera.* Extracts were prepared at five different concentrations (0.625, 1.25, 2.5, 3.75 and 5 mg/mL). Fresh eggs were exposed for 48 hours to the various concentrations, while embryonated eggs and larvae were exposed for 6 and 24 hours, respectively. Distilled water and 1.5% DMSO were used as the negative control. At 3.75 and 5 mg/mL, the ethanolic leaf extract of *Moringa oleifera* was shown to be the most effective on eggs, inhibiting 60.3% ± 8.2% and 92.8% ± 6.2% egg embryonated, respectively 55.

12.17 Antimicrobial Activity: Ervianingsih *et al* (2019) reported the antimicrobial activity of *Moringa oleifera* L. leaf extract against the growth of Staphylococcus epidermidis. Three different concentrations of Moringa leaf extract were used, namely 2% b/v, 4% b/v and 8% b/v which were tested on *S. epidermidis* bacteria using the paper disk diffusion method. The results showed that *Moringa oleifera* L. extract could inhibit the growth of *S. epidermidis* by showing the inhibition zone around the extract. The biggest inhibition zone at a concentration of 8% b/v was 14 mm, for a concentration of 4% b/v was 10.8 mm, and the smallest zone at a concentration of 2% b/v was 9.3 mm [56].

12.18 Hypolipidaemic Activity: For 30 days, Albino Wistar rats were administered methanolic extract of *M. oleifera* (150, 300, and 600 mg/kg, p.o.) and simvastatin (4 mg/kg, p.o.) along with a hyperlipidemic diet to observe the hypolipidemic effect. *M. oleifera* and simvastatin were demonstrated to lower serum cholesterol, triacylglyceride, VLDL, LDL and atherogenic index while increasing HDL levels when compared to a high-fed cholesterol diet group (control). *M. oleifera* was also found to increase fecal cholesterol excretion. As a result, *M. oleifera* possesses a Hypolipidaemic effect [57].

CONCLUSION: In today's market, there is a significant need for plant-based pharmaceuticals, food supplements, health products, Pharma-ceuticals, cosmetics *etc*. The plant or individual parts of the plant, including leaves, bark, seeds, pods, gum, flower, and fruit, are used to treat a variety of human ailments.

The plant possesses many secondary metabolites and has various pharmacological activities, as discussed in the present paper. In conclusion, it can be further investigated in the future for the development of nutritional supplements that may be effective in a range of disease circumstances and thus improve quality of life.

ACKNOWLEDGEMENT: The authors are thankful to Principal G. H. G Khalsa College of Pharmacy, Gurusar Sadhar (Ludhiana), and the management for providing us all the facilities.

CONFLICTS OF INTERESTS: The authors declared no conflicts of interest.

REFERENCES:

1. Gopalakrishnan L, Doriya K and Kumar DS: *Moringa oleifera*: A review on nutritive importance and its medicinal application. Food Science and Human Wellness 2016; 5: 49–56.
2. Devkota S and Bhusal KK: *Moringa oleifera*: A miracle multipurpose tree for agroforestry and climate change mitigation from the Himalayas – A review. Cogent Food & Agriculture 2020; 6(1): 1-8
3. Sholapur HPN and Patil BM: Pharmacognostic and phytochemical investigations on the bark of *Moringa oleifera* Lam. Indian Journal of Natural Products and Resources 2013; 4(1): 96-101.
4. Paikra BK, Dhongade HKJ and Gidwani B: Phytochemistry and Pharmacology of *Moringa oleifera* Lam. Journal of Pharmacopuncture 2017; 20(3): 194-200.
5. Sudad K, Al Taweel and Iman HA Al-Anbari: *Moringa olifera*: a review on the phytochemical screening, Proximate analysis, medicinal, nutritional and plant

biostimulants values of its leaves, pods, seeds and roots. Plant Archives 2019; 19(2): 1612-1622.
6. Chorage CA, Solanke GM and Ranjeet Kalel: Processing of *Moringa oleifera* Leaves to Develop Powder for Consumption: A Review. International Journal of Science and Research 2020; 9(5): 617-619.
7. Razis AFA, Ibrahim MD and Kntayya SB: Health benefits of*Moringa oleifera*. Asian Pacific journal of cancer prevention 2014; 15(20): 8571-8576.
8. Tripathi A, Dixit S and Kumar P: Medicinal properties of *Moringa oleifera*: a review. International Journal of Education and Science Research 2016; 3(2): 173-185.
9. Nadkarni KM: Indian materiamedica. Bombay, India: Popular Prakashan 2000; 1: 811.
10. Bhargave A, Pandey I, Nama KS and Pandey M: "*Moringa oleifera* Lam. – Sanjana (Horseradish Tree) - A Miracle food plant with multipurpose uses in Rajasthan-India-An overview. International Journal of Pure Applied Bioscience 2015; 3(6): 237-248.
11. Raja R, Sreenivasulu M, Vaishnavi S, Navyasri DM, Samatha G and Geethalakshmi S: *Moringa oleifera*-An Overview. Research and Analysis Journal of Applied Research 2016; 2(9): 620-624
12. Government of India, Department of AYUSH, Ayurvedic Pharmacopoeia of India. Part I, vol. IV, Ministry of Health and welfare, Ghaziabad 1999; 2017: 130.
13. Saha S: *Moringa oleifera*: The Miracle Tree. International Journal for Scientific Research & Development 2017; 5(4): 509-512.
14. Sandeep G, Anitha T, Vijayalatha KR and Sadasakthi A: Moringa for nutritional security (*Moringa oleifera* Lam.). International Journal of Botany Studies 2019; 4(1): 21-24.
15. Leone A, Spada A, Battezzati A, Schiraldi A, Aristil J and Bertoli S: *Moringa oleifera* Seeds and Oil: Characteristics and Uses for Human Health. International Journal of Molecular Science 2016; 17(2141): 1-14.
16. Sahoo JP, Mohapatra U, Sahoo S and Samal KC: Insights into the miracle plant *Moringa oleifera*. Pharma Innovation 2020; 9(7): 473-479.
17. Dutta AK: *Moringa oleifera*: A Review on Its Importance and Medicinal Application in Recent Age. World Journal of Pharmacy and Pharmaceutical Sciences 2017; 6(12): 1829-1843.
18. Patel S, Thakur AS, Chandy A and Manigauha A: *Moringa Oleifera*: A Review of There Medicinal and Economical Importance to the Health and Nation. Drug Invention Today 2010; 2(7): 339-342.
19. Thapa K, Poudel M and Adhikari P: *Moringa oleifera*: A Review Article on Nutritional Properties and its Prospect in the Context of Nepal". Acta Scientific Agriculture 2019: 47-54.
20. Mishra S, Lakhawat S and Pandey H: Moringa Oleifera: A miracle plant. Popular Kheti 2020; 8(2): 29-30.
21. Saa RW, Fombang EN, Ndjantou EB and Njintang NY: Treatments and uses of *Moringa oleifera* seeds in human nutrition: A review. Food Science and Nutrition 2019; 7: 1911-1919.
22. Vyas R, Chhipa H and Sharma K: Benzoil Tree: A Review On Uses of *Moringa oliefera* to overcome malnutrition In India. World Journal of Pharmacy and Pharmaceutical Sciences 2021; 10(5): 1699-1729.
23. Bennett RN, Mellon FA, Foidl N, Pratt JH, Du pont MS, Perkins L and Kroon PA: Profiling glucosinolates and phenolics in vegetative and reproductive tissues of the multipurpose trees *Moringa oleifera* L. and *Moringa stenopetala* L. Journal of Agricultural *and* Food Chemistry 2003; 51(12): 3546-3553.
24. Milla PG, Penalver R and Nieto G: Health Benefits of Uses and Applications of *Moringa oleifera* in Bakery Products. Plants 2021; 10(318): 1-17.
25. Toma A and Deyno S: Phytochemistry and pharmacological activities of moringa oleifera. International Journal of Pharmcognosy 2014; 1(4): 222-231.
26. Srivastava M, Dhakad PK and Srivastava B: A Review on Medicinal Constituents and Therapeutic Potential of *Moringa oleifera*. Universal Journal of Plant Science 2020; 8(2): 22-33.
27. Shingare B, Vikhe S and Vikhe D: Nutritional Value of *"Moringa oleifera"* A Review. World Journal of Pharmacy and Pharmaceutical Sciences 2020; 9(6): 621-631.
28. Priyatama VP: *Moringa oleifera*: Panaromic view on nutritional, therapeutic activity and patent landscape. International Journal of Pharmaceutical Sciences and Developmental Research 3(1): 24-28
29. Shah SK, Jhade DN and Chouksey R: *Moringa oleifera* Lam. A Study of Ethnobotany, Nutrients and Pharmacological Profile. Research Journal of Pharmaceutical, Biological and Chemical Sciences 2016; 7(5): 2158- 2165.
30. Swati, Virk AK, Kumari C, Ali A, Garg P, Thakur P, Attri C and Kulshrestha S: *Moringa oleifera* - A Never Die Tree: An Overview. Asian Journal of Pharmaceutical and Clinical Research 2018; 11(12): 57-65
31. Mehta J, Shukla A, Bukhariya V and Charde R: The Magic Remedy of Moringa Oliferia: An Overview. International Journal of Biomedical and Advance Research 2011; 2(6): 215-227
32. Tahiliani P and Kar A: *Achyranthesa spera* elevates thyroid hormone levels and decreases hepatic lipid peroxidation in male rats. Journal of Ethnopharmacology 2000; 71: 527-32.
33. Sial N, Musawer A, Shamas S, Shahzad MI, Ashraf H, Abid S, Taj S, Jamshaid M, Yaseen A: *Moringa oleifera* impacts on growth performance of *Ctenopharyngod onidella* fingerling. Ciencia E Tecnica Vitivinicola 2019; 34(8): 40-46.
34. Mishra G, Singh P, Verma R, Kumar S, Srivastav S , Jha KK and Khosa RL: Traditional uses, phytochemistry and pharmacological properties of Moringa oleifera plant: An overview. Der Pharmacia Lettre, 2011, 3(2): 141-164.
35. Fahey JW: *Moringa oleifera*: A review of the medical evidence for its nutritional, therapeutic, and prophylactic properties. Part 1. Trees for Life Journal 2005; 1: 5.
36. Chaudhary K and Chaurasia S: Neutraceutical Properties of Moringa Oleifera: A Review. European Journal of Pharmaceutical and Medical Research 2017; 4(4): 646-655.
37. Mall TP and Tripathi SC: *Moringa oleifera*: A Miracle Multipurpose Potential Plant in Health Management and Climate Change Mitigation from Bahraich (UP) India - An Overview. International Journal of Current Research in Biosciences and Plant Biology 2017; 4(8): 52-66.
38. Anwar F, Latif S, Ashraf M and Gilani AH: Moringa oleifera: A Food Plant with Multiple Medicinal Uses. Phytotherapy Research 2007; 21: 17–25.
39. Foidl N, Makkar HPS and Becker K: The potential of Moringa oleifera for agricultural and industrial uses. In: "The Miracle Tree/ the Multiple Attributes of Moringa" (Ed. Lowell J Fuglie). CTA USA 2001; 12.
40. Arulselvan P, Tan W, Gothai S, Muniandy K, Fakurazi S, Esa N and Kumar S: Anti-Inflammatory Potential of Ethyl Acetate Fraction of *Moringa oleifera* in Down regulating

the NF-κBSignaling Pathway in Lip polysaccharide-Stimulated Macrophages. Molecules 2016; 21(11), 1452.
41. Rathi BS, SL Bodhankar and Baheti AM: Evaluation of aqueous leaves extract of *Moringa oleifera* Linn for wound healing in albino rats. Indian Journal of Experimental Biology 2006; 44: 898-901.
42. Sharma V, Paliwal R, Pracheta and Sharma S: Phytochemical analysis and evaluation of antioxidant activities of hydro-ethanolic extract of *Moringa oleifera* Lam. Pods. J of Pharmacy Research 2011; 4(2): 554-557.
43. Hamza AA: Ameliorative effects of *Moringa oleifera* Lam seed extract on liver fibrosis in rats. Food and Chemical Toxicology 2010; 48(1): 345–355.
44. Choudhary MK, Bodakhe SH and Gupta SK: Assessment of the Antiulcer Potential of *Moringa oleifera* Root-Bark Extract in Rats. Journal of Acupuncture and Meridian Studies 2013; 6(4): 214–220.
45. Al-Malki AL and El Rabey HA: The Antidiabetic Effect of Low Doses of *Moringa oleifera* Lam. Seeds on Streptozotocin Induced Diabetes and Diabetic Nephropathy in Male Rats. BioMedical Research International 2015; 1–13.
46. Agrawal SS, Vishal D, Sumeet G, Shekhar C, Ashish N, Parul D, Ankita S, Prakash A, Prakash T, Kumar P and Varun S: Antifertility Activity of Ethanol Leaf Extract of Moringa oleifera Lam. in Female Wistar Rats. Indian Journal of Pharmaceutical Sciences 2018; 80(3): 565-570.
47. FahadJ, Vijayalakshmi, Kumar MCS, Sanjeeva, Kodancha GP, Adarsh B, Udupa AL and Rathnakar UP: Antiurolithiatic activity of aqueous extract of bark of *Moringa oleifera* (lam.) in rats. Health 2010; 02(04): 352–355.
48. Al-Abria M, Ashiquea M, Ramkumara A, Nemmarb A and Badreldin H Al, Al-Abri M, Ashique M, Ramkumar A, Nemmar A and Ali BH: Motor and Behavioral Effects of *Moringa oleifera* Leaf Extract. Natural Product Communications 2018; 13(1): 89-92.
49. Amrutia J, Lala M, Srinivasa and Moses RS: Anticonvulsant activity of *Moringa oleifera* leaf. International Research Jof Pharmacy 2011; 2(7): 160–162.
50. Sutar NG, Bonde CG, Patil VV, Narkhede SB, Patil AP and Kakade RT: Analgesic activity of seeds of *Moringa oleifera* Lam. International Journal of Green Pharmacy 2008; 2(2): 108-110.
51. Bandana M, Khanikor HN, Lahon LC, Mohan P and Barua C: Analgesic, anti-inflammatory and local anaesthetic activity of Moringa in laboratory animals. Pharmaceutical Biology 2003; 41(4): 248-252.
52. Nandave M, Ojha SK, Joshi S, Kumari S and Arya DS: 2009. *Moringa oleifera* leaf extract prevents isoproterenol-induced myocardial damage in rats: evidence for an antioxidant, antiperoxidative and cardioprotective intervention. J of Medicinal Food 2009; 12(1): 47-55.
53. Farooq F, Rai M, Tiwari A, Khan AA and Farooq S: Medicinal properties of *Moringa oleifera*: An overview of promising healer. Journal of Medicinal Plants Research 2012; 6(27): 4368-4374.
54. Kekuda TRP, MallikarjunN, Swathi D, Nayana KV, Aiyar MB and Rohini TR: Antibacterial and Antifungal efficacy of steam distillate of *Moringa oleifera* Lam. Journal of Pharmaceutical Science and Research 2010; 2(1): 34-37.
55. Tayo GM, Pone JW, Komtangi MC, Yondo J, Ngangout AM and Mbida M: Anthelminthic activity of *Moringa oleifera* leaf extracts evaluated *In-vitro* on four developmental stages of haemonchuscontortus from goats. American Journal of Plant Sciences 2014; 5(11): 1702-1710.
56. Ervianingsih, Mursyid M, Annisa RN, Zahran I, Langkong J and Kamaruddin I: Antimicrobial activity of moringa leaf (*Moringa oleifera* L.) extract against the growth of *Staphylococcus epidermidis*. IOP Conf. Series: Earth and Environmental Science 2019; 343: 1-4.
57. Jain PG, Patil SD, Haswani NG, Girase MV and Suran SJ: Hypolipidemic activity of *Moringa oleifera* Lam., Moringaceae, on high fat diet induced hyperlipidemia in albino rats. Brazilian Journal of Pharmacognosy 2010; 20(6): 969-973.

How to cite this article:
Jaiswal V, Singh G and Kaur J: Miracle tree: *Moringa oleifera*. Int J Pharm Sci & Res 2022; 13(5): 1924-34. doi: 10.13040/IJPSR.0975-8232.13(5). 1924-34.